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The Internationalization of Corporate R&D

Leveraging the Changing Geography of Innovation

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Foreword

Recent trends show that multinational companies increasingly distribute their innovative activities across several countries and purposefully create global R&D networks. While companies can improve their competitiveness, countries can benefit from this process in several ways, for example by increased productivity, inward R&D investments and talent circulation.

This report consists of several studies, covering different countries, industry sectors and analytical approaches. Together, the studies provide a multi-faceted account of the extent of corporate R&D internationalization, its driving forces and its potential implications for countries, with a particular focus on Sweden. As argued in the report, policymakers can further strengthen the Swedish position to take advantage of the increasing global flows of corporate R&D.

The studies have been conducted by the Swedish Institute for Growth Policy Studies (ITPS), with financial support from the Swedish Governmental Agency for Innovation Systems (VINNOVA). For the report, ITPS has benefited from its official statistical databases on corporate R&D in Sweden and its network of science and technology offices around the world. Analysts from ITPS offices in Tokyo, Beijing, Stockholm, Östersund, Washington, D.C. and Los Angeles, along with partners from Swedish academia and the U.S., have participated in the studies.

Östersund, May 2006

Sture Öberg
Director General

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The Authors

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Summary

Companies are changing the way they innovate...

Multinational companies are building networks of distributed research and development (R&D). Companies like IBM, Microsoft, Ericsson and AstraZeneca have established R&D facilities away from their headquarters at many locations worldwide.

The rise of cross-border corporate R&D became significant in the mid–1980s following the broader internationalization pattern of manufacturing in the 1970s. This trend has expanded into knowledge-intensive services and more systematic R&D activities during the 1990s. International corporate R&D involves investment, trade, mobility of people and exchange and collaboration around the world with suppliers, universities, research institutes, customers and even competitors.

The challenge for multinational companies is to manage their global innovation networks resourcefully and to find the right balance between local in-house R&D, external R&D, and R&D performed in other countries. Companies are becoming integrators of globally distributed R&D.

...with implications for countries and their innovation systems.

Technological change and innovation driven by R&D have been important sources of productivity growth, competitiveness and increased welfare. The globalization of R&D and innovation is making this relationship increasingly complex and more important to analyze and understand for policy makers.

Increased international investment, trade and exchange related to R&D will most certainly have both positive and negative effects for individual countries. However, outcomes are uncertain and might not be observable without a considerable time lag. So far, no major negative implications have been observed in Sweden.

Individual countries must find ways to maintain and strengthen national innovation capabilities while companies increase their share of R&D abroad and while foreign companies increase their control of domestic R&D activities.

A policy response might include measures designed to: strengthen the national science and technology base; foster attractive conditions for knowledge-intensive activities, production and leading markets; stimulate the internationalization and mobility of researchers and engineers; and maximize economic benefits from corporate R&D activities. Policy makers are changing their mindset from supporting R&D and innovation activities of “their” companies, to making their country the best place for companies around the world to innovate and perform R&D.

About the Studies

The studies in this report analyze international flows of corporate R&D and discuss the implications for countries and their national policies. Key questions are:

- What is the extent of the internationalization of corporate R&D, and what are the trends, driving forces and barriers?
- What are the potential, future implications for countries, and what are the options for national policies, with a particular focus on Sweden?

The report has a global scope and includes studies of Sweden, the U.S., Japan, China and India. The studies build upon existing literature and try to contribute more up-to-date empirical evidence based on interviews, surveys and additional data analysis. The main findings are summarized below.

R&D and innovation is still rooted at "home"...

Corporate R&D is the least internationalized activity of multinational companies. Companies continue to keep a proportionally larger part of their R&D activities close to their home base, when compared to production and other business activities. For example, U.S. pharmaceutical companies spend a major share of their R&D money in the U.S., and Swedish-controlled multinational companies have a higher R&D intensity at home than at subsidiaries abroad.

The reasons for keeping R&D at "home" include the complex and strategic nature of innovation, as well as the embeddedness of R&D activities in the domestic environment. In Sweden, several large, technology-intensive multinational companies have contributed to – and benefited from – strong national innovation systems in the past.

...but international R&D is increasing.

The domestic character of R&D has changed over the past two decades as a growing share of corporate R&D is undertaken abroad. As an example, R&D investments by companies in Sweden have increased both in Sweden and abroad, but the share of investments outside Sweden is increasing. The pattern of internationalization can be seen in many industrial sectors, including the pharmaceuticals, information and communications, and automotive sectors. European companies, especially from smaller countries, are more internationalized in terms of R&D than U.S. and Japanese companies.

In the case of Sweden, 20 major enterprise groups performed approximately 40 percent of their R&D outside of Sweden in 2003, up from 20 percent in 1995. The communications manufacturing industry has been the main driver behind R&D investments abroad.

During the same period, the share of foreign-controlled R&D in all industry sectors in Sweden increased from 10 to 45 percent. Sweden is one of the most internationalized countries in the world when it comes to corporate R&D.

Most R&D is located within the Triad...

The greater part of the internationalization of R&D takes place within the Triad (the U.S., Europe and Japan). The U.S. is the major location for foreign R&D. U.S. multinational companies invested 11.3 billion dollars in the European Union in 2001. The automobile industry accounted for 37 percent of this investment. In the opposite direction, EU-15 R&D investment in the U.S. (total 16.7 billion dollars) was concentrated mainly in the pharmaceutical sector, accounting for 30 percent of that investment. Also in the case of Sweden, the largest share of R&D abroad is within the OECD.

Japanese companies are least internationalized, and Japan is the least favored location within the Triad. Japanese companies are planning to expand their international innovation networks, but so far they lag behind because of industry structure and corporate culture.

...but the share of developing countries is increasing.

More recently, developing countries are attracting corporate R&D. The increase in developing Asia (most notably China and India) is the most dramatic. Moreover, multinational companies are planning to increase R&D investments in the region, while not increasing, or even decreasing, at home in the near future. Despite recent increases, the levels of corporate R&D activities in developing countries are still low.

If not interrupted by national events, political or otherwise, it is likely that foreign companies will continue to increase R&D activities in China and India. In the case of Sweden, corporate R&D activities in India and China have been growing rapidly during the last five years, but are still in an early phase of development.

Foreign R&D is driven by acquisitions and political requirements,...

Mergers and acquisitions are important drivers for the internationalization of corporate R&D. However, the motives behind mergers and takeovers might not be only to acquire strategic R&D capabilities. More often, the objective is broader, targeting larger market shares, economies of scale in production, or expanding brand portfolios. History and organic growth are important factors explaining the development and configuration of corporate R&D networks.

Other non-strategic drivers for foreign R&D are various forms of government requirements, for example as a condition for market access in a particular country.

...as well as company strategies to be close to production, markets and knowledge,...

Foreign R&D is becoming increasingly integrated into the overall R&D strategies of multinational companies. In a more rational approach, companies are strategically establishing or re-locating R&D activities to be close to production facilities, leading markets and centers of front-line research and innovation, with access to skilled personnel, on a global scale. Localization decisions are based on cost-benefit analyses, which take into consideration the cost and coordination difficulties as well as other possible constraints for a particular R&D activity.

As production becomes more and more international, companies in some sectors decide to move or establish certain R&D activities close to manufacturing facilities. This might be a driver for foreign R&D in the communications and automotive sector, but less so for pharmaceuticals.

For multinational companies it is also important to have certain types of R&D in countries with specific regulatory conditions (i.e. pharmaceuticals), to adapt products to local market conditions (i.e. software), to participate in standardization processes (i.e. communications equipment) or to launch new products and services on leading markets with advanced users (i.e. information technology services).

With increasing competitive pressure, cost and complexity of technological developments, companies are also searching globally for new technologies, leading-edge knowledge and skilled researchers and engineers. In Japan, for example, the aging population – and the resulting lack of skilled researchers and engineers – drives Japanese multinational companies to seek foreign locations for R&D.

...and is facilitated by technology, people and new actors.

An important enabler for any type of geographically distributed collaboration, including R&D, has been the development of global information and communications networks. Researchers and engineers at different locations can work around the clock as one integrated and global “virtual” team.

Another factor stimulating the internationalization of corporate R&D is the presence of large groups of highly-skilled and motivated immigrants in certain technology-intensive regions in the world. Immigrants from India and China, for example, are important players in the internationalization of the Silicon Valley region.

New intermediary players, most of them U.S.-based, are emerging on the global R&D market. Their business idea is to help companies solve specific problems and find technologies by employing their networks with global reach.

As an example, a company can reduce cost and time by posting a specific research problem in an open marketplace for problem-solving, and then have researchers and engineers worldwide compete to provide the solution.

International R&D is becoming more advanced...

International activities of multinational companies are moving up the value chain. It may begin with basic support for manufacturing and move up to development, technology design and even research, (e.g. telecommunication manufacturing companies in China). Or it may start with the offshoring (re-location) of low-end services and move up to more advanced development and design services, (e.g. software companies and knowledge process outsourcing in India).

It is important to note that most R&D abroad is either production-supportive or for the adaptation of products and services to local markets. Adaptive R&D is thus often located close to production facilities and key markets. Even if adaptive R&D still dominates, the share of international innovative R&D is increasing. Innovative R&D is typically located close to centers of excellence or clusters of companies and universities with global technology leadership.

...and is beginning to involve also smaller companies.

International R&D is still dominated by large multinational companies. However, even smaller high-tech companies have now started to locate R&D abroad to some extent. In the Silicon Valley region, this is a significant change from the past and mainly driven by requirements from venture capital companies. The rationale is that access to foreign talent and large emerging markets will reduce cost and time to market for new technologies. This trend is not yet significant in other markets.

The implications for national economies are not yet fully known...

The findings in this report show that it is still too early to fully evaluate the impact of R&D internationalization on specific national economies. The internationalization of corporate R&D is only one factor behind economic restructuring and labor market changes, and appears to be relatively less important compared to other factors, such as technological change and domestic outsourcing.

...and we need better research and forward-looking analysis.

In general, findings regarding trends, scope and strategies behind the internationalization of corporate R&D are heterogeneous and still limited. In addition, available data is often incomplete, difficult to compare between countries, difficult to interpret, and only available after considerable time lag.

Policy-relevant analysis must not only be current but also forward-looking, as well as identify trends, challenges and possible implications in a long-term perspective.

Sweden will benefit from the internationalization of R&D...

It is important to point out that Sweden has, so far, largely benefited from the internationalization of corporate R&D. For example, an increasing flow of knowledge into companies based in Sweden can be an important explanation for the recent productivity growth. Based on a number of indicators, Sweden seems to be in better shape than many comparable countries when it comes to R&D internationalization.

...but needs to proactively consider challenges.

For policymaking to be forward-looking, we suggest considering a set of future challenges for the internationalization of corporate R&D. The six identified challenges described in the report are based on the analysis of trends and driving forces.

1. As companies take advantage of R&D opportunities abroad, can the level of R&D activities in Sweden be sustained?
2. With increased globalization and specialization, can Sweden maintain and develop leading research and innovation environments?
3. Will foreign-controlled companies maintain their level of R&D activities in Sweden even under economic pressure?
4. Will Swedish public investments in education and research, and R&D performed in Sweden benefit the domestic economy?
5. Will there be fewer employment opportunities for researchers and engineers in certain areas in Sweden?
6. How will the long-term performance and renewal capabilities of Swedish national innovation systems be affected?

Sweden is a small country, dependent on a few large, export-oriented and R&D-intensive multinational companies with corporate R&D concentrated to basically three industry sectors: communications equipment, pharmaceuticals and automotive. Only within the communications sector is most of the R&D still under domestic ownership and control. These challenges are highly relevant since Sweden is one of the most R&D-internationalized countries in the world.

An integrated Swedish policy response...

A Swedish policy response should be based on a vision embracing internationalization. Policy objectives should include: establishing Sweden, in selected industry sectors, as a center of globally distributed R&D activities; establishing Sweden as the most attractive location for R&D; and establishing Swedish-based companies, institutes and universities as preferred partners for international science and technology collaboration.

An integrated Swedish policy response should build on the strengths of Swedish innovation systems and have a forward-looking, long-term perspective.

...should consider the following strategies and policy measures.

Based on the studies in this report and the current Swedish policy context, we would like to point out five specific areas that need particular attention and additional resources in order to address the challenges raised by the internationalization of corporate R&D:

1. Ensure the quality of the Swedish education and research system
2. Create conditions for excellent R&D and innovation environments
3. Develop proactive strategies for R&D internationalization for key countries
4. Develop stronger national attraction policies
5. Support the inflow of foreign talent and international skills of Swedish students

In order to support the strategies and policy measures discussed above, it is necessary to further develop Swedish capabilities for monitoring and analysis. We need to increase our understanding of the processes of internationalization in general and in relation to specific economies, such as China and India as well as those in Eastern and Central Europe. With improved data collection, international collaboration and adequate resources for analysis, we will be better equipped to provide foresight and early warning of trends and implications.

With this report as the starting point, the next step should be to more systematically evaluate the results and effects of the different policy measures discussed.

Sammanfattning

Företagen hittar nya sätt att vara innovativa...

De multinationella företagen utvecklar nätverk för distribuerad forskning och utveckling (FoU). Företag som IBM, Microsoft, Ericsson och AstraZeneca har etablerat FoU-anläggningar på många platser utanför huvudkontoren.

I mitten av 1980-talet ökade företagens FoU över gränserna kraftigt som ett resultat av att tillverkningen internationaliserats alltmer under 1970-talet. Under 1990-talet spred sig trenden till kunskapsintensiva tjänster och mer systematisk FoU-verksamhet. De internationella företagens FoU-verksamhet omfattar investeringar, handel, människors rörlighet samt utbyte och samarbete runt om i världen med leverantörer, universitet, forskningsinstitut, kunder och t.o.m. konkurrenter.

För de multinationella företagen handlar utmaningen om att hantera sina globala innovationsnätverk på ett effektivt sätt och hitta rätt balans mellan lokal FoU inom företaget, extern FoU och FoU som utförs i andra länder. Företagen integrerar globalt distribuerad FoU i sin verksamhet.

...och det påverkar länderna och deras innovationssystem.

Tekniska förändringar och innovationer med FoU som drivkraft har varit viktiga faktorer för ökad produktivitet, konkurrenskraft och välfärd. Globaliseringen av FoU och innovation gör detta samband mer komplext och viktigt att analysera och förstå för beslutsfattare.

Ökade internationella investeringar, handel och utbyte kopplade till FoU kommer helt säkert att få både positiva och negativa konsekvenser för enskilda länder. Resultatet är dock osäkert och kan kanske inte studeras förrän efter en lång tid. Än så länge har inga stora negativa konsekvenser märkts i Sverige.

Enskilda länder måste hitta sätt att bibehålla och stärka nationella innovationsfunktioner samtidigt som företagen utökar sin andel FoU utomlands och utländska företag ökar sin kontroll över inhemsk FoU-verksamhet.

Utmaningarna kan mötas med åtgärder som utformas för att stärka den nationella vetenskaps- och teknikbasen, främja attraktiva villkor för kunskapsintensiv verksamhet, produktion och ledande marknader, stimulera internationaliseringen av och rörligheten för forskare och ingenjörer samt maximera de ekonomiska fördelarna av företagens FoU-verksamhet. Beslutsfattarna ändrar tänkesätt från att stödja "sina" företags FoU- och innovationsverksamhet till att göra sitt land till den mest attraktiva innovations- och forskningsmiljön för företag från hela världen.

Om studierna

Studierna i rapporten analyserar de internationella flödena av företagens FoU. Dessutom diskuteras konsekvenserna för berörda länder och deras nationella policy. De viktigaste frågorna är:

- Hur omfattande är internationaliseringen av företagens FoU och vilka är trenderna, drivkrafterna och hindren?
- Vilka potentiella framtida konsekvenser kan detta få på nationell nivå och vilka alternativ finns för den nationella policyn, framför allt när det gäller Sverige?

Rapporten har en global räckvidd och innehåller studier från Sverige, USA, Japan, Kina och Indien. Studierna bygger på befintlig litteratur i ämnet och försöker tillföra ny empiri utifrån intervjuer, marknadsundersökningar och ytterligare dataanalys. De viktigaste slutsatserna sammanfattas nedan.

FoU och innovation har fortfarande sin bas "hemma"...

Inom multinationella företag är FoU den minst internationaliserade verksamheten. I jämförelse med produktion och annan affärsverksamhet fortsätter företagen att ha en proportionellt större andel av sin FoU-verksamhet nära hemmabasen. Amerikanska läkemedelsföretag spenderar t.ex. den största delen av sin FoU-budget i USA och svenskkontrollerade multinationella företag har en högre FoU-intensitet hemma än inom dotterbolagen utomlands.

Några anledningar till att företagen väljer att behålla sin FoU hemma är verksamhetens komplexa karaktär och strategiska betydelse samtidigt som FoU-verksamheten historiskt sett varit införlivad i den inhemska miljön. I Sverige har flera stora teknikintensiva multinationella företag bidragit till – och dragit fördel av – starka nationella innovationssystem.

...men internationell FoU ökar.

FoU-verksamhetens nationella karaktär har förändrats under de senaste två decennierna i takt med att den andel av företagens FoU som sker utomlands ökat. Ett exempel är att svenska företags FoU investeringar har ökat både i Sverige och utomlands, men samtidigt växer andelen investeringar utanför Sverige. Internationaliseringsmönstret förekommer inom många industrisektorer, t.ex. inom läkemedels-, information och kommunikations- samt fordonssektorn. Europeiska företag, framför allt från mindre länder, är mer internationaliserade när det gäller FoU än amerikanska och japanska företag.

År 2003 genomförde 20 större svenska företagskoncerner cirka 40 procent av sin FoU utanför Sverige, vilket är en ökning från 20 procent jämfört med 1995. Utvecklingen inom informations- och kommunikationsområdet har varit den starkaste drivkraften bakom FoU-investeringarnas expansion utomlands. Under perioden 1995-2003 ökade andelen utlandskontrollerad FoU inom alla industrisektorer i Sverige från 10 till 45 procent. Sverige är ett av de mest internationaliserade länderna i världen när det gäller företagens FoU.

Den största andelen FoU sker inom triaden...

Den största delen av internationaliseringen av FoU sker inom triaden (USA, Europa och Japan). Mest utländska FoU-medel investeras i USA. Amerikanska multinationella företag investerade 11,3 miljarder dollar inom EU 2001. Bilindustrin stod för 37 procent av denna investering. FoU-investeringarna i USA från EU-15 (totalt 16,7 miljarder dollar) koncentrerades framförallt till läkemedelssektorn som stod för 30 procent av dessa investeringar. När det gäller Sverige lokaliseras den största delen FoU utomlands till OECD.

De japanska företagen är de som är minst internationaliserade samtidigt som Japan attraherat mindre FoU-investeringar än övriga delar av triaden. De japanska företagen planerar att utöka sina internationella innovationsnätverk, men än så länge ligger de efter p.g.a. sin industristruktur och företagskultur.

...men andelen utvecklingsländer ökar.

På senare tid har utvecklingsländerna blivit mer attraktiva för lokalisering av företagens FoU. Ökningen i Asien (framför allt i Kina och Indien) är mest dramatisk. Dessutom planerar de multinationella företagen att utöka sina FoU-investeringar i detta område, samtidigt som man inom den närmaste framtiden inte planerar någon ökning eller t.o.m. avser att minska investeringarna hemma. Trots den senaste tidens ökningar ligger dock företagens FoU-verksamhet i utvecklingsländerna fortfarande på en låg nivå.

Såvida inte nationella händelser, politiska eller andra, påverkar situationen kommer de utländska företagen förmodligen att fortsätta att utöka sin FoU-verksamhet i Kina och Indien. När det gäller Sverige har företagens FoU-verksamhet i Indien och Kina ökat snabbt under de senaste fem åren, men befinner sig fortfarande i ett tidigt skede.

Utländsk FoU drivs av förvärv och politiska krav...

Sammanslagningar och förvärv är viktiga drivkrafter när det gäller internationaliseringen av företagens FoU. Motiven bakom sammanslagningarna och uppköpen handlar dock inte enbart om att förvärva strategiska FoU-funktioner. Oftast är syftet bredare och handlar om att få tillgång till större marknadsandelar, skalfördelar inom produktion eller att utöka varumärkesportföljen. Historiska förhållanden och organisk tillväxt är viktiga faktorer som förklarar utvecklingen och sammansättningen av företagens FoU-nätverk. Olika typer av statliga krav är andra icke-strategiska drivkrafter för utländsk FoU, t.ex. som ett villkor för tillgång till marknaden i ett visst land.

...samt företagsstrategier för att vara nära produktion, marknader och kunskap...

Utländsk FoU integreras alltmer i de multinationella företagens övergripande FoU-strategier. Från rationella utgångspunkter etablerar eller utlokaliserar företagen strategisk FoU-verksamhet i global omfattning så att den är nära produktionsanläggningar, ledande marknader och center för spetsforskning och innovation med tillgång till välutbildad personal. Lokaliseringsbesluten bygger på lönsamhetsbedömningar som beaktar såväl kostnader och samordningssvårigheter som andra möjliga begränsningar för en viss FoU-verksamhet.

I takt med att produktionen blir alltmer internationell beslutar företag inom vissa sektorer att flytta eller etablera viss FoU-verksamhet i anslutning till sina tillverkningsanläggningar. Detta är en drivkraft för utländsk lokalisering av FoU inom kommunikations- och fordonsindustrierna, men inte i lika stor utsträckning inom läkemedelsindustrin.

För multinationella företag är det även viktigt att ha viss typ av FoU i andra länder av hänsyn till specifika regelverk (t.ex. inom läkemedelsindustrin), för att anpassa produkterna till lokala marknadsförhållanden (t.ex. inom programvaruindustrin), för att delta i standardiseringsprocesser (t.ex. inom kommunikationsutrustningsindustrin) eller för att lansera nya produkter och tjänster på ledande marknader med avancerade användare (t.ex. inom informationsteknologiområdet).

I ett klimat som präglas av ökad konkurrens och ökande komplexitet och kostnader för teknisk utveckling försöker företagen att även globalt få tillgång till ny teknik, banbrytande kunskap samt välutbildade forskare och ingenjörer. I Japan leder t.ex. bristen på forskare och ingenjörer som är ett resultat av en åldrande befolkning, till att de japanska multinationella företagen söker efter ny lokalisering utomlands för sin FoU.

...och underlättas av teknik, människor och nya aktörer.

Utvecklingen av globala informations- och kommunikationsnätverk har varit en viktig förutsättning för etableringen av geografiskt spritt samarbete i olika former, inklusive FoU. Forskare och ingenjörer på olika platser kan arbeta dygnet runt i ett globalt virtuellt team.

En annan faktor som stimulerar internationaliseringen av företagens FoU är förekomsten av stora grupper välutbildade och motiverade invandrare i vissa teknikintensiva områden i världen. Invandrare från t.ex. Indien och Kina är viktiga aktörer när det gäller internationaliseringen av Silicon Valley-området.

Nya aktörer som fungerar som mellanhänder, varav de flesta är baserade i USA, har gjort sitt intåg på den globala FoU-marknaden. Deras affärsidé är att hjälpa företag att lösa specifika problem och hitta tekniska lösningar genom att utnyttja nätverk med global räckvidd. Ett företag kan t.ex. spara både kostnader och tid genom att presentera ett specifikt forskningsproblem på en öppen marknadsplats för problemlösning och sedan få forskare och ingenjörer världen över att tävla om att hitta lösningen.

Internationell FoU blir allt mer avancerad...

De multinationella företagens internationella verksamhet klättrar uppåt i värdekedjan. Det kan börja med grundläggande stöd för tillverkning och sedan övergå till utveckling, teknikdesign och t.o.m. forskning (t.ex. företag för tillverkning av kommunikationsutrustning i Kina). Eller så kan det börja med utlokalisering av enkla tjänster och sedan övergå till mer avancerade utvecklings- och konstruktionstjänster (t.ex. programvaruföretag och outsourcing av kunskapsintensiva tjänster till Indien).

Det är viktigt att notera att den största delen FoU utomlands är stöd till produktion eller FoU som syftar till att anpassa produkter och tjänster till lokala marknader. Anpassningsrelaterad FoU sker därför ofta i närheten av produktionsanläggningar och viktiga marknader. Även om anpassningsrelaterad FoU fortfarande dominerar ökar andelen internationell innovativ FoU. Innovativ FoU sker normalt i närheten av spetsforskningscentra eller kluster av företag och universitet med globalt tekniskt ledarskap.

...och även de mindre företagen börjar delta.

Internationell FoU domineras fortfarande av stora multinationella företag. Nu har emellertid även mindre högteknologiska företag till viss del börjat placera sin FoU-verksamhet utomlands. I Silicon Valley-området är detta en stor förändring jämfört med tidigare. Förändringen har framför allt skett p.g.a. krav från riskkapitalbolag. Resonemanget bygger på att tillgång till utländsk välutbildad arbetskraft och stora växande marknader kommer att leda till minskade kostnader och kortare utvecklingstider för ny teknik. Den här trenden är ännu inte betydande på andra marknader.

Konsekvenserna för nationella ekonomier är ännu inte helt kända...

Slutsatserna i rapporten visar att det fortfarande är för tidigt att fullständigt utvärdera konsekvenserna av internationaliseringen av FoU för specifika nationella ekonomier. Internationaliseringen av företagens FoU är endast en faktor bakom ekonomisk omstrukturering och förändringar på arbetsmarknaden, och tycks relativt sett vara mindre viktig än andra faktorer så som tekniska förändringar och inhemsk outsourcing.

...och vi behöver bättre forskning och framsynt analys.

I allmänhet är tillgängliga resultat beträffande såväl omfattning som trender och strategier bakom internationaliseringen av företagens FoU heterogena och fortfarande begränsade. Dessutom är tillgängliga data ofta ofullständiga, svåra att jämföra mellan länder och tolka samt endast tillgängliga efter lång tid. En policyrelevant analys måste inte bara vara aktuell utan även framåtblickande samtidigt som trender, utmaningar och eventuella konsekvenser uppmärksammas ur ett långsiktigt perspektiv.

Sverige kommer att gynnas av internationaliseringen av FoU...

Det är viktigt att påpeka att Sverige än så länge i stort sett har gynnats av internationaliseringen av företagens FoU. Ett ökat kunskapsinflöde till Sverigebaserade företag kan t.ex. vara en viktig förklaring till den senaste tidens ökade produktivitet. En rad indikatorer tyder på att Sverige befinner sig i en bättre position än många andra jämförbara länder när det gäller internationaliseringen av FoU.

...men måste proaktivt beakta utmaningar.

För ett framåtblickande beslutsfattandet föreslås att flera framtida utmaningar för internationaliseringen av företagens FoU beaktas. De sex utmaningarna som identifieras i rapporten bygger på analys av trender och drivkrafter.

1. Kan samma nivå på FoU-verksamheten bibehållas i Sverige när företagen alltmer utnyttjar möjligheterna med FoU utomlands?
2. Kan Sverige behålla och utveckla ledande forsknings- och innovationsmiljöer trots ökande globalisering och specialisering?
3. Kommer utlandskontrollerade företag att behålla nivån på sin FoU-verksamhet i Sverige även vid hårdare ekonomiska krav?
4. Kommer svenska offentliga investeringar i utbildning och FoU inom Sverige den inhemska ekonomin tillgodo?
5. Kommer det att bli färre arbetstillfällen för forskare och ingenjörer i Sverige?
6. Hur kommer den långsiktiga utvecklingen och förnyelseförmågan av de svenska nationella innovationssystemen att påverkas?

Sverige är ett litet land, som är beroende av ett fåtal stora, exportinriktade och FoU-intensiva multinationella företag vars FoU i stort sett är koncentrerad till de tre industrisektorerna kommunikationsutrustning, läkemedel och fordon. Endast inom kommunikationssektorn ägs och kontrolleras fortfarande den största delen FoU av inhemska intressen. Dessa utmaningar är ytterst relevanta eftersom Sverige är ett av de mest FoU-internationaliserade länderna i världen.

En integrerad svensk policy...

En svensk policy bör bygga på en vision som bejakar internationalisering. Policymålen bör omfatta att etablera Sverige som ett center för globalt distribuerad FoU-verksamhet inom utvalda industrisektorer, och den mest attraktiva platsen för FoU, samt att etablera Sverigebaserade företag, institut och universitet som attraktiva samarbetspartners för internationellt vetenskapligt och tekniskt samarbete.

En integrerad svensk policy bör bygga på styrkorna i de svenska innovationssystemen och ha ett framåtblickande långsiktigt perspektiv.

...bör beakta följande strategier och policyåtgärder.

Utifrån studierna i rapporten och aktuella svenska förhållanden utpekas fem specifika områden där det krävs särskild uppmärksamhet och ytterligare resurser för att kunna ta itu med de utmaningar som internationaliseringen av företagens FoU innebär.

1. Säkerställa kvaliteten i det svenska utbildnings- och forskningssystemet
2. Skapa förutsättningar för att utveckla miljöer för spetsforskning och innovation
3. Utveckla proaktiva strategier för internationalisering av FoU i förhållande till viktiga länder
4. Utveckla en starkare nationell attraktionspolitik för företagens FoU i Sverige
5. Främja inflödet av utländsk välutbildad arbetskraft och de svenska studenternas internationella färdigheter

För att kunna stödja de strategier och policyåtgärder som diskuteras ovan är det nödvändigt att vidareutveckla de svenska funktionerna för uppföljning och analys. Vi måste öka vår förståelse för internationaliseringsprocesserna på ett övergripande plan och för specifika ekonomier så som Kina och Indien samt ekonomierna i Öst- och Centraleuropa. Med förbättrad datainsamling, internationellt samarbete och tillräckliga analysresurser kommer vi att vara bättre rustade för att leverera kvalificerade framtidsbedömningar och tidiga varningar beträffande trender och konsekvenser.

Med denna rapport som utgångspunkt, bör nästa steg vara en mer systematisk utvärdering av resultat och effekter av de olika policyåtgärder som diskuterats.

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1 The Challenges of International Corporate R&D
Magnus Karlsson

1.1 Introduction

1.1.1 Companies are Creating Global Innovation Networks

Companies are changing the way they innovate. Multinational companies and, in some cases, smaller high-tech companies, are building networks of distributed research and development (R&D). Companies like IBM, Microsoft, Ericsson and AstraZeneca have established R&D facilities away from their headquarters at many locations worldwide.

The rise of cross-border corporate R&D became significant in the mid–1980s following the broader internationalization pattern of manufacturing in the 1970s. This trend has expanded into knowledge-intensive services and more systematic R&D activities during the 1990s. International corporate R&D involves investment, trade, mobility of people and exchange and collaboration around the world with suppliers, universities, research institutes, customers and even competitors.

The practice of establishing R&D activities in foreign countries has so far mostly occurred within the Triad (the U.S., Europe and Japan). However, during the last five years, there has been a rapid increase in locating R&D to developing countries, including India, China, Singapore as well as Eastern and Central Europe. The trend can be observed in a number of industrial sectors, including information technology, communications, biotechnology and pharmaceuticals.

The drivers to extend R&D beyond company borders include the need for adaptation to local markets, support for foreign manufacturing and increasingly, to reach globally for knowledge, technologies and talent. R&D abroad is dominated by development but the share of research is increasing.

Companies are also responding to the fact that innovation itself is changing. First, the process of turning knowledge into commercially viable products and services is occurring more rapidly because barriers of geography and access have come down. The development of communications technologies is an important enabler. Second, the process is increasingly complex and collaboration across disciplines and specialties is necessary. Third, innovation is collaborative, requiring active cooperation between scientists, engineers and leading end-users, as well as between the design, manufacturing, supply and marketing functions of the company. Fourth, it is becoming more expensive to develop new products and services, and external partnerships can reduce cost and risk. Finally, the innovation process is becoming global in scope. Knowledge is created at centers of excellence around the world (see for example IBM 2004, NII 2004).

The challenge for multinational companies is to manage their global innovation networks resourcefully and to find the right balance among local in-house R&D, external R&D performed outside the company and foreign R&D performed at affiliates in other countries. Companies are becoming integrators of globally distributed R&D.

1.1.2 The Changing Geography of Innovation

The global pattern of international corporate R&D is a result of both intensified merger and acquisition activity and more deliberate internationalization strategies by companies. The forces of globalization and innovation are shaping a world that is more interconnected and more competitive.

In recent books, authors such as Thomas Friedman and Richard Florida argue that globalization is a fundamental historical phenomenon. In this new "flat world," companies build global supply chains for manufacturing and services creating opportunities for developing countries to participate in the global economy (Friedman 2005). Countries in developing Asia, such as India and China, are gaining economic and technological strength. They are competing with a highly skilled workforce, building their national R&D capabilities and successfully attracting foreign direct investment.

As a result the global competition for talent and ideas is intensifying. The real advantage for a country lies in its ability to attract these economic drivers from around the world. According to Florida, the U.S. is not the given winner in this game, but is in fact "now facing its greatest challenge since the dawn of the Industrial Revolution" (Florida 2005).

Despite the fact that the U.S. still has by far the world's strongest economy and leads the world in research and discovery, many observers have argued that the advantage is rapidly eroding. The U.S. share of the world's science and engineering degrees is declining. Fewer Ph.D. students are going to the U.S. and, among those who do, more are returning to their home countries after graduating. In addition, the interest in science and technology careers is low among young Americans. Of the world's 25 most competitive information technology companies, only six are based in the U.S. while 14 are based in Asia (Hicks 2004, Freeman 2005).

The fear of losing its competitive advantage has sparked a campaign in the U.S. to take action and increase spending on higher education and basic research, among other things. Politicians, industrialists and academics are joining forces to create a sense of urgency about this threat to U.S. competitiveness (AEA 2005, Colvin 2005, NA 2005). Democratic Senator Joseph Lieberman has pointed out R&D offshoring (moving R&D abroad) as a particularly alarming trend (Lieberman 2004). In response, the President launched the American Competitiveness Initiative in January 2006 (ACI 2006).

A number of other countries already have innovation strategies designed to deal with stagnating R&D expenditures and capabilities for renewal (for example EC 2005c and Regeringskansliet 2004).

The internationalization of corporate R&D is likely to continue, perhaps interrupted by periods of consolidation, and will create a global market of innovation resources. On the basis of current trends, the new dynamic may be characterized as follows (see for example ETAN 1998):

- Knowledge and technology generated in one country will be utilized more and more internationally.
- International science and technology collaboration between government, industry and academia in different countries will continue to increase.
- Many companies will source knowledge and innovations globally, and many will locate their innovation activities wherever it is most advantageous.
- An international division of labor in R&D will emerge. Both public and corporate R&D efforts will continue to specialize. Particular areas of technological activity may become concentrated in relatively few locations across the world.
- New world centers of technological activity will emerge. Especially countries in developing Asia will grow stronger as global players.
- Intensified global competition will heighten the importance of maintaining national conditions for attracting R&D, absorbing knowledge and technologies developed elsewhere, and creating opportunities for production of innovative products and services.

1.1.3 Countries Will Win, Lose and Transform

Technological change and innovation driven by R&D have been important (if not the most important) sources of productivity growth, competitiveness and increased welfare (see for example Edquist & McKelvey 2000). The globalization of R&D and innovation is making this relationship more complex and more important for policy makers to analyze and understand.

Increased international investment, trade and exchange related to R&D will most certainly have both positive and negative effects. However, outcomes are uncertain and might not be observable without a considerable time lag since the dynamics of the international R&D system is expected to have significant inertia. Analysis is even more difficult because available systematic data is a few years old and information about the most recent developments is incomplete and anecdotal.

Policy-relevant analysis must therefore be not only up to date but forward-looking in order to identify trends, challenges and possible implications in the long-term perspective.

On the one hand, a given country can benefit from R&D internationalization. Positive implications include the following three categories.

1. For a multinational company based in that country, increased R&D investment in foreign countries could strengthen its innovative capabilities. The strategic sourcing of knowledge and technologies globally might increase R&D productivity, create more innovations at lower cost and, as a result, boost the competitiveness of the company and contribute to increased economic activity in the home country.

2. Foreign ownership of R&D in that country means an inflow of foreign investment that might create "spillovers" to local companies, centers of excellence and innovative environments. Multinational companies benefit from and contribute to the national R&D effort and create employment opportunities for researchers and engineers in the host country.

3. The internationalization of corporate R&D might create opportunities for attracting "downstream" business activities, such as manufacturing and supply, to that country. Centers of excellence and strong innovative environments can generate possibilities for specialized production close to the R&D centers. Knowledge and technologies developed elsewhere can be integrated into innovative systems, and solutions and be turned into domestic employment opportunities.

On the other hand, for each category of benefits there are also challenges and risks.

1. Increased R&D investment in foreign countries could undermine the national R&D effort and the domestic innovation system. R&D activities in the home country might decrease in relative or even absolute terms. A weaker science and technology base at home might also erode the capacity to absorb knowledge and technologies developed elsewhere. How many research and engineering jobs can be performed abroad?

2. Foreign ownership of R&D means less national (host country) control and consideration in corporate decision-making. Multinational companies under competitive pressure might reconsider their R&D locations from time to time and consolidate their innovation network. R&D facilities might be relocated or closed in the host country, especially if they were acquired as part of a larger merger and acquisition with R&D only as a secondary motive.

3. The internationalization of corporate R&D might result in decreasing “downstream” business activities. Knowledge and technologies from an R&D facility might leave the country and be integrated into innovative products and services elsewhere. Foreign companies can benefit from educated researchers and engineers and a developed innovation system in a certain country, but employment opportunities for manufacturing and marketing, as well as profits are generated in other countries.

The challenges might increase for small countries, such as Sweden, which are highly internationalized and heavily dependent on a few, large multinational companies (see NIFU 2005 for a discussion of recent foreign takeovers in Sweden). Taken together, the positive and negative implications will, to varying degrees, shape the dynamics and future challenges of national innovation systems.

With increasing specialization, R&D can expand both at home and abroad. So far, no major negative implications have been observed in Sweden (ITPS 2004, NIFU 2005) or elsewhere. At the same time, there is nothing that indicates that the internationalization of corporate R&D will remain a win-win game. Some countries, such as Canada, Ireland, China and India, have adopted systematic polices to attract foreign R&D activities. Some of these efforts have been successful and contributed considerably to current internationalization trends. Policymakers in other countries are preparing to adapt to these new realities.

The toolbox for developed countries includes a number of policies to support the national science and technology base, to develop highly qualified workers to ensure the presence of leading edge customers, to support international linkages by actors in the innovation system and to introduce innovation friendly regulations and standards. An overview of various policy measures implemented by different countries is provided later in this chapter.

Policymakers are changing their mindset from supporting R&D and innovation activities of “their” companies to making their country the best place for companies around the world to innovate and perform R&D. National innovation systems must be transformed to leverage the changing geography of global innovation. Countries seek to embrace internationalization and the global division of labor in R&D by specializing in internationally strong areas and by supporting the national capability to acquire and assimilate knowledge and technologies developed elsewhere in the world.

1.1.4 Purpose and Approach of the Studies

The studies in this report analyze international flows of corporate R&D and discuss the implications for countries and their national policies. The report tries to answer the following questions about the internationalization of corporate R&D:

- What is the extent of R&D internationalization and what are the trends?
- What are the driving forces and barriers?
- What are the potential future implications for countries?
- What are the options for national policies, with a particular focus on Sweden?

The report is focused on the internationalization of R&D by companies and is not considering academic science and technology at institutes and universities, or the internationalization of higher education and research in general. Moreover, the internationalization of manufacturing and services in general is only commented upon when it is related to R&D and innovation activities.

The report has a global scope and includes studies of Sweden, the U.S., Japan, China and India. Other important regions, such as the European Union and Eastern Europe, are discussed in several studies but are not the focus of a specific chapter in this report. The information and communications technology (ICT) and pharmaceutical sectors come into specific focus in two of the chapters. Other important industries, such as the automotive and engineering sectors, are discussed more briefly throughout.

The studies have been conducted by the Swedish Institute for Growth Policy Studies (ITPS), with financial support from the Swedish Governmental Agency for Innovation Systems (VINNOVA), as a response to the Swedish government's increased interest in the issue.

There is ample evidence that the internationalization of corporate R&D is increasing. However, there is still a need to further understand the impact on the national economy as well as the range and effectiveness of different policy instruments. The studies build upon existing literature and try to contribute more up-to-date empirical evidence based on interviews, surveys and additional data analysis.

For the report, ITPS has benefited from its official statistical databases on corporate R&D in Sweden and its network of science and technology offices around the world. Analysts from ITPS offices in Tokyo, Beijing, Stockholm, Östersund, Washington, D.C. and Los Angeles, along with partners from Swedish academia and the U.S., have participated in the studies. Reference groups of external experts in mainly Sweden, the U.S., India and China have given advice and reviewed the different parts of the report.

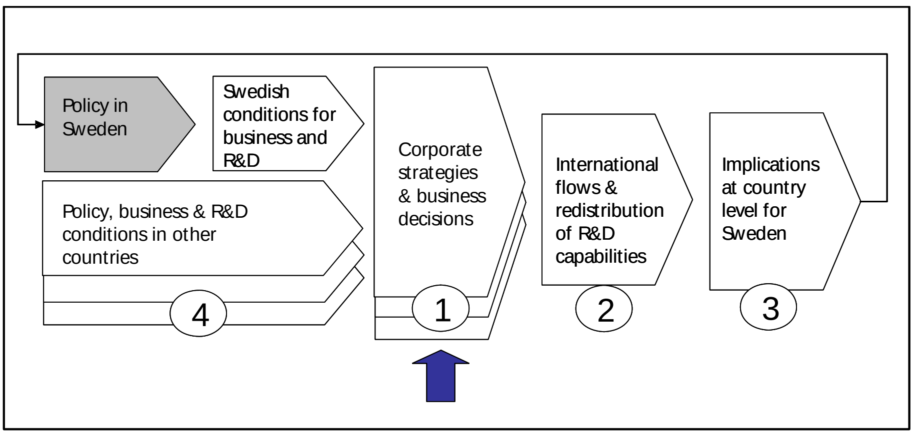
The studies have relied on a growing body of literature and international conferences covering the internationalization of R&D and industry localization strategies (see for example Narula 2003, Kenney & Florida 2004, Serapio & Hayashi 2004, Patel 2004, UNCTAD 2004, 2005, OECD 2005a and NA 2006). Selected findings from previous research are reviewed and discussed, where relevant, in the chapters of this report.

Framework for the Analysis

The process of R&D internationalization is analyzed in two interconnected, basic dimensions: companies and countries. On the one hand, multinational companies are the principal drivers of the process, as they seek to optimize their economic and innovative performance by combining and managing different geographical R&D locations across several countries. On the other hand, countries seek to maximize economic and innovative activities within their borders by implementing policies that attract R&D and "downstream" business activities that generate tax revenues and employment. In terms of R&D investment, a given country is both a host for foreign R&D facilities and a home for companies with R&D abroad.

As a general framework for the analysis, a simple model for understanding the internationalization process is used. The model includes four different levels of analysis (see Figure 1-1).

Figure 1-1 An illustrative model of the process of R&D internationalization at company, global, country and policy level with Sweden as an example.



Source: ITPS.

First, corporate strategies and business decisions involving R&D activities are the prime movers of the internationalization process (company level). Matters of R&D localization may be part of broader strategic decisions, involving production, marketing as well as mergers and acquisitions. Second, these decisions result in international flows and a redistribution of R&D capabilities, such as capital, talent and knowledge. Third, the flows have an impact on national innovation systems (country level), for example on employment, innovative capabilities and national value creation.

Finally, national policies**,** as part of the general business and R&D conditions in a country, are influencing the decision-making process of companies. Strategic decisions regarding R&D localization are influenced by factors such as the configuration of local innovation systems and the linkages with other companies, public research institutions, universities and standardization bodies, the availability of skilled research and engineers as well as broader government policies on higher education, trade, competition, investment and innovation (see below for an overview of policies).

1.1.5 Outline of the Report

The report presents a number of studies, each with a different approach to analyzing the internationalization of corporate R&D. The ambition is not to make a comprehensive and systematic analysis of this phenomenon, but rather to provide a broad overview with a multi-perspective approach that includes selected countries and industrial sectors. For example, Chapters 2 and 3 have a global scope, Chapters 5 and 6 are sector studies and Chapters 4, 5, 8, 9, 10 and 11 have regional or country perspectives. Some studies are based on secondary sources (Chapters 2 and 3), and empirical data analysis (Chapters 4 and 5) while others also employ a qualitative approach using interviews (Chapters 6 to 11).

The next section of Chapter 1 provides an overview of policy responses implemented or considered by different countries to meet the challenges of the internationalization of corporate R&D.

Chapter 2 discusses concepts, measurement issues, global trends and drivers related to the internationalization of corporate R&D and serves as a background and framework for the chapters that follow. Chapter 3 provides additional insights from the literature and empirical studies of foreign direct investments, including corporate R&D.

In Chapter 4, analysis of the internationalization of corporate R&D in Sweden is based on survey data, including R&D abroad and foreign-controlled R&D in Sweden. The competitiveness challenges for the Swedish information and communications technology (ICT) sector, as a result of increased globalization, is discussed in Chapter 5.

Corporate innovation strategies and forces driving internationalization in the U.S. pharmaceutical sector are studied in Chapter 6. Chapter 7 describes some of the new global networks that companies use to access problem-solvers and technologies worldwide. The developments in Silicon Valley, in terms of internationalization and the drive to become a global innovation hub, are studied in Chapter 8.

The factors explaining the low level of internationalization of corporate R&D in Japan as well as current trends and driving forces are discussed in Chapter 9. China and India as emerging locations for R&D activities by multinational companies are analyzed in Chapters 10 and 11.

Finally, in Chapter 12, the main findings and trends from all the studies are summarized and the challenges for countries are discussed in a forward-looking perspective, with a particular focus on Sweden. The report concludes with a set of issues for Swedish policymakers to consider.

1.2 Structuring a Policy Response: An Overview

It is the general goal of national governments to ensure national competitiveness and long-term economic growth by, for example, creating the best possible conditions for economic activity, employment and industrial renewal. In the context of the internationalization of corporate R&D, this translates into putting in place framework conditions that enable a country or region to benefit fully from globalization while reducing the potential negative effects.

For governments, this means improving the adaptive capacity of the economy and facilitating restructuring and transition. The R&D sector itself creates knowledge-intensive employment opportunities. However, the business activities and new jobs that result from R&D are of great importance to the national economy and thus to policymakers.

Different Types of Policy Measures and Instruments

There are a large number of direct and indirect policy measures and instruments for policymakers to consider when addressing the issues at hand. A toolbox might include a set of broader policy frameworks and general policies to promote national innovation and economic growth, as well as more specific and targeted policies to specifically address internationalization and offshoring. Analysts point out that a combination of measures must be put together in a coherent and consistent policy approach to be effective. Such an approach requires coordination across different policy areas and policy levels (BEPA 2005). It is important to recognize that the benefits from policy changes might take a long time to materialize. However, there is also evidence that a region can make strong progress in a short time.

The internationalization of corporate R&D is recognized as an important policy issue in most OECD countries. A few overviews of policy measures implemented or considered have been published recently (see for example OECD 2005c, UNCTAD 2005, GAO 2005, TIP 2005, NIFU 2005). Policy surveys and overviews are still incomplete; much work remains to establish full understanding of the measures being taken in different countries. More systematic mapping of what governments have done and can do to realize the benefits of the internationalization of corporate R&D would facilitate policy learning between countries.

The following sections summarize some of the policy measures and instruments implemented or discussed in different countries and regions. The overview is based on the studies in this report and various secondary sources. The policy measures are categorized in the following four levels or domains (see Figure 1-2 below):

A. Strengthen the national science and technology base, including public investments in science and technology, education and training, and infrastructure and regulations to support innovative activities.

B. Foster attractive conditions based on excellent R&D conditions, highly developed production structures and attractive leading markets.

C. Stimulate internationalization and mobility by measures to attract foreign R&D activities, internationalize domestic companies, and attract foreign talent and increase mobility.

D. Maximize economic benefits and minimize negative effects by stimulating downstream economic activities stemming from R&D efforts and supporting the transition for individuals and regions.

In most countries, politicians emphasize the opportunities presented by globalization and the fact that it is necessary to embrace the emerging global division of labor. Similarly, the main view of globalization in Sweden is that it is favorable for society as a whole in the long-run. Policies thus aim to promote and realize the benefits of internationalization and offshoring.

Policies to Reduce or Prevent Offshoring

However, it is important to note that in some countries and regions, politicians are taking or preparing policy measures to prevent or reduce offshoring, including R&D activities. For example, in Poland the government is reducing support for companies relocating R&D or production abroad (OECD 2005d). Protectionist policies have been debated in many countries but very few such measures have actually been implemented.

In this regard, it is important to monitor the development in the U.S. During 2005, Congress and nearly all 50 states introduced bills with the objective to reduce offshoring of services. Measures included state contract bans and data transfer restrictions. Of the few bills that actually became law, most were weak and some even had negative consequences. However, lobbying efforts to pass stronger legislation to restrict international trade in services appear to be intensifying according to analysts (NFAP 2005, GAO 2005). Democrats are more eager to pursue restrictive policies than Republicans, and a similar pattern can be noted for free-trade issues in general.

In the ongoing debate, most think tanks and independent economists argue that offshoring is good for the U.S. According to the Brookings Institution, U.S. policymakers should stimulate more international trade and the opening of other markets, like India (Brainard & Litan 2004). The fears about job losses and wage cuts due to offshoring, which have been fueled recently by the U.S. media, are dramatically overstated, according to studies by McKinsey Global Institute. Protectionism will not save jobs in the long run, but stifle innovation and job creation (Farrell & Rosenfeld 2005).

Nevertheless, analysts also point out that there are areas for policy reform in the U.S. For example, the current corporate tax system may artificially encourage offshoring by permitting deferral of taxation on foreign earnings but not on domestic earnings (Brainard & Litan 2004).

1.2.1 Strengthen the National Science and Technology Base (A)

Policymakers in many countries are considering and implementing broad frameworks with the objective to create world-class innovation systems. The basic component is a strong national science and technology base, featuring public investments in (A1) science and technology, (A2) education and training, and (A3) infrastructure and regulations to support innovative activities. A strong science and technology base is becoming an increasingly important factor for attracting domestic and foreign corporate R&D activities. Comprehensive overviews of innovation policies in Europe and in other countries can be found in EC 2004 and OECD 2005b.

Integrated Strategies and National Policy Frameworks

Several countries have recently launched integrated strategies to strengthen innovation systems and competitiveness. These policy frameworks include measures to build up the national science and technology base.

In the U.S., several framework proposals have recently been launched in Congress, including bi-partisan Senate bills titled: Protecting America's Competitive Edge Act (PACE Act), and, in January 2006, a proposal from the administration called the American Competitiveness Initiative (ACI). The comprehensive proposal calls for: increased federal R&D investments in physical sciences and engineering; making permanent the research and experimentation tax credit; increased resources for basic and science education and for educating teachers in mathematics and science; a program for workforce training; and an initiative for immigration reform (ACI 2006). The recent wave of innovation initiatives largely follows the recommendations of a few, highly publicized reports (NII 2004, NA 2005).

The European Commission launched an integrated policy approach to E.U. research and innovation in October 2005. The action plan included several initiatives in the areas of state aid, intellectual property protection, research funding, and university-industry partnerships. The main goal for the new approach was to improve the conditions for private-sector investment in R&D (EC 2005c). The purpose was to accelerate the implementation of the Lisbon strategy and its objective to increase investment in R&D to 3 percent of GDP by 2010 (EC 2000). Additional instruments integrated into the efforts at European level are the European Research Area (ERA) and the 7th Framework Programme (EC 2005a, Potočnik 2005).

Ireland was a forerunner of the integrated approach, with the release of the first Irish government white paper on science, technology and innovation in 1996. The approach is regarded a success in terms of inward investment policy (OECD 2005a). Other countries with integrated strategies inlcude; the U.K. (DTI 2003), Canada (see Liljemark 2004), Australia (BAA 2001) as well as Japan, China and India (described later in this report). More specific strategies for the internationalization of science and technology have been developed by Finland (STPC 2004) and Norway (MER 2004). The Norwegian strategy focuses on North America in particular.

In Sweden, the government launched the strategy "Innovative Sweden" in 2004 (Regeringskansliet 2004). The strategy included the following main policy intentions:

- Knowledge base for innovation: (i) Ensuring that Swedish education and research are of world class, (ii) Concentrating efforts in Swedish profile areas, (iii) Seizing the opportunities presented by globalization.
- Innovative trade and industry: (i) Strengthening the innovative capacity of existing small and medium-sized enterprises, (ii) Increasing the commercialization of research results and ideas.
- Innovative public investment: (i) Using the public sector as an engine for sustainable growth, (ii) Promoting renewal and efficiency in the public sector, (iii) Developing infrastructure that promotes renewal and sustainable growth.
- Innovative people: (i) Stimulating entrepreneurship and enterprise, (ii) Making the most of people's skills.

In 2005, the innovation strategy was followed by a research bill "Research for a Better Life;" a bill on university reform (Regeringskansliet 2005a and 2005c); and a number of industry sector strategies (for example in the information and communications technologies, pharmaceutical and biotechnology, and the automotive industries). For an overview of initiatives, see Regeringskansliet (2005b).

Public Investments in Science and Technology (A1)

Continued and increased public investments in R&D are vital to building a strong national science and technology base. Countries seek to boost both basic sciences and industry-relevant research; to specialize and establish centers of excellence in internationally competitive areas (e.g. information technology, biotechnology and nanotechnology); to support international research collaboration; and to design programs for risk-sharing to support long-term and high-risk R&D programs. In addition, policies are promoting connections between the public science and technology base and industry with programs for the commercialization of research results, university-industry collaboration, as well as support for industrial research institutes and research programs for small- and medium-sized companies.

In Sweden, the recent research bill focused on increasing the investments in R&D to promote high scientific quality, and concentrating of research efforts in three areas: medicine, technology and sustainable development. Priority should be given to internationally competitive research environments in Sweden. Other parts of the bill included collaborative R&D programs to promote the transfer of knowledge from academia to industry, and the strengthening of industrial research institutes (Regeringskansliet 2005a). More recently, the Swedish government announced setting a target of 1 percent of GDP for public R&D funding. In addition, in 2006, a new R&D program targeting small companies was implemented in Sweden by the Swedish Governmental Agency for Innovation Systems (VINNOVA).

Investments in Talent: Education and Training (A2)

A strong national science and technology base is dependent on the availability of highly educated researchers and engineers. Examples of government policies include investments in the education system at all levels, promotion of science and engineering education, life-long learning, encouragement of international student and researcher mobility, new regulations for attracting qualified immigrants and support for language and entrepreneurial skills. Some countries are calling for more comprehensive education system reforms as in the case of the U.S.

To meet the challenge of offshoring of services and production, the strategy is to increase the educational level and thus the knowledge intensity of the domestic talent pool – in other words, to move up the value ladder. However, this might be increasingly difficult since knowledge-intensive work can also be located abroad. At the same time companies require new advanced skills to deal with an internationalized environment, such as the ability to manage remote teams and projects in multicultural and multinational settings. These changes require a re-structuring of labor markets with new combinations of low- and high-skilled workers.

Sweden has a strong educational system but is addressing attitudes toward the value of science and entrepreneurship. Programs have been implemented to increase young students’ interest in science and engineering careers, along with measures to stimulate entrepreneurship.

Other suggested measures include establishing individual competence accounts to support re-training and life-long learning (Edling 2005), and improving upper-secondary-school vocational training in the industrial field (IVA 2005).

Infrastructure and Regulations to Support Innovative Activities (A3)

A national science and technology base must be supported by a well-developed infrastructure and communications, innovation-friendly regulations, favorable economic policies and a stable macroeconomic environment in general. Policymakers are looking at trade and competition policies, protection of intellectual property, tax policies (including the lowering of corporate taxes), and regulatory regimes in specific industry sectors. For example, deregulation in the information and communication technologies sector has fundamentally changed the conditions for innovation in many countries.

The challenge for governments is to create conditions that support the capability to participate in the international division of labor and specialization, as well as the build up of domestic environments attractive to internationally mobile production factors, such as venture capital and specialized knowledge workers. Specific policy measures for this are described below. Specialized policy areas, such as cyber-security and consumer protection, must be addressed when dealing with international flows of sensitive data (see GAO 2005).

Sweden, together with the other Nordic countries, has a stable microeconomic environment that is characterized by openness and transparency. The corporate tax level is low compared to many other E.U. countries, and rules and restrictions affecting inward investment have been liberalized over the recent period. The markets for telecommunications and energy have also been re-regulated in the early 1990s (NIFU 2005).

Weaknesses can be identified in specific countries. The U.S., for example, faces potential disadvantage in the telecommunication infrastructure (regarding quality and coverage of wireless networks and broadband connectivity) and the challenge of rising health care costs (Farrell & Rosenfeld 2005). In Sweden, the lack of flexibility in the labor market (Svenskt Näringsliv 2005) and the need to improve the business and investment environment (ISA 2005) have been pointed out.

1.2.2 Foster Attractive Conditions Based on Knowledge, Production and Markets (B)

Multinational companies are searching for countries with (B1) excellent R&D conditions, including highly skilled persons, (B2) highly developed production structures and (B3) attractive growing and leading markets. These conditions or environments build on, and are interlinked to various degrees with, the national science and technology base. The concept of local or regional clusters, for example, emphasizes the presence and strategic collaboration between universities, research institutes and innovative companies, combining public and private resources and capabilities at a particular geographical location.

Governments in different countries seek to identify and support the establishment of innovative clusters in strong areas. Policymakers often take an integrated approach to designing cluster policies, including measures that will attract foreign companies, capital and talent. See Andersson et al. 2004 for an overview of cluster policies. The differences in internationalization patterns and driving forces for different industry sectors must be taken into account when designing policies. For example, science-based sectors (e.g. pharmaceuticals) are attracted to excellent research centers, and standards-based sectors (e.g. communications) are attracted to leading markets.

The importance of the dynamics of local or regional innovation clusters from a globalization perspective has been stressed in the Swedish context (NUTEK 2002). Policies include: supporting local links between industry and universities; creating local critical mass of R&D; and building local infrastructures with the objective of creating clusters or “hotspots” of economic activity dispersed over the country (Söderström 2001, Eliasson & Eliasson 2005).

Excellent R&D Conditions (B1)

At the core of innovative clusters is the production of knowledge. Increased competition and specialization drives the creation of centers of excellence that might develop into regional or even global science and innovation hubs or nodes. Such concentrations of world-class science and knowledge-intensive activities within national borders are important for attracting international as well as national investments.

For example, science parks are used to attract foreign R&D investment. Approximately 600 parks existed worldwide in 2004, and two thirds of these were located in the U.S. and Europe (Andersson et al. 2004). Apart from the Silicon Valley region, there are a number of other well-known parks: Research Triangle Park (United States), Sophia Antipolis (France), Hsinchu Science Park (Taiwan), Zhongguancum Science Park (China), the Electronic City in Bangalore (India) and Kista Wireless Valley (Sweden).

The political efforts aimed at strengthening the national science and technology base often include policies to focus R&D resources in particular areas of national strength, with the explicit or implicit purpose of attracting investments, including R&D, from multinational companies. In the case of Sweden, see Regeringskansliet 2005a.

Highly Developed Production Structures (B2)

R&D and production are closely interlinked in several industries. The dynamics of innovative clusters often include specialized production that requires the proximity of R&D facilities. Close interaction and co-location of manufacturing and R&D is important in high-tech manufacturing industries (Bengtsson et al. 2005).

Creating a highly developed production structure and excellent conditions for production in a country might help attract and retain certain types of production and related R&D activities. By promoting excellent conditions and linkages between R&D and production in specific sectors or niches, politicians can capture a larger share of the value resulting from R&D activities.

In Sweden, the importance of developing leading-edge production technologies and production systems has been pointed out. Policies should be implemented to support Swedish companies in developing better manufacturing practices, such as lean production, in order to further increase productivity and competitiveness. According to analysts, it is also necessary to decrease the impact of labor cost and at the same time increase the demand for customization, flexibility and delivery time (Bengtsson et al. 2005).

Furthermore, the resources of universities and research institutes in production-related research should be developed and better coordinated to secure collaboration between industry, academia and government. Establishing a production council within the government to develop a national production strategy, has also been suggested (IVA 2005).

Attractive Leading Markets (B3)

Companies are searching for leading, future-oriented markets, with large groups of advanced users eager to try out new products and services. Leading markets are also used by companies to interact with users and customers during the development process (co-creation) and as a source of knowledge and ideas. Besides expanding internationally in large emerging markets such as China and India, companies take an interest in smaller, specialized markets, for example in Scandinavia and Northern Europe.

Policymakers can stimulate the development of leading markets by procurement of advanced goods and services. Technical requirements can be critical for stimulating R&D investments both by domestic and foreign companies. By encouraging the establishment of integrated process chains (world-class R&D, specialized production, advanced and demanding consumers and buyers), even more value from R&D can be captured nationally.

In Sweden, the old regime of public procurement and development partnerships with industry has largely disappeared with deregulation of several industry sectors. New approaches to develop public sector procurement capabilities, for example in health care and education, have been suggested (NUTEK 2002, Eliasson & Eliasson 2005).

The Swedish government strategy is to use the public sector as an engine for sustainable growth and to ensure that publicly financed activities contribute to creating products and services for export (Regeringskansliet 2004). A government inquiry was launched in April 2006 to further study how public procurement can be a driving force for innovation and renewal in Sweden (Regeringskansliet 2006).

1.2.3 Stimulate Internationalization and Mobility (C)

A strong national science and technology base, conditions for excellent R&D, developed production structures, and attractive leading markets constitute the foundation for a country to become an attractive player in the game of R&D internationalization. At the next level, countries design policy measures to stimulate internationalization by implementing measures to (C1) attract foreign R&D activities, (C2) internationalize domestic companies, and (C3) attract foreign talent and increase mobility (see for example TIP 2005 for an overview).

It is important to note that there is a variety of policy measures that influence the internationalization of corporate R&D even if the policies were not specifically designed to do so. These indirect measures have grown in importance and include general tax incentives – personal and corporate tax rates and policies to attract foreign direct investment in general. According to OECD, only a few countries have policies specifically targeting R&D internationalization, and only a few countries have developed a more integrated policy response to deal with this specific issue (OECD 2005c).

Attract Foreign R&D Activities (C1)

With the purpose to attract and benefit from foreign direct investments, including R&D activities, different countries create incentive packages and information kits outlining their specific differentiating features (“nation branding”) to prospective investors. Many OECD countries have dedicated investment promotion agencies like: Invest in Sweden Agency (ISA), Investment Partnerships Canada (IPC), Invest Australia and Enterprise Ireland.

Most of the agencies also actively promote R&D investments both in OECD economies and in developing Asia. Of 46 agencies targeting R&D investment, more than half used tax incentives and the promotion of linkages between foreign affiliates and universities as policy tools. Seven countries used R&D requirements as a condition for market entry, most of them in developing Asia (UNCTAD 2005). Other incentives include direct funding of R&D projects, the granting of preferential loans or subsidies, and the provision of various services.

Several countries have an open policy and provide full access for foreign companies to national R&D and technology programs. This is the case in Sweden, Denmark, Finland, Norway and the Netherlands. Other countries are more restrictive, such as Korea, Poland and Italy, where foreign companies have little or no access to national R&D funding. In New Zealand, participation is only possible if the R&D activities satisfy the criterion of “national benefit” (NIFU 2005, OECD 2005c).

Some developing countries are forcefully developing investment incentives to attract multinational companies. China and India have strengthened their support for foreign R&D, including more flexible establishment rules, tax and custom duty exemptions. In Singapore, 100 percent of R&D expenses are deductible. Brazil applies a tax reduction on imported products if companies are investing in R&D (UNCTAD 2005, EIU 2004). For an overview of tax deductions and other financial incentives, see World Bank 2004.

General tax incentives schemes for R&D investments have been implemented by two thirds of OECD countries and sometimes foreign companies are also eligible (OECD 2004). Canada has one of the most beneficial systems and the country has noted a substantial inflow of R&D investments. The Nordic countries have long been exceptions for not having R&D tax credits. However, Norway introduced a tax reduction scheme for small- and medium-sized companies in 2002 that was extended to include all companies in 2005, including large and foreign-controlled companies based in Norway. Similarly, the U.K. has extended their tax incentive schemes to cover large companies as well (OECD 2005c). A general R&D tax credit has been proposed in Sweden (ISA 2005).

Apart from incentive packages, both developed and developing countries have introduced specific R&D investment requirements to foreign investors and trade partners. These types of measures work in countries with a large and attractive domestic market, such as China (for example in the automobile and communications industry) and to certain degree, in India. In addition to R&D investments, requirements might come in the form of technology transfer or joint-ventures. Foreign R&D investment requirements may also be a part of public procurement. In Poland for example, foreign suppliers of military equipment must make compensatory investments in Poland. Financial support for local researchers and entrepreneurs as well as investments in knowledge transfer in several key sectors, are preferred under the policy (OECD 2005c).

Internationalize Domestic Companies (C2)

Governments can support domestic companies to connect and collaborate with foreign sources of innovation and global centers of excellence. In the process both companies and countries need to increase their abilities to internalize and assimilate knowledge and technologies developed elsewhere in the world. To strengthen this absorptive capacity, companies must maintain a certain degree of in-house R&D and technological capacity in order to understand and evaluate new technological trends and innovations and acquire outside technologies. Countries need to create local environments open to technological development, with well-developed innovative clusters and a robust national science and technology base (Blomström & Kokko 2003).

Policymakers in certain countries provide funding for international collaborative R&D projects at national level and, through the European Framework Programme, negotiate bilateral science and technology agreements to facilitate international collaboration and design programs such as the Innovation Partnership Subsidy (the Netherlands) and the Intelligent Manufacturing Systems initiative in Australia. These types of programs support international collaboration in the development of advanced manufacturing and processing technologies (OECD 2005c). More detailed policy recommendations in the European context are provided in ETAN 1998 and BEPA 2005.

Research agencies can give priority to projects promoting international collaboration in the R&D funding selection process (Finland and Australia) or help companies, especially small- and medium-sized ones, find international R&D partners (e.g. the Industrial Research Assistance Program in Canada). Match-making activities can be supplemented with consulting services that advise how to access international funds and how to coordinate international projects.

Other policy measures used include: support for technology intelligence and monitoring, foresight activities, international fairs, conferences, seminars and technology missions.

Attract Foreign Talent and Increase Mobility (C3)

Attracting highly skilled researchers and engineers, as well as removing barriers for international mobility, are also priorities for policymakers. Governments have implemented various policies that seek to attract, retain, repatriate and circulate talent. Such policy measures include immigration regime reforms, income taxation policies and support for returning researchers and engineers.

Immigration policy reforms are triggered by real or feared skills shortages, driven by demands from companies and business associations. Countries have liberalized immigration policies (i.e. Singapore), simplified immigration procedures and expedited application process (recent reform in Finland, the Netherlands and Germany), issued work permits for foreign researchers (Finland, Norway), and increased entry quotas and special funding programs, for example post-doc programs. See ISA 2001 for an overview of these policy measures. In Sweden, a parliamentary committee is currently reviewing immigration regulations (KAKI 2004).

After 2001, students from developing countries in Norway can take residence after completing a higher education. There are ideas in Europe to establish an EU-wide "green card" for highly skilled workers coming from outside the E.U. (EC 2005b). A similar idea has been suggested in the U.S., that every foreign student who earns a doctoral degree should also get a green card granting permanent residency.

Tax discounts are provided by several countries to attract foreign skilled workers (Australia, Austria, Denmark, the Netherlands, Sweden, and the U.K.). In Denmark a special 25 percent tax scheme was designed and implemented to provide favorable conditions for skilled foreign workers and researchers. The scheme also applies to Danish expatriates returning from abroad (OECD 2005c). Sweden introduced an expert tax rate in 2001. The 25 percent tax relief on income can be utilized for foreign personnel for three years (NIFU 2005). The Swedish expert tax has been evaluated by the Swedish Institute for Growth Policy Studies (ITPS) during 2005/06.

Policies to attract skilled people from large Diasporas have been put in place by countries like Korea and China. Taiwan was one of the first countries to systematically try repatriating foreign researchers and engineers. Policies to support returning highly skilled workers include fellowship programs (Federation Fellowships in Australia), awards for supporting higher salaries (targeted grants in Finland) and fixed-period tenure at a university or research institution (Italy). Several networking initiatives have been launched to link foreign researchers and engineers to their home countries, for example the German Academic International Network (GAIN) and ERA-Link at the European level (for an overview, see Reggiani 2005).

Finally, to promote increased talent mobility, some policymakers are addressing other barriers, such as culture and language obstacles, accreditation of academic qualifications (e.g. the Bologna Declaration in Europe; see Regeringskansliet 2005c for the government's proposal to internationalize Swedish universities), as well as science and technology regulations (ethics, safety and intellectual property regulations). Within the E.U. for example, Sweden, Finland, the Netherlands, Belgium and the U.K. have more liberal legislation governing responsible stem cell research.

1.2.4 Maximize Economic Benefits and Minimize Negative Effects (D)

At the final policy level, R&D internationalization is placed in its economic and social context. Governments need to find ways to (D1) stimulate downstream economic activities stemming from R&D efforts and (D2) support the transition for individuals and regions as a result of innovative activities and industry restructuring.

Stimulate Downstream Economic Activities (D1)

Policymakers want to create the highest possible spillover effects from R&D performed by domestic and foreign multinational companies. The R&D efforts in a country have the potential to create "downstream" economic activities involving production, services and suppliers, which lead to more employment opportunities. Ownership of the R&D does not matter so much as the type of innovative activity (ETAN 1998).

Policies require coordination between industrial policy and science and technology policy, and might focus on fostering knowledge-based cluster formation with emphasis on networks of R&D and production. Joint R&D efforts between domestic and foreign companies can be encouraged to increase the likelihood for spillovers and the degree of embeddedness in the national innovation system of foreign R&D activities.

In France, the government has approved and supports 55 "competitiveness clusters" in nine industrial areas. State aid through various programs and tax exemption schemes are provided to companies located within the borders of these clusters (OECD 2005d).

Other policy measures focus on smaller companies (startups or spin-outs). Examples of policy instruments are support for business incubation systems, early-stage public financing (Innovationsbron in Sweden), networking and technical assistance, as well as different types of support for entrepreneurship and commercialization of research results.

Support the Transition for Individuals and Regions (D2)

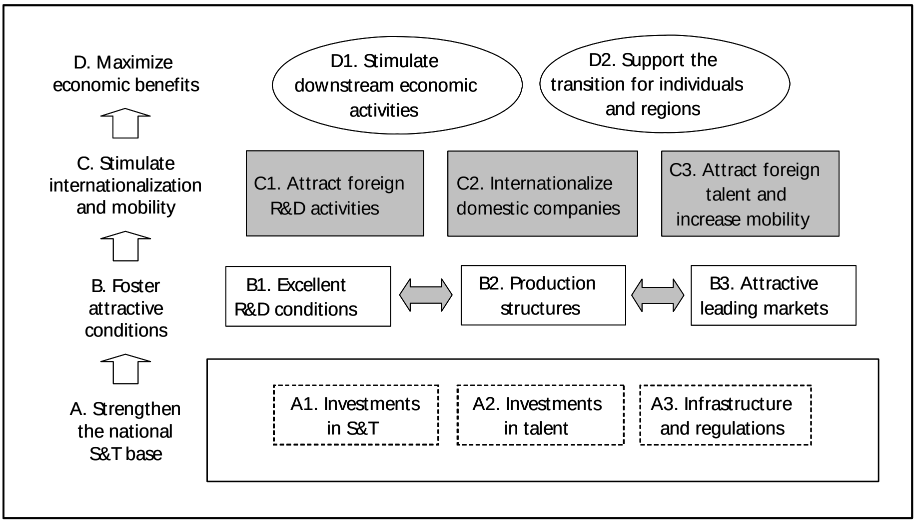
The internationalization of production, services and R&D, together with technological development and other economic forces, bring about industrial restructuring, shifts in regional economies and labor market changes. Highly skilled workers face potential unemployment in the wake of accelerated, manufacturing job losses.

Governments can proactively implement policies to reduce the impact of internationalization and offshoring, and facilitate these transitions for people and regions. Education and training to improve skills for re-employment, and to collaborate with unions, industry associations and companies to anticipate job changes help prepare people for more frequent job and location changes during their working lives (BEPA 2005, Farrell & Rosenfeld 2005).

According to an OECD survey of 11 countries in 2005, no country had tried to identify offshoring companies to encourage them to create jobs at home. However, several countries, including Germany, Switzerland and the U.K., promote special training and adjustment programs for people who have lost their jobs to offshoring (or for other reasons) (OECD 2005d). The Brookings Institution in the U.S. has proposed a new wage insurance program to provide incentives for rapid re-employment and on-the-job-training. In addition, the Trade Adjustment Assistance program should be extended to also include services workers, according to the analysts (Brainard & Litan 2004, see also GAO 2005).

The different types of policy measures summarized in this section are illustrated in Figure 1-2.

Figure 1-2 Illustrative structure of policy measures in four different levels or domains, in response to the internationalization of corporate R&D.



Source: ITPS.

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2 International R&D Trends and Drivers

Magnus Karlsson

This chapter gives an overview of R&D internationalization in the corporate sector based on secondary sources. It serves as a background and context to the studies that follow. This chapter focuses on the following questions:

- What is corporate R&D and how is it structured in country and industry sector perspectives? What are the key trends in corporate R&D?
- What is the internationalization of corporate R&D and how can it be measured?
- What is the extent of internationalization according to different measures? How can different forms of internationalization be categorized and what companies and countries are involved?
- Why is it happening now? How can the internationalization of corporate R&D be explained in terms of enablers, drivers and barriers?

The chapter concludes with a summary of trends pertaining to the internationalization of corporate R&D.

2.1 Corporate R&D

2.1.1 What is Corporate R&D?

Corporate research and development (R&D) covers activities undertaken by companies for the purpose of discovering or developing new products (goods and services) or more efficient production processes, including improved versions of existing products and processes (from OECD 2002).

R&D is usually defined in terms of three generic activities. First, *basic research* refers to original investigation for the advancement of scientific knowledge without specific commercial objectives. Basic research is more frequently conducted at universities than at companies. Second, *applied research* means original investigation with specific commercial objectives, and third, *development* is an activity for the improvement and extension of existing products, services and processes (see for example NRC 2005a). The boundary between research, development and other forms of technological innovation activities is difficult to establish in reality. Therefore, R&D data based on different definitions must be compared with caution.

In a hierarchy of corporate functions, different activities can be ranked in terms of technical complexity both in manufacturing and in services (Figure 2-1). Higher technical complexity means higher value added as well as higher requirements for skills and capabilities. A company's decision to establish or relocate activities abroad typically starts with functions of lower technical complexity and may then gradually move up the value ladder (see for example *BusinessWeek* 2005).

Figure 2-1 Illustrative levels of technical complexity of corporate activities in the partly overlapping categories of manufacturing and services.

Complexity	**Manufacturing**	**Services**
High-level	Advanced R&D, "frontier innovation," & specialized R&D services	
Mid-level	Development, design and adaptation	High-end services (i.e. software development)
Low-level	Basic manufacturing	Low-end services

Source: based on UNCTAD 2005a.

R&D is related to the broader notion of innovation. Innovation can be defined as the introduction of new products, services or processes into the market. The term is used to cover both the creation of new technologies (new to the world) and the use of existing technologies (new to a particular user or market). In this context, R&D can be seen as one source of innovation or a particular type of innovative activity.

Modern corporate innovation typically requires cross-functional cooperation and interaction throughout the company, including R&D-units, manufacturing, marketing, sales and service, as well as with external parties, such as customers, competitors, suppliers, subcontractors, standardization bodies, universities and research institutes. For example, customer insights from marketing, sales and service teams are essential to identify attractive opportunities for new products and services. Also, manufacturing and suppliers can offer critical suggestions on design for manufacturability (see for example BAH 2005 and CoC 2005). Tight collaboration in a value chain including the customer, is particularly important in services R&D (Ruetsche 2005).

In this way, the R&D function becomes highly embedded in the value chain (or value network) of the company with extensive internal and external reach. At the same time, the overall production process is becoming increasingly modularized, opening up the possibility for multinational companies to relocate specific processes or functions across the company, both nationally and internationally (see *BusinessWeek* 2006).

The location of a certain R&D facility within a company's value network thus depends on the type and purpose of the R&D activities performed. The main forms of localization linkages include: proximity to a production facility, proximity to a particular market, proximity to a center of research and innovation activities, or a combination of two or all three factors. The driving forces behind the localization of R&D are discussed in more detail below.

2.1.2 The Structure of Corporate R&D

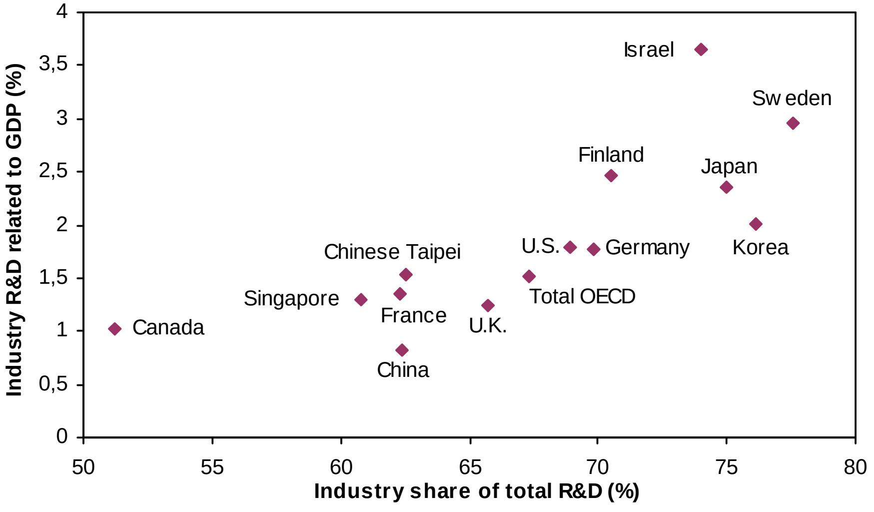
Multinational companies are the leading players in the global R&D landscape. They are driving R&D spending and the internationalization process with a significant impact on the economies of both home and host countries. OECD countries are increasingly relying on the creation and utilization of science and technology to enhance growth and productivity. High-technology industries account for an increasing share of added value and international trade in the economy and are expected to play an important role in strengthening national competitiveness (see for example OECD 2004).

Corporate R&D spending can be discussed and measured from at least two perspectives: data on business sector R&D expenditures per country and its share of total R&D spending in that country, and data on R&D expenditure as reported by the companies and an analysis of different industry sectors.

In most OECD countries, the business sector is dominating R&D expenditures. The industry share of the total R&D enterprise has increased rapidly during the last two decades. R&D performed by industry in OECD countries reached about 458 billion dollars in 2003 (up from 262 billion dollars in 1991), or 67 percent of total R&D expenditures. A few countries, such as Sweden, Korea and Japan, have a significantly higher share of industry R&D of around 75 percent. Sweden also stands out as a country of high industry R&D expenditure as a percentage of GDP (about 3 percent in 2003), together with Israel, Finland and Japan (MSTI 2005, Figure 2-2).

Not surprisingly, the U.S. is dominating in the world of corporate R&D. In 2003, the U.S. business sector spent 196 billion dollars on R&D, followed by EU-25 (134 billion dollars) and Japan (85 billion dollars). Chinese business enterprise expenditure on R&D is closing in (53 billion dollars) and is ahead of countries like Germany, France and the U.K. [MSTI 2005, all data in current PPP (purchasing power parity) dollars]. In 2003, companies in Sweden spent 9 billion dollars (72 billion SEK), a doubling since 1991 (SCB 2005).

Figure 2-2 Industry share of total R&D expenditures (percent) and industry R&D expenditure as a percentage of GDP in selected OECD and non-OECD countries, 2003.



Source: MSTI 2005.

The 320 top R&D spending companies in the world invested 331 billion dollars in 2004, according to an analysis of companies investing more than 80 million dollars on R&D annually. About half of the total R&D spending (but only 35 percent of total sales) is accounted for by three large industrial sectors: pharmaceuticals, electronics and electrical equipment, and motor vehicles and parts.

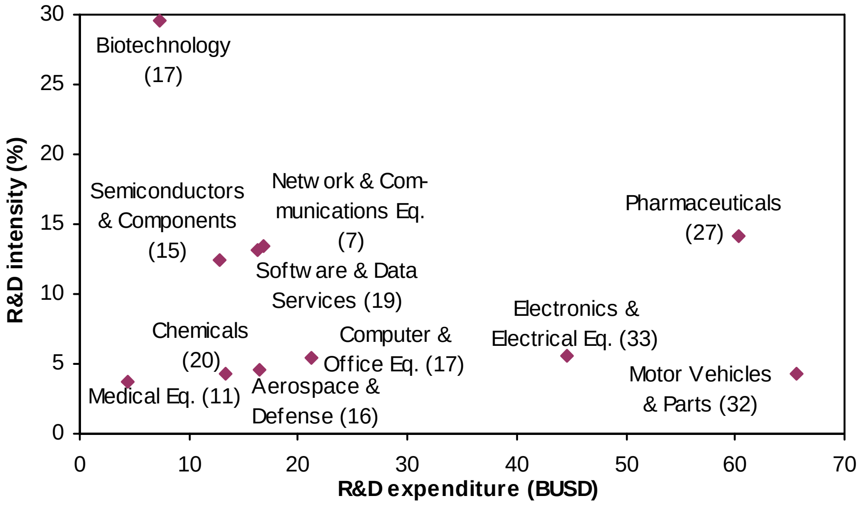
R&D is concentrated in a few large companies. One third of the total investment was made by the top 20 R&D-spending companies, such as IBM, Matsushita Electric, Siemens, Ford Motor, DaimlerChrysler, Nokia, Sanofi-Aventis, Pfizer, Intel and Microsoft.

The average R&D intensity (R&D as a percentage of sales) among all the companies was just over 4 percent. The most R&D intensive sector was biotechnology (29 percent), with a number of companies spending more on R&D than their total sales. Biotechnology was also the smallest industry (both in terms of total R&D and sales) compared to other high-tech sectors such as semiconductors and electronic components, network and communications equipment, software and data services, and pharmaceuticals. All four sectors had R&D intensities between 12 and 14 percent (Figure 2-3, Bowonder et al. 2005, see also EC 2004 and BAH 2005).

R&D-spending companies are concentrated in a few countries around the world. Over 70 percent of the 700 largest R&D-spending companies came from three countries in 2003. The U.S. accounted for 38 percent of these companies, Japan for 22 percent, and Germany for 13 percent. Sweden ranked number seven with 15 (2 percent) of the total 700 companies (DTI 2004).

The top five Swedish-controlled companies in terms of total R&D spending in 2004 were Ericsson with 3011 million R&D dollars (17 percent R&D intensity), Volvo 1225 (4.3 percent), TeliaSonera 381 (3.4 percent), Autoliv 335 (6 percent) and Scania 315 (4 percent) (EC 2005b).

Figure 2-3 R&D expenditure (billion dollars) and R&D intensity (R&D as a percentage of sales) in 2004 in selected industry sectors (with the number of companies in the sector indicated).



Note: Data from annual reports from the 320 top R&D-spending companies worldwide, classified by industry sector according to the Standard Industrial Classification (SIC) System.

Source: Bowonder et al. 2005.

2.1.3 Corporate R&D Trends

The structure of corporate R&D is changing in a number of ways that have implications for innovation systems and policymakers (see for example Karlsson 2004).

End of growth pattern. Corporate R&D investment has experienced steady growth in most OECD countries since the early 1990s. However, after a peak around 2001, R&D investments have shifted to a pattern of stagnating and even decreasing levels of investments.

American companies made steep cutbacks and R&D performed by industry declined from 2.0 to 1.8 percent of GDP between 2001 and 2003. The decline in Sweden was from 3.3 to 2.9 percent of GDP (Armbrecht 2005, MSTI 2005, SCB 2005).

With improving economic prospects, a turnaround in industry R&D can be expected. According to the Technology Review Corporate R&D Scoreboard, the top 150 companies again increased their overall R&D spending between 2003 and 2004, but not in all sectors. R&D investments at biotechnology, pharmaceutical and computer software companies grew the most, while network and communications, and computer hardware companies, on average, decreased their R&D outlays (NSF 2005b, Technology Review 2005, Ayers 2006).

Competition from developing countries. A few major developing economies are increasing their share of the global R&D enterprise. Six of the top ten R&D-spending developing countries were located in Asia in 2002. Double-digit annual R&D growth rates were recorded for China and India. At the same time, the share of industry R&D was growing rapidly in developing Asia, reaching the level of the European Union in 2002 (62 percent), up from about 50 percent in 1996. According to forecasts by Battelle, China and India will continue to dramatically increase their overall R&D spending in the next few years (UNCTAD 2005a, Battelle 2005, BAH 2005).

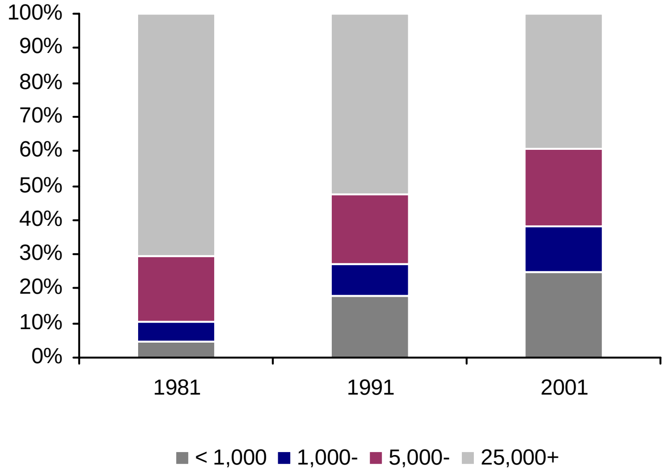
R&D is concentrated in a few sectors and companies. As shown above, a few industry sectors and large companies tend to dominate corporate R&D investments. In large countries, such as the U.S. and Japan, five sectors account for half of total corporate R&D. In some smaller countries only one sector might dominate (Finland). In Sweden, three industries accounted for over 80 percent of total R&D in 2003: electronics/optics (including communication equipment), transportation and pharmaceuticals. The top 20 R&D-spending companies made up 68 percent of the total in Sweden (NSF 2004, SCB 2004).

More development, less research. The share of research in relation to total corporate R&D is generally declining in many OECD countries. In Sweden, companies spent, on average, 12 percent on research (down from 17 percent in 1999) and 88 percent on development in 2003. The research intensity (R as a percentage of R&D) varies between industry sectors. A research intensity of around 30 percent can be found in the pharmaceutical and chemical industry, while the share for IT and communications is between 10 and 15 percent, and in the automotive sector around 5 percent (examples from Sweden, SCB 2003b, SCB 2004).

Increasing R&D in services. Services account for a growing share of total industry R&D spending in OECD countries. The share increased from 15 to 23 percent between 1991 and 2000. The U.S. reported a share of about 40 percent in 2003. The R&D intensity of companies in some service sectors, such as software publishing and scientific R&D services, was higher than that for manufacturing companies. Innovation in services will be increasingly important for economic growth and innovation processes differ from those in manufacturing. Services accounted for 70 percent of total value added in the OECD in 2000. The share of R&D in services was only 9 percent of total corporate R&D in Sweden 2003 (down from 12 percent in 2001) (NSF 2005b, OECD 2004, SCB 2004, Ruetsche 2005).

Increasing R&D by small- and medium-sized companies. Large U.S. companies have gradually decreased their share of total industrial R&D. Companies with more than 25,000 employees performed about 40 percent of total R&D in 2001, down from 70 percent in 1981. At the same time, smaller companies (less than 1000 employees) increased their share from four to 25 percent (Figure 2-4, NSF 2005a). In Sweden, the share of R&D by companies with less than 1000 employees was 26 percent in 2003 (SCB 2004).

Figure 2-4 Percentage of U.S. industrial R&D by size of company, number of employees.



Source: NSF 2005a.

Growth of external R&D. Companies are increasingly performing R&D outside their own organizations (for example at other companies, institutes and universities). In the U.S., external manufacturing R&D (performed outside the company, but in the U.S.) grew faster than internal R&D during the last couple of years. External R&D grew with about 5 percent annually between 1993 and 2001. External corporate R&D (performed outside one's own business unit, including abroad) increased with about 50 percent in Sweden between 1997 and 2003. Of total external R&D, 65 percent was performed by domestic or foreign affiliated companies (NSF 2004, SCB 2004).

A survey of over 200 large companies world-wide showed that an increasing share of companies relied heavily on external sources of technology. The share was about 85 percent in 2001, up from 30 percent in 1995 for North American companies, and up from 47 percent for Japanese and European companies (Roberts 2001).

2.1.4 From Traditional to Distributed Innovation

The growth of external R&D indicates a shift away from the traditional in-house R&D model and the big corporate labs, such as Palo Alto Research Center (PARC) by Xerox and Bell Labs by AT&T.

Large companies have realized that it is costly and risky to research and develop all technologies in-house. Increased competitive pressure requires companies to find ways to get more R&D for less money. These strategies include, consolidating current efforts, refocusing on core competencies, aligning R&D more closely with business plans (less long-term research), moving R&D costs to suppliers and using new advanced research and design tools, as well as looking outside the company for knowledge, technologies and innovations.

The result of these efforts is increased external investment, trade and collaboration with suppliers, competitors, customers, research institutes and universities to pool resources and reduce risks. Companies such as IBM, Intel, Nokia, Merck and GlaxoSmithKline have to various degrees adopted this model of distributed or “open” innovation (see for example Chesbrough 2003, Hauser 2005, *BusinessWeek* 2006).

At the same time, a whole host of smaller high-tech companies are increasing their share of R&D (see above), with support from a growing venture capital industry, extending and strengthening innovative capabilities and front-line R&D outside large companies. This environment or external “innovation market” is supported by universities engaged in commercialization and licensing of research results, large companies spinning out non-core projects and technologies, and individual researchers and engineers offering their services through problem-solving companies such as InnoCentive and NineSigma, thereby reaching talent worldwide.

In the new model of distributed innovation, the internal R&D effort by the company is supplemented by an inflow of external research projects, venture investing, technology in-licensing and technology acquisition. At the same time, knowledge and innovations are flowing out in the form of R&D and technology spin-outs, licensing and sales, thus generating income for the company. The challenge for companies is to manage and integrate these internal and external flows into a coordinated innovation process, sometimes reaching across national borders creating international or even global corporate innovation networks (Kuemmerle 1997, NRC 2002, Chesbrough 2003, Karlsson 2004).

2.2 Internationalization of Corporate R&D

2.2.1 What is the Internationalization of Corporate R&D?

Internationalization is generally defined as the mobility across national borders of goods and services (trade), and of production factors such as people and capital. The term is often used to describe a dynamic process of increasing cross-border flows and economic integration, involving a number of interconnected activities and actors using formal and informal channels (see ITPS 2004, OECD 2005b).

In the context of this report, internationalization means the distribution of R&D operations of companies, primarily large ones, among different countries and the cross-border flows of R&D-related resources such as knowledge, technologies, researchers and engineers, and capital (investment and trade).

The term "globalization" is sometimes used when internationalization has deepened to include a large number of countries worldwide and when the process has become increasingly detached from a particular home country or parent company. This distinction will not be emphasized in this report and both terms will be used interchangeably.

The internationalization of corporate R&D takes many forms (see UNCTAD 2005a, OECD 2005b). First, multinational companies are performing R&D at subsidiaries located abroad (outside the parent company's home country). These R&D facilities may have been established by "greenfield" investment (establishments set up from scratch), by the transfer of R&D operations within the corporate group or by the acquisition of existing R&D, for example a high-tech startup company, or as part of a larger corporate merger. The result for a given country can be both inward investment, when a foreign-controlled affiliate is established, and outward investment, when R&D activities are set up abroad.

Second, companies are accessing knowledge and technologies produced or located abroad through international trade. It might be the import or export of patents, licenses, inventions, know-how, technical assistance, R&D services or the utilization of global knowledge markets for solving specific research problems. International trade can occur within the company, between the parent company and foreign R&D affiliates, or between the company and external, third-party, public or private entities.

Third, companies are engaging in international cooperation through R&D networks, agreements and alliances between national and multinational companies, or between companies and government, university or institute R&D entities. Activities include joint R&D projects, scientific exchanges, strategic technology alliances and standardization activities.

Fourth, companies are recruiting foreign R&D workers for employment in the home country or at foreign R&D facilities. Workers may bring localized knowledge or high-level scientific and technological skills. Sometimes companies have internal exchange programs for scientists and engineers contributing to the international flow of R&D workers.

Finally, other forms of internationalization of corporate R&D include the transfer of knowledge associated with foreign manufacturing of innovative products, trade in high-tech products, and sometimes the unintentional diffusion of technologies by reverse engineering of imported goods. This report does not focus on the trade and diffusion of high-tech products.

The internationalization of corporate R&D is part of the broader process involving the outsourcing and offshoring of manufacturing and services (see Mann 2005, GAO 2005, Collins & Brainard 2005, Karlsson 2005, Mattila & Strandell 2006 and ACM 2006). Figure 2-5 provides a commonly used categorization of outsourced and offshore corporate R&D.

Figure 2-5 Categorization of where corporate R&D is performed based on organizational and geographical location.

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Geographical Location of R&D Activity</td></tr>
<tr><td>In Home Country (domestic)</td><td>In Foreign Country (offshore)</td></tr>
<tr><td rowspan="2">Organiza-tional Location (control)</td><td>Inside Company (in-house)</td><td>1. Domestic in-house R&D</td><td>2. Offshore in-house R&D (by an affiliated company)</td></tr>
<tr><td>Outside Company (outsourced)</td><td>3. Domestic outsourced R&D (by an unaffiliated company)</td><td>4. Offshore outsourced R&D (by an unaffiliated company)</td></tr>
</table>

Source: based on MGI 2003, GAO 2004.

The traditional mode of performing corporate R&D is inside the company and in the same country (type 1). Outsourcing means that a part of the production process, such as R&D, is located outside the company (performed by and purchased back from a third party provider) regardless of whether it is in the same or a foreign country (type 3 and 4). Offshore production processes are located in one or more foreign countries regardless of whether it is inside (affiliated) or outside (unaffiliated) the company (type 2 and 4). Offshore outsourced R&D is performed outside the company in a foreign country (type 4). The word offshoring is usually used when a company moves or relocates an activity abroad.

The focus in this report is on where R&D is conducted, rather than on job movement or the potential loss of jobs due to the process of internationalization. Even if investment in R&D performed abroad and imports of R&D services are increasing, job opportunities might grow at both locations (ACM 2006).

2.2.2 How to Measure Internationalization?

It is difficult to define and measure the internationalization of corporate R&D. It is a complex process and it cannot be measured with direct indicators. Available data is incomplete, hard to compare among countries, difficult to interpret and only available with a considerable time lag.

To capture the complexity, it is necessary to use indirect measures and different study approaches (research methods). However, that may lead to differences in results and comparability problems.

A detailed discussion on measurement issues can be found in the OECD *Handbook on Economic Globalisation Indicators* (OECD 2005b), see also NRC 2005a.

Despite the limitations, several efforts to gather systematic data are under way. Some of the key data sources relevant for the internationalization of corporate R&D include the OECD (MSTI 2005, OECD 2005c, OECD 2005d), UNCTAD (UNCTAD 2005a), the European Commission (EC 2004, EC 2005a, EC 2005b), in the U.S. (see Mattila 2005 for an overview); the Bureau of Economic Analysis of the U.S. Department of Commerce (BEA 2004, BEA 2005) and the National Science Foundation (NSF 2004, 2006) and in Sweden, Statistics Sweden (SCB 2004) and the Swedish Institute for Growth Policy Studies (ITPS 2005).

The following is a short description of some indicators and their benefits and weaknesses (see OECD 2005b, NRC 2005a).

International R&D investment, sometimes referred to as inward and outward R&D foreign direct investment (FDI), is measured in terms of R&D expenditures and number of researchers, both of foreign affiliates and of parent companies. These data sets are well established and regularly available, but lack detail and usually underestimate design and software R&D. Some transactions take place inside companies and cannot be captured. In addition, there is certain overlap with trade indicators since there is a complex relationship between direct investment transactions and the technology balance of payments.

Companies with R&D activities in multiple industry sectors are classified in a single (primary) industry. When primary business of a company changes, reclassifying of R&D expenditures obscures data comparisons (for example when reclassifying IBM from computer manufacturer to computer services).

Trade in R&D services, in the form of receipt and payments, is part of the balance of payments account. A special technology balance of payments (TBP) has been developed consisting of the trade categories; computer services, royalties and license fees, and R&D, engineering and other technical services. According to several analysts, these indicators are unreliable and some countries (including Sweden) have discontinued the publication of TBP data. For example, trade in some categories is small and export data from one country does not always correspond with import data from the other country. Moreover, it is necessary to separate services at the sector level. For example, while the U.S. is an importer of programming services, it is an exporter of information technology research.

Data on patenting by companies is sometimes used to measure international collaboration. Analysts are debating the relevance of patent data as a measure of innovative activity. On one hand, data are available over long time spans and they cover a large set of companies across many sectors. On the other hand, patent data do not capture all innovative activity and not all patents lead to innovations. Moreover, the propensity to patent varies widely among countries, companies, technologies and sectors. Regarding international co-patenting, data can also be misleading. Certainly, all cross-border R&D collaboration does not result in co-patenting.

R&D and innovation surveys try to collect more up-to-date and detailed company-level data. In some cases these efforts suffer from uneven coverage and biases due to low response rates among companies. Offshoring of R&D, and to a greater extent production, is a delicate issue and many companies choose not to give comments or provide information. For example, in a recent survey by UNCTAD on the internationalization of R&D by companies, the response rate was about 20 percent (UNCTAD 2005a, see also UNCTAD 2005b).

Most analysts agree that there is a need for more systematic and detailed data collection and analysis, as well as the standardization of data across countries. Several projects are under way to link different data sets (for example, the R&D data linking project involving NSF/Census industrial R&D and BEA foreign direct investment surveys in the U.S.) and to suggest the development of new indicators (see NRC 2005b, USCB 2005).

2.3 The Extent of Internationalization

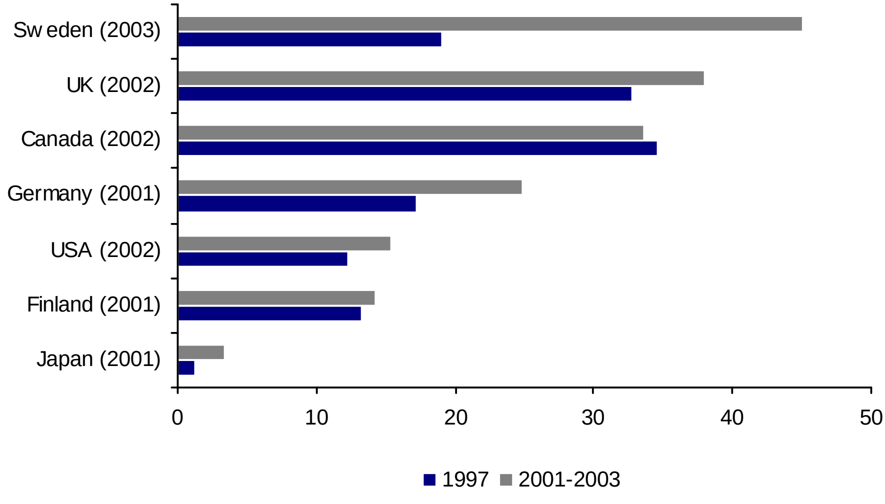
There is clear evidence that the internationalization of corporate R&D is gaining momentum and that investment, trade, co-patenting, cooperation and the number of foreign R&D facilities and projects is growing. Nevertheless, corporate R&D remains among the least internationalized segments of the production process. R&D is lagging behind other functions like production, financing, sales and marketing.

International R&D by companies is not a new phenomenon, but it did not begin to increase significantly until in the mid–1980s. The trend accelerated during the 1990s with an increasing amount of cross-border, R&D-related transactions as well as a wider geographical reach, including locating R&D to developing countries. This is documented for example in Norgren 1995, Kuemmerle 1999, Reddy 2000 and von Zedtwitz & Gassmann 2002.

2.3.1 Foreign-Controlled R&D – Inward Investment

The R&D expenditure of foreign affiliates as a share of total industry R&D varies significantly between countries; it is less than 5 percent in Japan and over 70 percent in Hungary and Ireland. The share in Sweden was about 45 percent in 2003, up from 19 percent in 1997 (Figure 2-6). The foreign-controlled R&D in Sweden is concentrated among a small number of owner countries. The U.S. and the U.K. accounted for 73 percent of all foreign R&D expenditures in Sweden in 2003 (MSTI 2005, ITPS 2005).

Figure 2-6 R&D expenditures of foreign affiliates as percentage of total R&D expenditures of enterprises. Data from latest available year compared with 1997.



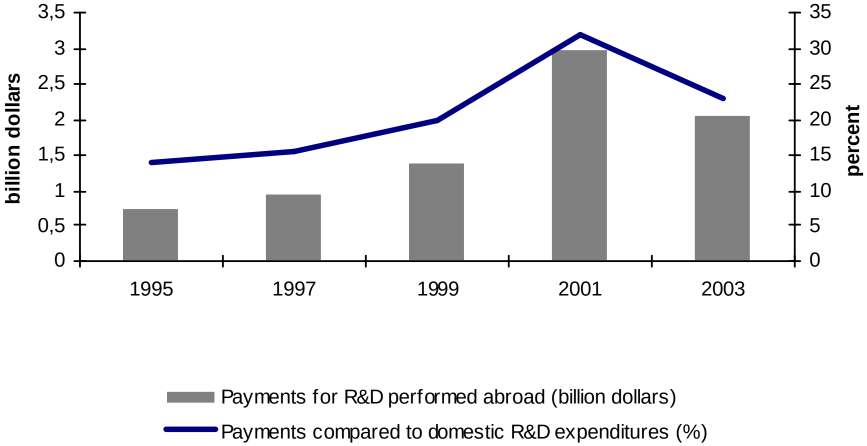
Source: MSTI 2005, data for Sweden ITPS 2005.

Foreign-controlled industrial R&D is growing in all major OECD countries. The total investments of foreign affiliates increased from 29 billion dollars in 1995 to 52 billion dollars in 2001. The U.S. accounted for more than 42 percent (21 billion dollars) of this amount, followed by Germany, the U.K. and Japan, attracting about 15, 12 and 5 percent respectively of the total investments. On an aggregated level, the share of R&D expenditure of affiliates under foreign control, in total business sector, R&D grew from 12 to 16 percent between 1993 and 2001 in major OECD countries (OECD 2005c).

2.3.2 R&D Facilities Abroad – Outward Investment

Some countries collect data concerning R&D activities of their own multinational companies abroad. Switzerland is the only country where R&D expenditure abroad is higher than R&D investment at home (for the year 2000). For Germany (2001) and Finland (1998), R&D abroad is approximately 25 percent of corporate R&D expenditures at home. The U.S. share of around 10 percent has been fairly stable since 1995 (OECD 2005c, NSF 2004).

Figure 2-7 Payments for R&D performed abroad by companies in Sweden in billion dollars and compared to domestic R&D expenditures (percent).



Source: SCB 2003a, SCB 2004.

Companies in Sweden made payments of 2.1 billion dollars for R&D performed abroad in 2003. The main part of this R&D was performed in foreign affiliates to the companies in Sweden (76 percent) and almost all of it was in the manufacturing sector (94 percent). The payments for R&D abroad as a percentage of domestic R&D expenditures reached 23 percent in 2003, up from 14 percent in 1995 (see Figure 2-7). This ratio varies between sectors. In Sweden it was 27 percent in the manufacturing sector as a whole in 2003, 15 percent in the pharmaceutical sector and as high as 68 percent for electrical and optical products (including communication equipment) (SCB 2004).

Eight Swedish multinational companies performed more than half of their R&D abroad in 2003 (ITPS 2005). The share of foreign R&D performed in developing economies by 20 R&D-spending Swedish enterprise groups increased from 2.7 to 7.2 percent between 1995 and 2003 (data from ITPS published in UNCTAD 2005a).

Majority-owned foreign affiliates of U.S. parent companies spent about 22 billion dollars on R&D abroad in 2003. Developed economies dominated as locations for R&D but the share of developing countries increased from 7.6 percent in 1994 to 15 percent in 2003. Mainly countries in developing Asia, such as China, Singapore and Korea, compensated for the declining share of developed countries. In Asia (excluding Japan), computers and electronic products was the dominating industry sector for R&D investment. Sweden ranked fourth in Europe (after U.K., Germany and France) and accounted for 1.4 billion dollars (6 percent) of R&D spending by U.S. affiliates abroad (BEA 2005).

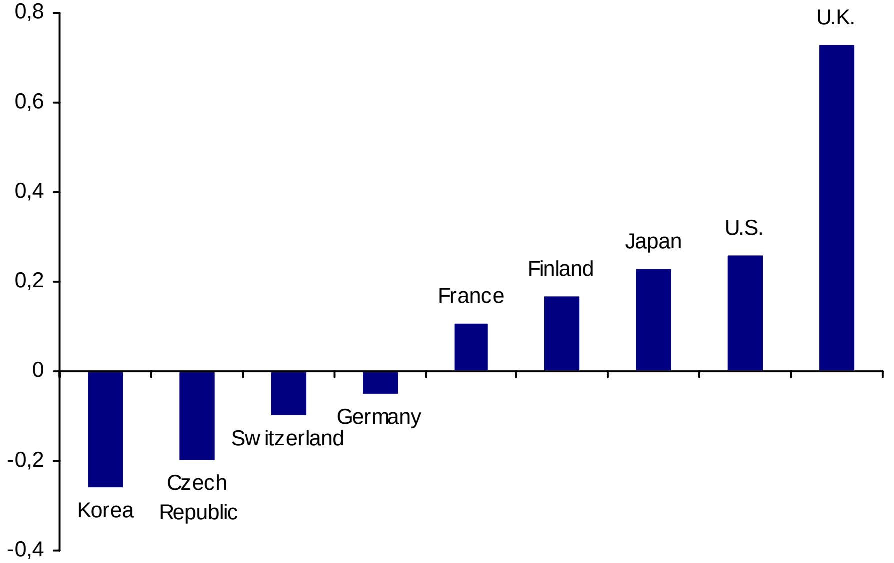
A number of survey studies confirm that corporate R&D spending abroad is increasing (see for example Roberts 2001, von Zedtwitz & Gassmann 2002, *BusinessWeek* 2005 and UNCTAD 2005a).

From a country perspective, the level of internationalization can be measured both in terms of industrial R&D activates abroad (home country) and domestic activities of foreign companies (host country). For example, Germany and Finland are more internationalized abroad than in the domestic market, while in the U.S., Japan and Sweden, in terms of total industry, R&D is more internationalized in the domestic market (OECD 2005c).

2.3.3 Trade in R&D – Technology Balance of Payment

In most OECD countries, technology receipts and payments increased during the 1990s. Obviously, the OECD area was a net technology exporter to the rest of the world, while the European Union had a deficit on its technology balance of payments. Japan increased its positive trade balance dramatically from almost nothing in 1993 to 0.2 percent of GDP in 2003. The U.S. had a stable positive trade balance during the 1990s of 0.25 percent of GDP. The U.K. was a major net exporter (almost 0.8 percent of GDP) while Ireland was a major net importer (over 10 percent of GDP), see Figure 2-8. In absolute terms, the U.S. net trade balance (receipts minus payments) was the largest (over 28 billion dollars) followed by the U.K. (13 billion dollars) and Japan (8 billion dollars) (OECD 2005c, MSTI 2005).

Figure 2-8 Technology balance of payments (receipts minus payments) as percentage of GDP, 2003.

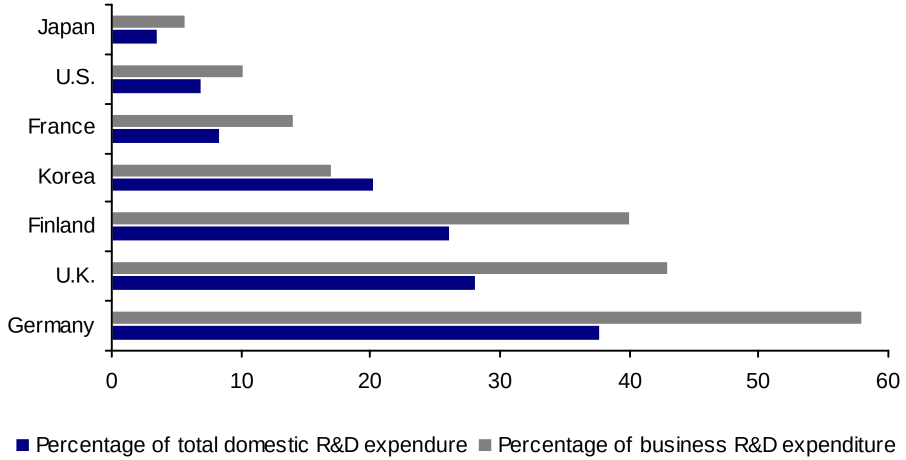


Source: MSTI 2005, no data for Sweden.

U.S. trade in the category of research, development and testing services has grown substantially during the last couple years. Imports from unaffiliated companies reached almost 1.3 billion dollars in 2003, more than a doubling since 1997. The largest exporter to the U.S. was the U.K. (28 percent of imports). U.S. exports in the category was also 1.3 billion and the largest customer was Japan (21 percent) (BEA 2004, see also GAO 2004).

Another method of measuring the degree of internationalization is to compare the acquisition of foreign technology with the national R&D effort. To what degree does a country rely on foreign technologies (technology payments) in relation to domestic development of technologies (business R&D expenditures)? In some countries, such as Ireland, Austria and Hungary, payments to acquire foreign technology is greater than domestic business R&D investment. The opposite is true for most other OECD countries. Japan and the U.S. have low levels of technology imports (between 5 and 10 percent) in relation to their national business R&D effort, while Finland, the U.K. and Germany have higher levels of foreign technology spending (between 40 and 60 percent) (MSTI 2005, OECD 2005c), see Figure 2-9.

Figure 2-9 Technology balance of payments: payments as percentage of total domestic R&D expenditure and business R&D expenditure, 2003.



Source: MSTI 2005, no data for Sweden.

2.3.4 Cross-Border Ownership and Co-Ownership of Patents

Foreign ownership of domestic inventions is increasing, according to EPO (European Patent Office) patent data. On average in OECD countries, 15 percent of all inventions were owned or co-owned by foreign residents in early 2000, up from 11 percent in 1992. Countries like Sweden, Germany and the U.S. show a similar level and trend as the OECD average.

Domestic ownership of inventions made abroad is also increasing. OECD countries owned about 15 percent of foreign inventions in early 2000. The level is higher in small, open economies such as Switzerland (48 percent), Ireland (42 percent) and the Netherlands (30 percent). About 28 percent of all inventions owned by residents in Sweden were made abroad, a doubling since the early 1990s. Japan and Korea have a very low level of internationalization in terms of cross-border ownership by both measures (OECD Patent Database, OECD 2005c).

Patent data have also been used to estimate the degree of international cooperation in science and technology. A world average of 7 percent of patents was the result of international cooperative research in early 2000. There were large differences among countries. In the Slovak Republic and Luxembourg, 53 percent of patent applications to the EPO had foreign co-inventors. The share for Sweden, France, the Netherlands, the U.S. and Germany was between 10 and 20 percent. The level for Japan was only 3 percent (OECD Patent Database, OECD 2005c).

Another study using patent data between 1996 and 2000 shows that European companies had a greater tendency to locate R&D activities abroad than American and Japanese companies. The study also confirmed that multinational companies from small countries, like Belgium, the Netherlands, Sweden and Switzerland, had the highest degrees of internationalization of corporate R&D (Criscuolo & Patel 2003).

2.3.5 R&D Collaboration and Alliances

The number of newly established international strategic technology alliances has increased considerably since the 1980s, according to studies based on the Cooperative Agreements and Technology Indicators database (MERIT CATI). However, during the same period, the share of international R&D partnerships in relation to the total number of R&D partnerships has declined. The share of international R&D partnerships fell below 50 percent during the late 1990s. The largest share of R&D partnerships in the database was intra-North America (about 41 percent during the 1990s) followed by EU-North America partnerships (25 percent). The strong growth of intra-North America collaboration largely explains why international partnerships, despite growth in absolute numbers, still take only about 50 percent of the total number of R&D partnerships (Hagedoorn 2002).

The industry composition of alliances shifted strongly between 1991 and 2001. The share of pharmaceuticals and biotechnology grew from 11 to 58 percent while alliances in the information technology industry declined from 54 to 28 percent (UNCTAD 2005a).

Other surveys confirm that most cooperative agreements were found to be with national, rather than international, partners. More than 80 percent of partnerships among innovative European companies involved national partners in both manufacturing and services during the late 1990s (Eurostat-CIS survey, OECD 2005a).

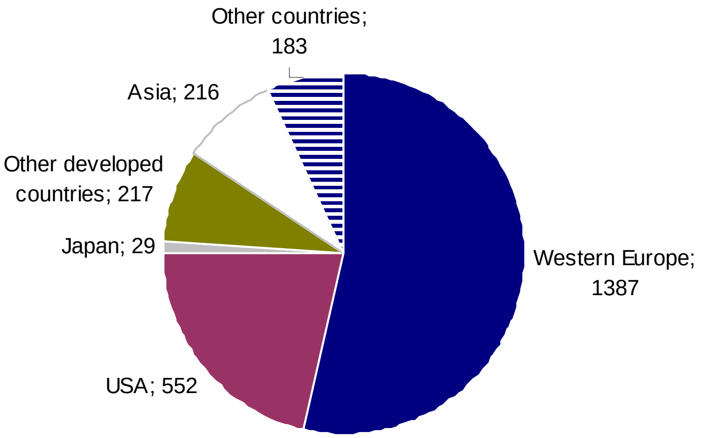
Data for U.S. companies in MERIT CATI shows that about 80 percent of technology alliances from 1991 to 2001 involved at least one U.S.-owned company. Of these alliances, about half involved only U.S.-owned companies (regardless of where the companies were located) (NSF 2004, see also NSF 2006).

2.3.6 Surveys of Foreign R&D Facilities and Projects

A number of surveys of company-level data also reflect the increasing internationalization of corporate R&D. In 1992, the U.S. was host for 250 foreign R&D facilities, of which many were newly established. The number grew rapidly to 715 facilities owned by 375 foreign parent companies in 1997. Two hundred fifty-one of the facilities were established by companies from Japan, followed by Germany, UK and France. At the same time the U.S. had established 169 R&D facilities abroad, 88 in Europe and 45 in Japan (Dalton & Serapio 1999). See also a similar study in Kuemmerle 1999.

Available survey data is more up-to-date than other indicators and they reveal the growing participation by developing countries in the internationalization of corporate R&D. According to data compiled by UNCTAD, there were around 2600 majority-owned foreign affiliates worldwide engaged in R&D in 2004. About 70 percent of these were located in the Triad (the U.S., Europe and Japan) and 10 percent in developing economies, mostly in Asia (UNCTAD 2004), see Figure 2-10.

Figure 2-10 Geographical distribution of foreign R&D affiliates, 2004 (on the basis of majority-owned foreign affiliates engaged in commercial research, noncommercial research organizations and testing laboratories).



Source: UNCTAD, based on the Dun & Bradstreet Who Owns Whom database (UNCTAD 2004).

The U.S. and the U.K. were the top two destinations for R&D in a survey of multinational companies in 2004. China and India ranked third and sixth with 35 percent of the companies having R&D units in China, and 25 percent of them in India (UNCTAD 2005a).

In another survey of R&D projects worldwide, 1770 greenfield and expansion foreign direct investment projects, including software development projects, were identified between 2002 and 2004.

A majority of the projects was initiated by companies from developed countries (over 90 percent) and most of them were located in developing countries (62 percent), dominated by developing Asia, particularly China and India (LOCOmonitor from UNCTAD 2005a).

Over 100 multinational companies had established R&D facilities in India by 2004 According to official sources in China, 700 foreign R&D centers had been established in that country by the end of 2004, most of them after 2001. The centers were concentrated in the larger cities, specifically Beijing and Shanghai, and in the information and communications sectors (see for example Sigurdson 2004b, UNCTAD 2005a). Eight of the top 10 R&D spending companies in the world in 2004 have established R&D activities in China or India (Microsoft, Pfizer, DaimlerChrysler, General Motors, Siemens, Matsushita Electric, IBM and Johnson & Johnson) (BAH 2005).

IBM and Ericsson are two examples of companies with large international R&D networks, including in developing Asia. IBM has the world's largest information technology R&D organization with eight research laboratories and 24 development facilities worldwide. The international research network originates from the 1950s and includes laboratories in Zurich, Haifa, Tokyo, Beijing, Delhi and three locations in the U.S. The company spends over 5 billion dollars annually on R&D and produces more U.S. patents than any other company (Ruetsche 2005, Chesbrough 2003).

Ericsson spent 3.1 billion dollars on R&D in 2005, according to the company. The research part was 2–3 percent of total R&D spendings. Ericsson has gone through radical restructuring and focused its R&D following the stagnating communications market in the early 2000s. However, during the general downsizing of R&D in the company, R&D activities increased in China and today Ericsson has R&D in six locations in China. Ericsson has R&D centers in more than 18 countries worldwide but the major growth is in China and Sweden (see CEB 2004a, Sigurdson 2004a, Ericsson press releases).

Apart from China and India, R&D in developing economies is concentrated in a few host countries such as Brazil (Motorola, General Motors), Mexico (Delphi Automotive), Singapore (Flextronics, Aventis, Merck), Korea (Microsoft, Siemens), Eastern Europe and South Africa. A few other locations are also emerging, for example the Russian Federation (Intel, Airbus), Thailand (Toyota) and Vietnam (Honda) (UNCTAD 2005a, *BusinessWeek* 2005).

Besides the emerging pattern of multinational companies increasing R&D investment and trade with developing countries, two even smaller flows of cross-border R&D activities can be identified as illustrated in Figure 2-11.

Figure 2-11 Four types/categories of international R&D flows based on the geographical location of R&D units (host country) in relation to the location of the parent company (home country).

		Host Country	
		Developed Economy	Developing Economy
Home Country	Developed Economy	1. “Traditional,” e.g. intra-Triad Largest flow	2. “Modern,” e.g. E.U.→India Increasing, from low level
	Developing Economy	3. “Catch-up,” e.g. China→E.U. Very small flow	4. “Expansionary,” e.g. China→India Very small flow

Source: based on von Zedtwitz 2005.

There are only a few examples of R&D flows from developing to developed countries (type 3, catch-up) and flows between developing countries (type 4, expansionary). Chinese multinational companies had established 26 foreign R&D units in developed countries in 2004, among them 11 in the U.S. and 11 in Europe. For example Huawei, a major communications equipment company, had established R&D units in Stockholm, Bangalore, Moscow and Dallas. Leading Indian software companies, such as Infosys and Wipro, have operations in the U.S. (von Zedtwitz 2005, UNCTAD 2005a).

Moreover, companies from China, Malaysia, Korea, Singapore and Thailand have set up R&D activities in India related to software development. Indian companies have R&D operations in Uruguay and Hungary (Reddy 2000, UNCTAD 2005a).

2.3.7 Forward-Looking Surveys

According to surveys of investor intentions, a majority of the largest multinational companies expect foreign direct investment, including R&D, to increase over the next five years. Developing economies are dominating in these investment plans with a focus on developing Asia (mainly China and India) as well as Eastern and Central Europe (for example Poland and the Czech Republic) (A.T. Kearney 2004, Ayers 2005, Thursby & Thursby 2006).

About 70 percent of the companies in the UNCTAD survey said that they intended to increase the share of foreign R&D between 2005 and 2009, only 2 percent said they were about to decrease it. The intention to increase foreign R&D was particularly strong among Japanese and Korean companies (90 and 80 percent respectively). The results are very clear when it comes to which countries are most attractive for R&D investment. In most surveys, China is ranked as number one by 40 to 60 percent of the companies, followed by India (about 30 percent) and the

U.S. (30 to 40 percent of responding companies). In the survey by the Economist Intelligence Unit, 3 percent of companies mentioned Sweden as their preferred country (UNCTAD 2005a, EIU 2004b).

This investment pattern was also confirmed in a survey by the Corporate Executive Board in 2004. Over 90 percent of responding companies would increase both research and development in China in the next five years. India and Eastern Europe followed albeit with a focus on development investment (76 and 58 percent of the companies respectively) (CEB 2004b).

2.4 Explaining Internationalization of Corporate R&D

2.4.1 Enablers of R&D Internationalization

Underlying the internationalization of corporate R&D is a number of enabling forces that have emerged during the past 10 to 15 years. On a systemic level, these forces made possible and promoted the tradability and cross-border mobility of R&D activities and services (see for example RAND 2000, Mann 2005, Ruetsche 2005 and *BusinessWeek* 2006).

First, the rapid development of a global *information and communication infrastructure* has enabled the internationalization of R&D investment, trade and exchange. Internet combined with international telecommunications networks and the penetration of personal computers has drastically reduced the cost of communication and facilitated global work sharing, flexible networking and communication among geographically scattered centers of competence.

Second, distributed innovation is also facilitated by the use of *digitization and standardized tools*. Global standards for digital documents, multimedia information, operating systems and other software are enabling internationalized R&D. Certain R&D activities can be modularized and performed using computer-aided expert systems and simulation tools. Partial designs and solutions from several locations can, for example, be integrated rapidly and electronically.

Third, the overall production process is becoming increasingly distributed among many multinational companies. The *fragmentation of the production process* means that tasks, including manufacturing and R&D, are separated from other business activities and can be performed in remote locations. Technology is becoming more modularized in industry sectors such as microelectronics, biotechnology and software. R&D can follow more easily when manufacturing moves abroad.

Fourth, *more countries are actively building scientific capabilities* and are participating in the global R&D community. Developing countries, such as China and India, have developed their innovation systems and rapidly improved host country environments.

Economic reforms, training of scientists and engineers, development of R&D clusters and technical infrastructure, strengthening of supplier networks and targeted policies to attract foreign investment in these countries have broadened and leveled the global R&D playing-field.

Finally, *intensified cross-border science and technology activities* in general, such as increasing mobility of scientists and engineers, a larger share of research projects involving participants from more than one country and the shift towards more institutionalized, routinized and systematic processes of internationalization, act as enablers for the internationalization of corporate R&D.

2.4.2 Drivers of R&D Internationalization

Decisions of large, technology-intensive multinational companies are the main driving forces behind R&D internationalization. Companies decide to go abroad for knowledge, research and technologies for several reasons, including the motives of implementing distributed innovation discussed above. Increased technological complexity of products and services and increased global competition from more differentiated products and producers are making technology a key factor for competitiveness. Companies are actively building international R&D networks, in-house and with partners, to share the costs and risks involved in R&D, to exploit research synergies, reduce duplication and to innovate faster and more efficiently. The growing similarities among technologies across industrial sectors and the cross-fertilization of technologies that is occurring between sectors can also be seen as drivers.

Companies are exploring new organizational strategies to manage their R&D networks. The challenge includes enabling effective collaboration between external and international R&D teams, managing people in diverse cultural environments and aligning global research activities with business strategy. Some companies have managed to create an integrated "innovation chain" that is truly global – a process for innovating that transcends local clusters and national boundaries (Santos et al. 2004, EIU 2004b).

Company decisions also drive cross-border control and ownership of corporate R&D. The degree and structure of inward and outward R&D investment can be explained in two principal ways.

First, the internationalization pattern is partly a result of corporate activities that are not primarily focused on R&D facilities and innovation. For example, the main driver behind a large international merger or acquisition may be to gain market shares or to eliminate a competitor, rather than acquire R&D capabilities. In this way, foreign-controlled R&D may be an *unintended outcome of corporate decisions with other primary goals*. A single, large international merger or acquisition can lead to sharp increases in ownership ratios (see for example McGuckin et al. 2004, Patel 2004).

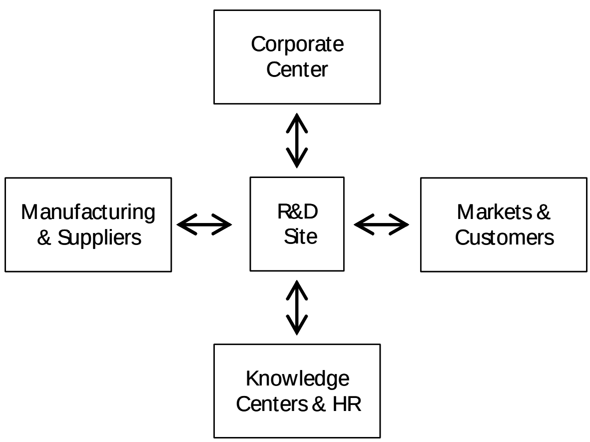
Second, the pattern is partly explained by companies making deliberate and *strategic decisions to acquire or invest in particular R&D facilities*. In this case, the primary driver is the acquisition of innovation capabilities, by itself or part of a larger business deal with additional objectives.

In the 1980s and early 90s the main method was to acquire existing foreign R&D intensive companies. In the second half of the 90s, an increasing number of new R&D units were greenfield investments (Kuemmerle 1999).

2.4.3 Determinants for Locating R&D

There are a number of possible functional and geographical localization options for corporate R&D investment depending on the type of R&D performed and its relationship to other activities in the company's value chain. At least four localization options can be distinguished (see Figure 2-12), each with a different set of motives (see for example Roberts 2001, Mattila 2004 and Thursby & Thursby 2006).

Figure 2-12 Four basic functional and geographical localization options for corporate R&D.



Source: ITPS.

Locating R&D close to the *corporate center* is the traditional model and is still common when companies want to tightly control strategic R&D activities, maintain critical mass of R&D activities and protect intellectual property rights. Coordination, transaction and management costs can also be kept lower.

Moving away from the corporate center can be motivated by the need for R&D to be close to manufacturing, markets or knowledge centers at other geographical locations, sometimes combined with a cost advantage. In addition, companies might consider developing radical, disruptive innovations far from the corporate center.

R&D is located close to *manufacturing and suppliers* to support local production, develop production processes or to collaborate with local suppliers. Also, co-location of R&D and manufacturing can promote learning of design for manufacturability and as a result, decrease cost and time to market.

R&D is located close to *markets and customers* when technologies should be adapted to a local market or when the company wants to learn from leading customers. Other motives might be to participate in local standardization activities, take advantage of tax incentives, avoid trade barriers, or comply with local market-access regulations and pressures.

Increasingly, companies are locating R&D close to “centers of excellence” to access *knowledge and skilled research personnel*. Sometimes these centers take the form of technology clusters specializing in a particular technology or discipline. By participating in these clusters, companies can keep abreast of new technologies and take advantage of technologies developed by other companies. Some companies are looking for skilled researchers and engineers in large numbers and must locate R&D activities in centers with a considerable supply of technical students.

One geographical location, in the home or a foreign country, might combine two or more of the functions and related motives.

There are several attempts in the literature to identify different types of R&D units based on their function or motives behind their realization (see Chapter 3). Two main types are used by most analysts: *adaptive R&D,* to adapt technologies, products and processes to local conditions in the host country, and *innovative R&D,* to create new technologies, products and processes for local, regional or global markets. Adaptive R&D is dominating but innovative R&D is increasing as a result of specialization and internationalization, according to a number of studies.

Ease of access to technologies and to skilled scientists and engineers is becoming an increasingly important driver for R&D localization. This is true especially in technological areas closely linked to basic research, such as in the biotechnology and pharmaceutical sectors. Support for manufacturing and adaptation to local market conditions are more important in the chemical and automotive sectors.

2.4.4 R&D in Developing Countries – Cost and Other Challenges

The recent increase in international R&D investment and collaboration involving developing countries, such as India and China, is also driven by the factors discussed above, such as proximity to manufacturing as well as market, technology and manpower access (ACM 2006). Lower cost is usually considered an important driver by many analysts, often in combination with the availability of qualified R&D personnel (Reddy 2000, UNCTAD 2005a).

However, the importance of lower wages for R&D workers as a key driver has been questioned by other analysts and contradicted by industrialists. In recent studies (McGuckin et al. 2004, Thursby & Thursby 2006) lower cost was not a major factor, especially not for research. According to IBM: “our decisions on the locations of research centers are based on access to locally based talent, far more than on labor rates” (Ruetsche 2005). Closeness to manufacturing is the most important reason for locating R&D to China according to Ericsson (Ny Teknik 2005).

Even if wages are lower in developing countries, the total savings are not huge, once infrastructure and coordination costs for managing distributed R&D facilities are included, according to a survey study among 190 U.S. senior executives (EIU 2004a). Reduced economies of scale and challenges related to integration, knowledge transfer and management also contribute to higher costs.

Analysts and industrialists have identified a number of other challenges and barriers for setting up R&D in developing countries, including: attracting and keeping researchers and engineers; preventing leakage of key technologies and know-how to local competitors; protecting intellectual property rights; managing cultural differences and lack of face-to-face communication, as well as frequent failures, longer learning curves and concerns over political instability (EIU 2004b, Thursby & Thursby 2004).

The sustainability of R&D facilities in emerging economies is still unclear, since it takes a number of years for new R&D investments to achieve real impact on company operations. It is still too early to tell if benefits outweigh costs in the long run (ACM 2006). Nevertheless, the cost aspect combined with the long-term availability of skilled workers seems to support the argument for increased investments in developing countries, according to the trends described above.

2.5 Internationalization of Corporate R&D – Summary of Trends

The discussion in this chapter of concepts, measurement issues, trends and drivers related to the internationalization of corporate R&D serves as a background and framework for the chapters that follow. A few important trends can be highlighted from this overview:

- A growing share of corporate R&D is undertaken abroad. R&D is still less internationalized than production.
- Most R&D internationalization takes place within the Triad (the U.S., Europe and Japan).
- European companies, especially from smaller countries, are more internationalized than U.S. and Japanese companies.
- The U.S. is the major location for foreign R&D. Japanese companies are the least internationalized and Japan is the least favored location within the Triad.
- Sweden is one of the most internationalized countries within the OECD.
- High-tech industrial sectors, such as the pharmaceutical and communications industry, are most internationalized.
- More recently, developing countries are attracting corporate R&D. The increase in developing Asia (China and India) is the most dramatic.
- Multinational companies are planning increases in R&D investment in developing Asia, while not increasing, and sometimes even decreasing, at home.
- The development of global information and telecommunications networks and modularized innovation processes are key enablers of internationalization.
- Adaptive R&D is still the dominating form among foreign R&D units, but innovative R&D is increasing.
- Access to technologies and skilled researchers and engineers are becoming increasingly important motives for R&D localization.
- The share of greenfield investment in R&D is increasing compared to the acquisition of existing foreign R&D facilities.
- Foreign R&D is becoming more integrated into the overall R&D strategies of multinational companies, forming global innovation networks.

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3 Global Location of R&D

Börje Johansson & Hans Lööf

The main idea is that the foundations of competitive advantage no longer reside in any one country, but in many. New ideas and products may come up in many different countries and later be exploited on a global scale (Hedlund 1986).

3.1 Introduction

This chapter discusses offshore R&D investments, focusing mainly on large, multinational companies within the industrialized world. What do we know about offshore R&D activities in terms of trends, scope and destinations, driving forces and constraints? What do we know about consequences for the R&D investing company, for national systems of innovation, for regional R&D externalities, or for agglomeration and urban economies of home and host countries? Although there is considerable literature on foreign direct investments and outsourcing, much of it has focused on production. The effects of a growing globalization of R&D have not received the same attention.

The chapter draws upon recent literature on the internationalization of R&D, bearing in mind the difficulties of generalizing without systematic empirical studies or representative samples. In general, data sources consist of aggregate statistics provided by the United Nations Conference on Trade and Development (UNCTAD) or national statistical agencies, and selected sample studies or case studies. Studies based on extensive, company-level data are still rare.

Section 2 provides a short introduction to theoretical and empirical studies on the importance of overseas engagement in R&D activities. Section 3 presents some key determinants of offshore R&D investment and discusses motives such as adjustment to local demand conditions. Section 4 discusses empirical evidence on the relative importance on different global R&D strategies. Section 5 analyzes possible consequences for the national economy, and Section 6 serves as the conclusion.

3.2 Globalization of Innovation

The scope of international R&D investment and technology flow differs considerably among the industrialized countries, as well as among industries, branches and company sizes. However, over time, the trend toward increasing R&D investment is unambiguous (Kuemmerle 1999). Upon studying 32 multinational companies with headquarters in the U.S., Japan, Germany, France and Netherlands, Kuemmerle reports that the share of R&D conducted outside of their home country's boundaries increased from 6.2 percent in 1965 to nearly 26 percent in 1995.

Historically, one can identify a period when foreign direct investment (FDI) flows were directed to exploit natural resources (often referred to as the "primary sector" of a country's economy). However, the share of FDI into natural resources started to decline in the 1970s, whereas FDI in manufacturing (the "secondary sector") became more dominant. Currently, in certain industrialized countries, FDI in service production (the "tertiary sector") is rapidly increasing, while FDI in natural resources and manufacturing has declined. This latter change also includes investments in R&D activities abroad.

As Figure 3-1 shows, FDI in both the primary and secondary sectors declined for a set of European countries and the U.S. between 1990 and 2001. However, the remarkable change between 1990 and 2001 is a clear shift to FDI in the tertiary sector that includes sales offices, after-sales services and research laboratories. While information about Sweden is only available for 1990 and 1995, it shows a reduction of incoming FDI in the tertiary sector between 1990 and 1995.

Figure 3-1 Percentage composition of incoming FDI stocks into sectoral shares.

	Primary 1990	**Primary 2001**	**Secondary 1990**	**Secondary 2001**	**Tertiary 1990**	**Tertiary 2001**
France	6.4	0.2	37.5	19.7	56.1	80.2
Germany	0.1	0.2	36.4	11.5	63.4	88.4
Italy	3.5	2.9	38.2	39.8	58.3	57.2
Netherlands	0.2	1.3	55.5	33.2	44.3	65.5
Norway	49.0	29.1	10.6	20.3	40.4	50.6
United Kingdom	23.1	11.6	36.1	25.1	57.6	63.3
United States	13.5	2.2	39.0	35.7	40.8	62.1

Source: Johnson (2006) based on OECD data.

Figure 3-2 shows the amount of R&D investment in selected OECD countries by foreign companies. In Canada, 34 percent of all R&D investment came from foreign-controlled multinational companies. The other countries with a very high proportion of foreign R&D expenditures are Spain (33 percent) and the U.K. (31 percent). In contrast, only 15 percent of the R&D expenditures in Finland and the U.S. were associated with foreign-controlled companies. The corresponding figures for Sweden were 20 percent in 1995, and 40 percent in 2001.

Figure 3-2 R&D expenditure of foreign affiliates as a percentage of total R&D expenditures by all companies.

Country	**Percentage of R&D**
Canada (1998)	34.2
Spain (1999)	32.8
United Kingdom (1999)	31.2
Netherlands (1998)	21.8
France (1998)	16.4
United States (1998)	14.9
Finland (1999)	14.9
Japan (1998)	1.7

Source: UNCTAD 2002.

Examples of the relationship between industry and globalization of R&D exist in two extremes: mature technologies and emerging technologies. When a technology is mature, codifiable, and widely disseminated, constant interaction with customers is not important. In this case, R&D and production may be separated, and production becomes more globalized than research and development. In contrast, rapid change in emerging technologies often requires close interaction between R&D and production.

Larger companies still tend to dominate offshore R&D investments because they have comparably greater financial resources, and a greater capacity to absorb external localized knowledge. Moving R&D across borders requires a company to commit extensive resources to the collection, coordination and dissemination of information, and the company's absorptive capacity is correlated to a critical mass of accumulated R&D. As a result, some minimum threshold size of R&D activities exists in every specific location.

The literature shows that multinational companies have pursued different strategies for global expansion of R&D activities, reflecting an adjustment to the geographical patterns of national innovation systems, geographical proximity, industrial clusters and global networks. [See for example Jaffe et al. (1993), Audretsch & Feldman (1996) and Cantwell & Janne (1999).] Criscuolo et al. (2005) suggest that companies internationalize their R&D for largely the same reasons as they do other elements of the value chain.

The main explanation for the close association between globalization of production and globalization of R&D is that many of the largest companies engaged in FDI are also key actors in the generation and diffusion of new technologies. More than one-third of the top 100 multinational companies are active in the most R&D-intensive industries, such as electronics, pharmaceuticals and chemicals (Narula & Zanfei 2004). Similar to production activities, most offshore R&D investments are still largely limited to OECD countries. A majority of multinational companies have kept more than 90 percent of their R&D expenditures within the OECD (UNCTAD 2002).

For the typical OECD country, various forms of globalization of innovation activities are a two-way phenomenon. A growing share of the host country's R&D (and production) is controlled by foreign-owned multinational companies, and a growing share of the R&D activities (and production) within domestically-controlled multinational companies are conducted in other OECD countries.

As Figure 3-3 shows, between 1995 and 2001, the manufacturing production in foreign affiliates of Swedish-controlled multinational companies increased from 65 to 75 percent of total production (approximated by number of employees). During that same period, the corresponding R&D engagement conducted abroad increased from 34 to 48 percent.

Figure 3-3 Outward FDI from Sweden: production and R&D in foreign affiliates as a share of total production and research of Swedish-controlled multinational companies.

	1995	**2001**
Production	64.9%	75.0%
R&D	34.4%	47.7%

Source: ITPS 2005a.

The two-way process of globalization is reflected by FDI in Sweden for the same period. As Figure 3-4 shows, in 1995, about 21 percent of manufacturing production (approximated by employees) in Sweden was conducted in affiliates owned by foreign multinational companies. Six years later, that proportion had increased to 34 percent. This development was accompanied by an even stronger trend toward increased foreign control of the R&D investments in Sweden, which rose from 20 to 40 percent in the same period.

Figure 3-4 Inward FDI to Sweden: Production and R&D in Sweden conducted by foreign-controlled multinational companies as a proportion of total production and R&D in Sweden.

	1995	**2001**
Production	20.7%	33.9%
R&D	20.1%	40.3%

Source: ITPS 2005a.

3.3 The Decision to Offshore R&D

Archibugi & Michie (1995) separated the process of globalization of R&D into three different categories: (1) international exploitation of technology produced on a national basis; (2) global generation of innovations, i.e. the company carries out R&D and innovative activities both in home and the host countries (3) global technological collaborations in the form of joint, scientific projects. Each of these three categories might have a different impact on the economic and innovation performance of not only the individual company, but upon clusters of companies, regions or even countries. In addition, each of these types of globalization might have different implications for national economic or technology policies.

Vernon (1966) suggests that the main reason companies invest in foreign R&D activities is to exploit technological activities created within their home countries. More recent analysis (see Dunning & Narula 1995, among others) suggests that two other factors have become increasingly important: the need to monitor new technological developments, and the ability to generate entirely new technologies and products in foreign locations. Both of these have been attributed to increasing technological complexity and the resulting rise in R&D cost.

According to modern FDI literature, the internationalization of R&D by multinational companies stems from two different sets of motives. First, companies will invest in R&D affiliates abroad in order to exploit the affiliate's knowledge in the companies' home country, a process known variously in the literature as asset-exploiting R&D (Dunning & Narula 1995) or home-base exploiting activity (Kuemmerle 1996). Second, companies will augment their existing assets by acquiring technological spillovers from agglomeration effects in specific sectors, specific companies, public infrastructure or others in the host countries [see for example Criscuolo et al. (2005), Kuemmerle (1999), Cantwell & Janne (1999), Patel & Vega (1999)]. This practice is known variously as asset-seeking (Dunning & Narula 1995) or home-base augmenting (Kuemmerle 1996) R&D investment.

Many companies begin globalizing R&D by moving or acquiring R&D operations that are related to manufacturing or service production for the foreign local markets close to the customers. However, how do findings on the increasing globalization of R&D square with the consensus in the modern literature that an R&D facility's capacity to exploit and augment its technological competences is a function of the efficiency with which it can use complementary resources, in terms of formal and informal linkages, plus complex interdependencies between various factors in small local geographical areas?

The literature on proximity identifies two reasons for a company to locate R&D activities outside the home country: to access specialized knowledge, or to access new customers. First, in line with Dunning & Narula (1995), a company may locate R&D activity near places with specialized expertise, such as the ICT cluster in Kista outside Stockholm, which can encourage innovation that will benefit the entire company. This corresponds to a strategy where knowledge from several different and attractive R&D environments is combined into an asset for the entire organization.

Second, a company that relies on its home-base knowledge assets – the technology embedded in its internal network – may still need to adjust the attributes of its products (including services) to preferences in foreign markets, which will require R&D in those markets. While the term "offshore R&D" evokes a picture of a company establishing an independent R&D unit abroad, many companies choose to collaborate in a strategic partnership with existing foreign partners. In fact, since the 1970s, most international

R&D activities have been the result of strategic partnerships, also known as “strategic technology partnering” (STP) (Hagedoorn 2002). However, because information about STP is fragmented and ill-defined, available indicators of international STP have clear quality drawbacks. Despite the fragmented and uncertain nature of available STP information, recent literature agrees that international, inter-company alliances have become more frequent over the past two decades (Hagedoorn 2002).

There are clear reasons to believe that systematic technology cooperation has become an institutionalized form of strategic R&D among multinational companies. These collaborative activities started to grow rapidly during the 1980s, especially in the information and communication technology, biotechnology and composite materials sectors. By the early 1990s more than half of all alliances in Europe were based on agreements, including joint ventures, contract-based cooperation projects, and FDI-based collaboration using ownership as substitute for an explicit agreement.

Which are the motives behind strategic technology partnering? Why is this form of innovation network formation growing? The literature (see for example Hagedoorn 1993 and 2002) lists a variety of reasons such as:

- Companies in so-called high-tech industry sectors are forced into strategic R&D collaboration by high R&D costs, in combination with the increasing uncertainties associated with strategic projects.
- By joining forces with other companies, each individual company loses the opportunity to capture monopoly profits that may follow a successful innovation. In contrast, the cooperation brings about reduced risk. An alliance can guarantee that the individual company receives a flow of knowledge about technical solutions and markets – partly as a by-product, irrespective of whether particular R&D efforts are successful.
- Strategic partnering enables the participants to transfer technologies more efficiently. Moreover, partnering facilitates the exploitation of complementarities among participants with regards to experiences and knowledge.
- The partnering alliances can provide the participating company with knowledge about new markets and customer niches.
- Partnering with regard to R&D cooperation between several firms offers the participants additional benefits. It can shorten the development time, and hence speed the market introduction of novel products and services.
- Finally, in the course of cooperation between companies, each company will keep itself informed about technological opportunities that develop over time among its collaborators.

3.4 Empirical Evidence

The literature provides conflicting evidence on the relative importance of (1) asset-exploiting and (2) asset-seeking R&D activities in countries other than the company's home country and (3) strategic partnering, respectively.

Some survey information indicates that the second aspect above, asset-seeking R&D activities in foreign countries, may be growing in importance; see for example Pearce (1999), von Zedtwitz & Gassmann (2002) and ITPS (2005b). In a survey by the Swedish Institute for Growth Policy Studies (ITPS), 42 percent of Swedish-controlled multinational companies reported that an important reason for offshore R&D investments was to carry out demand-related adjustments of existing products and processes. See Figure 3-5. This type of adaptive innovation can also be considered a customization process (Kuemmerle 1999).

As Figure 3-5 also shows: 40 percent of Swedish-controlled multinational companies invested in offshore R&D related to production of goods; 23 percent wanted greater access to global research; and 16 percent wanted to be closer to other innovative companies.

Figure 3-5 Main objectives for Swedish multinational companies' R&D investments abroad.

Main Objective	**Share of the firms**
Adaptation of products and processes to customer demands	42%
Production-related R&D	40%
Access to global research	23%
Proximity to other innovative enterprises	16%

Note: A company can have more than one objective for offshore R&D investments.

Source: ITPS 2005b.

According to the ITPS survey, there are a number of structural reasons why Swedish multinational companies have offshore R&D. The primary reason is organic growth, which accounts for 55 percent of offshore R&D investments. Acquisition of other companies accounts for 32 percent. Only 13 percent of offshore R&D expenditures are related to direct investment in new or expanded R&D facilities ("greenfield investments"). See Figure 3-6.

Figure 3-6 Determinants for offshore R&D investments by Swedish multinational companies.

Main factor	**Proportion**
Organic growth	55%
Acquisition	32%
Greenfield investment	13%

Source: ITPS 2005b.

In their study based on the analysis of 220 of the most internationalized companies' technology patenting activities, Patel & Vega (1999) find that companies are most active outside their home countries in expanding technology areas where they have formed strategic alliances.

The Patel & Vega (1999) study shows that the vast majority (75 percent) of companies tend to locate technology abroad in core areas where they are strong at home. In a small minority of cases (10 percent), companies take areas of weakness abroad, to exploit technological advantages of the host country. The largest increases (especially for chemical and pharmaceutical companies) have occurred in technical fields where there are complementary strengths between domestic activity of a company and their host country. The results suggest that adapting products and processes to suit foreign markets, and providing technical support to offshore manufacturing facilities, remain major factors in offshore R&D investment. They are consistent with the observation that companies are increasingly engaging in small-scale activities to monitor and scan new technological developments in centers of excellence in foreign countries within areas of existing strength. Moreover, Patel and Vega find very little evidence to suggest that companies routinely go abroad to compensate for weaknesses at home.

Kuemmerle (1999) reports results from a survey of FDI in five different home countries. The survey identified 238 R&D sites, 156 of which were established abroad. His conclusion is that a majority of the offshore R&D investments (62 percent of the R&D facilities in the sample) are made to access unique resources and to capture externalities created by local institutions and companies.

Using patent citation data from the European Patent Office to quantify the relative importance of offshore R&D activity, Criscuolo et al. (2005) find that both foreign affiliates of European multinational companies in the U.S., and U.S. foreign affiliates in Europe rely extensively on home-region knowledge sources. Interestingly, these companies appear to exploit the host country's knowledge base as well.

Because of the continuous changing of technological leadership over time, and because products and processes often require multiple technological competences, Criscuolo et al. (2005), also suggest that most multinational companies undertake both adaptive and innovative R&D activities simultaneously.

3.5 Consequences for the National Economy

3.5.1 National Systems of Innovation

A vast body of the theoretical and empirical literature has convincingly shown that companies are more reluctant to expand or relocate their R&D operations abroad than to engage in other value adding activities, such as manufacturing, sales and marketing.

Investigating the reasons for this phenomenon, Freeman (1992), Ehrnberg & Jacobsson (1997), Narula (2002) and others suggest that the companies are embedded in various systems of innovation in their home countries, built on formal and informal networks among customers, suppliers, competitors, consultancies, universities, research institutes, government agencies and other funding organizations. Most likely, the cost of becoming familiar with – and integrating into – a new location may be prohibitive even when the host location is superior to the home.

Figure 3-7 Collaboration on innovation in Sweden. Share of companies conducting R&D and export.

	Foreign-controlled Companies	**Swedish-controlled Companies**	**Uni-national Companies**	**Non-affiliate Companies**
Scientific System of Innovation: Universities and Research institutes	32.4%	72.5%	19.2%	19.4%
Vertical System of Innovation: Customers and Suppliers	36.1%	82.3%	23.2%	25.7%
Horizontal System of Innovation: Competitors and Consultancies	26.3%	52.9%	17.3%	18.7%

Source: Johansson & Lööf 2005.

Figure 3-7 reveals considerable differences in "embeddedness" within various systems of innovation in Sweden. Based on data from the Community Innovation Survey, conducted in 2001, Johansson & Lööf (2005) find that foreign-controlled multinational companies in Sweden collaborate more intensively than non-affiliate (independent companies) and uni-national companies (belonging to a group with only domestic affiliates). More than 70 percent of Swedish multinational companies collaborate on innovation with the national scientific system of innovation (universities and research institutes). The corresponding figure for foreign-owned multinational companies in Sweden is about 30 percent. Among pure national companies engaged in innovation, only one in five companies collaborated with universities or research institutes. Considering vertical systems of innovation (customers and suppliers) along with horizontal systems of innovation (competitors or other companies in the same industry, and consultants), the study shows a similar pattern as for the scientific system of innovation.

3.5.2 Regional R&D Externalities

Investment in offshore R&D will naturally occur where opportunities for exploiting spillovers are highest (Coe & Helpman 1995). This implies seeking proximity to "technology leaders," and since companies tend to concentrate strategic R&D activities in their home location, this high level of competence is often reflected in the associated systems of innovation. Thus, asset-seeking activities are often associated with locations that exhibit some technological or comparative advantage (see Patel & Vega 1999, Le Bas & Sierra 2002).

It is worth noting that technology leaders are not always industry leaders. Companies – particularly in technology intensive sectors – increasingly need to have multiple competences (e.g. Granstrand 1998). Even where products are based on a single technology, the processes used to manufacture them often use several technologies. Furthermore, even within a given technology (and particularly in technology-intensive sectors), leadership can change rapidly. Criscuolo, et al. (2005) suggest that this is another reason companies may engage in both asset-exploiting and asset-augmenting activities simultaneously.

3.5.3 Aggolomeration and Urbanization Economies

From a bird's-eye view, cities are focal points for R&D-oriented FDI. When multinational companies invest in R&D activities abroad, they almost always do so in metropolitan regions. The conventional explanation for this pattern is that metropolitan regions provide greater choice of knowledge providers, customers and input suppliers.

In addition, the opportunities to sustain face-to-face interaction between dispersed R&D facilities are much greater if the different R&D nodes are placed in metropolitan regions, which offer superior infrastructure and interaction facilities.

This means that large urban regions across the globe increase their importance as places where multinational companies can benefit from intense interaction with specialized knowledge providers and research centers. The same places will also function as meeting places where multinational companies can exercise interface activities with important customers. In essence this means that the world map evolves into a set of "islands" where subsidiaries of multinational companies reside, while at the same time being combined into the internal networks of each multinational company.

3.6 Conclusions

The evidence regarding the trends, scope and strategies behind offshore R&D-investments is varied, and still limited. Some characteristics are fairly well documented: (1) large multinational companies play a dominant role in the innovation systems of their home countries; (2) the same enterprises own a large stock of advanced technologies in their home countries; (3) these companies have not internationalized their innovative activities in the same way as with their production activities; (4) the relatively lower degree of internationalization is explained by the complex nature of innovation and innovation systems as well as the embeddedness of R&D activities in the home environment; and (5) offshore R&D is mostly production-supportive and associated with international exploitation of technology produced on national basis (adaptive R&D).

An increasing number of studies, however, suggest that the process of innovation has become more globalized during the past two decades. Competitive advantage, especially in advanced technologies, no longer resides in any single cluster, region or country, but in many. This diffusion is the result of several overlapping factors:

- The increasing costs and complexity of technological development, which lead to a growing need to expand technology sourcing and interaction with different, geographically dispersed actors who bring complementary knowledge.
- The faster pace of innovation activities in a number of industries, which spur companies to search for application opportunities that are mainly location-specific.
- Existing innovation systems often have systematic and self-reinforcing lock-in characteristics, which change very gradually and constitute their technological specialization. In new and rapidly evolving industry sectors or areas, national innovation systems evolve more slowly, in general, than the technological needs of companies. As a result, companies may seek required technology abroad through offshore R&D investments (e.g. acquisitions, greenfield investments or strategic collaboration).

Current literature generally agrees that conditions in the home country are still important in the creation of global technological advantage even for the most internationalized companies; often their technological advantages primarily reflect those of innovation systems of the home country. Therefore it becomes important to improve our understanding of the reasons companies producing for the world market continue keeping proportionally larger parts of their R&D activities close to their home base.

New findings indicate that investment in offshore R&D has risen considerably over the last decades, and that companies invest in R&D in order to exploit or augment their existing knowledge base. Exploiting knowledge leads to R&D engagements that are close to existing production facilities and markets, while augmenting knowledge is more closely associated with establishments close to companies, clusters and universities that have a global technology leadership. It is important to keep in mind that this is a two-way phenomenon for the individual country.

In parallel with increasing offshore R&D-investments by the home-based multinational companies, the presence of R&D-intense foreign multinational companies in the home country increases rapidly, mainly through mergers and acquisitions.

From a policy perspective it is important to increase the understanding of how this ongoing globalization affects national innovation systems. An effect on the innovation system is positive if it improves conditions for industrial renewal, creates new areas of specialization or contributes to a country's economic growth. An effect is considered harmful if it renders the national innovation system less effective in stimulating renewal and growth.

Strategic R&D is a basic component of a company's long-term development. When the strategic parts of innovation activities remain in the home country, orchestration of the company's future and its assets remains there as well. If activities tend to drift abroad, a likely outcome is that the company as such gradually leaves its initial country of residence. In contrast, R&D spending abroad that aims at adjusting products and services to match customer demands and preferences in a foreign market does not imply that the control of knowledge assets are moving away from the home region of the company.

It is also necessary to identify and investigate those factors that have a strong influence on how "national" multinational companies allocate their R&D investments between the home county and abroad. Which are the factors that influence foreign multinational companies to locate their R&D activities to establishments in their home country?

In a similar way as for "national" multinational companies locating R&D abroad, we need to identify factors that are important for foreign multinational companies to engage in R&D in the host country. In this context it is important to understand which types of innovation activities that foreign multinational companies carry out inside in their home country instead of abroad.

Another important issue to investigate further is the effects of R&D globalization and the frequency of spin-offs from nationally-controlled and foreign-controlled multinational companies.

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4 The Internationalization of Swedish Corporate R&D

Philip Löf

4.1 Introduction

In a small, open economy such as Sweden's, companies depend on foreign markets for survival. Multinational companies play a pronounced role in the Swedish economy and account for 70 percent of the employment as well as over 90 percent of all corporate R&D expenditures. In an increasingly competitive and international economy, one of the most important policy issues is how to attract and retain R&D activities and R&D-intensive production that can bring added value to Sweden.

The main purpose of this chapter is to investigate what we know about the internationalization of Swedish R&D based on available data and studies. We address this by focusing on the following questions:

- What are the trends in outward and inward R&D investments in Sweden?
- Where do Swedish multinational companies perform R&D activities?

The study mainly draws on empirical studies covering Swedish multinational companies but also presents some new analysis of existing data.

In Section 4.2, related available data and Swedish empirical studies are discussed. Section 4.3 discusses the trend of Swedish R&D investments between 1990 and 2003. Section 4.4 describes the internationalization of the Swedish R&D. Section 4.5 discusses Swedish R&D investments over the last ten years, measured as R&D personnel within 20 Swedish multinational companies. In Section 4.6, conclusions are drawn.

4.2 Available Data

When discussing R&D data, it is important to separate data that cover R&D performance and data that cover R&D funding. Both data sets are usually collected via survey. R&D performance surveys are designed to reveal how much R&D is performed in different regions, while R&D funding surveys are designed to reveal how that R&D is paid for. Both data sources can be used as indicators of internationalization of R&D. R&D performance is usually measured by R&D expenditure or R&D personnel per region. R&D funding is usually measured by the amount of R&D money flowing between countries.

In Sweden there are mainly five data sets that researchers use when they want to study Swedish multinational companies[1] and their R&D investments. Most of the empirical studies concerning Swedish multinational companies are based on one of these data sets.

The first data set is collected by The Swedish Institute for Growth Policy Studies (ITPS) (ITPS 2005a). ITPS is officially responsible for statistics concerning multinational companies in Sweden. ITPS conducts surveys on R&D every other year. The surveys have been made by ITPS since 1995 and cover the 20 largest Swedish-owned multinational companies.[2] The surveys cover the R&D performance (R&D expenditure and R&D personnel[3]) and collect data on an enterprise group level. The surveys mainly focus on determining where the R&D is conducted. Surveyed companies accounted for about 30 percent of the total corporate R&D invested in Sweden in 2003. This data can be divided into R&D conducted in Sweden or R&D conducted in an affiliate abroad. One limitation of this data set is that the companies in the survey population change from year to year, due to ownership changes. In other words, if a company that previously was Swedish-owned becomes foreign, it is excluded from the survey and another Swedish-owned company replaces it.

A second data set is collected by Statistics Sweden (SCB). This survey has been conducted every second year from 1997 to 2003. In 2003 the survey included 1,963 companies, both Swedish-owned and foreign-owned[4] companies with affiliates in Sweden (SCB 2004). The survey collects performance data about the R&D performed in Sweden. It also collects data that cover payments made by companies in Sweden for R&D carried out abroad. The data concerning R&D funding abroad can be divided into funds sent to business units within the enterprise group, or funds that go outside of the enterprise group.

ITPS, together with SCB, also studies the R&D performance by all foreign-owned companies in Sweden (ITPS 2005a and 2004b). This survey is sent to all the foreign-owned companies and covers the R&D performance by the affiliates in Sweden. In 2003 the survey included about 300 foreign-owned companies in Sweden.

A fourth data set is collected by the Research Institute of Industrial Economics (IUI) (Hakkala & Zimmermann 2005). The survey is a follow-up of the surveys made by IUI since the 1970s. It includes all companies with manufacturing facilities in Sweden that have a minimum of 50 employees, and either control over one or several foreign subsidiaries *or* exports that account for at least 10 percent of their total sales. In 2003, the survey included 105 companies.

[1] Multinational companies are defined as companies with affiliates abroad, both Swedish- and foreign-owned.
[2] This data is used in the analysis in Section 4.5.
[3] R&D personnel is defined as R&D personnel person years.
[4] Foreign-owned companies are defined as entities in which a foreign majority has a controlling position (as in 50 percent or more of the total shareholders' vote) in a Swedish company.

A fifth data set is the European Community Innovation Survey (CIS 3) (Ebersberger & Lööf 2005). The survey is a European harmonized study which aims at studying the level of innovation in companies. The most recent data is from 2001. The data that is used discusses Nordic multinational companies and their investments in innovations and R&D, and covers about 3,400 companies. See Figure 4-1 for a summary of the recent empirical studies.

Figure 4-1 Empirical studies concerning the internationalization of Swedish R&D.

Study of Inward R&D	**Data Set**	**Main Findings**
Bandick & Hanson (2006)	Swedish manufacturing industry 1986–2000 Observations: 13,490 Data sources: ITPS and SCB	• No evidence that foreign-owned companies acquiring Swedish multinational companies (MNCs) have removed R&D activity from Sweden. • Swedish non-multinational[5] companies' R&D intensity[6] seem to increase in Sweden after a foreign acquisition. • The share of high-skilled workers increases when non-multinational Swedish companies become foreign-owned, but not when Swedish MNCs change ownership. • Technology sourcing is an important motive behind the acquisitions of Swedish MNCs.
Ebersberger & Lööf (2005)	Companies in the Nordic countries, 2001 Observations. 5,186 Data source: CIS3	• The probability of engaging in R&D and innovation activity does not differ between domestic-owned multinational companies and foreign-owned multinational companies. • In Sweden, the R&D intensity of Swedish-owned MNCs is significantly higher compared to all other types of companies. • Nordic-controlled MNCs were much more embedded in the four home-countries national innovation systems compared to Anglo-Saxon-owned or Continental European-owned companies.
ITPS (2004b)	Swedish manufacturing industry 1990–2000 Observations: 2,200, companies Data sources: ITPS and SCB	• Foreign-owned companies did not have a significantly lower R&D investment ratio in Sweden compared to the Swedish-owned manufacturing companies in the 1990s. • Multinational companies conducted more R&D in Sweden compared to non-multinational companies active in Sweden.

[5] Non-multinational companies are companies without affiliates outside of Sweden.
[6] R&D intensity can be defined in different ways, such as a country's total business R&D expenditure as a share of GDP, a company's R&D expenditure as share of sales or R&D personnel per 1000 employees. In this section it is defined as R&D expenditure as a share of sales.

Figure 4-1 *continued*.

Study of Outward R&D	**Data Set**	**Main Findings**
Hakkala & Zimmermann (2005)	Swedish-owned manufacturing companies with at least 50 employees that export or own foreign affiliates, 1970–2003. Data sources: SCB, ITPS and IUI	• The share of R&D conducted in Sweden by Swedish MNCs has decreased. • R&D expenditures of the largest Swedish MNCs during the late1990s took place, to large extent, outside of Sweden. • The geographical distribution of R&D expenditure in foreign affiliates has changed. Western Europe's share has decreased while that of North America has increased.
ITPS (2005a)	Covering the 20 largest Swedish-owned enterprise groups between 1995–2003 Observations: 20 enterprise groups Data source: ITPS	• R&D investments in Sweden are highly connected to the large manufacturing MNCs. • Swedish MNCs increased R&D investments both in Sweden and abroad between 1995 and 2003. • 45 percent of the R&D investments in Sweden in 2003 were invested by foreign-owned companies.
Ekholm & Hakkala (2003)	Country-level data covering the OECD Data sources: World Bank and OECD	• The amount of R&D based in Sweden is related to Sweden being the home country of many MNCs that operate in the high-tech sector. • These MNCs are conducting their R&D at home (in Sweden), but carrying out a substantial part of their actual production in the large OECD economies.
Norgren (1995)	Observations: 8 Swedish multinational companies	• R&D facilities that Swedish companies established abroad in the 1970s and 1980s were mostly related to adapting products and processes to foreign market demands.
Fors & Svensson (1994)	Swedish manufacturing industry, 1970–90 Data source: IUI	• An increased internationalization of corporate R&D occurred during the 1980s. There occurred a shift from directing foreign R&D solely to the adaptation of products and processes in the 1970s, toward more long-term and innovative R&D in the foreign affiliates in the 1980s.

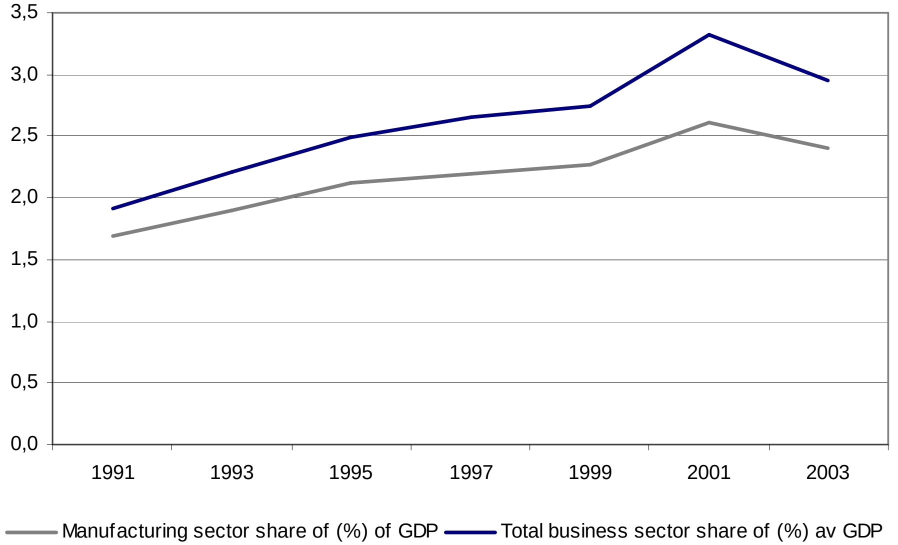
When studying the effects of internationalization, researchers often combine the data sets mentioned above with other data sources from SCB, such as financial account data or individual wage statistics. For example, the ITPS survey can be used to cover a company's foreign employment statistics or R&D invested abroad, and the financial account data from SCB can be used to cover the overall performance of companies in Sweden.

4.3 Trends in Swedish Corporate R&D

World R&D expenditures are geographically concentrated. Between 1996 and 2002, the ten countries with the greatest R&D expenditures accounted for about 88 percent of the world's total corporate R&D. Eight of them were developed countries; only two developing countries, China and the Republic of Korea, were among the top ten, (UNCTAD 2005). Sweden numbered eighth on the list in 2002, having spent 7.3 billion dollars on R&D (see Appendix Figure A-1).

In 2004, Sweden had the highest business R&D investment ratio (business R&D as share of GDP) within the OECD. The existence of a few, large multinational companies explains this high investment ratio. The six largest Swedish-owned manufacturing companies, in terms of R&D, accounted for almost 40 percent of all R&D expenditures in the business sector in 2003 (ITPS 2005a).

Figure 4-2 Swedish R&D expenditure as percent of GDP, 1991–2003.



Source: SCB 2004.

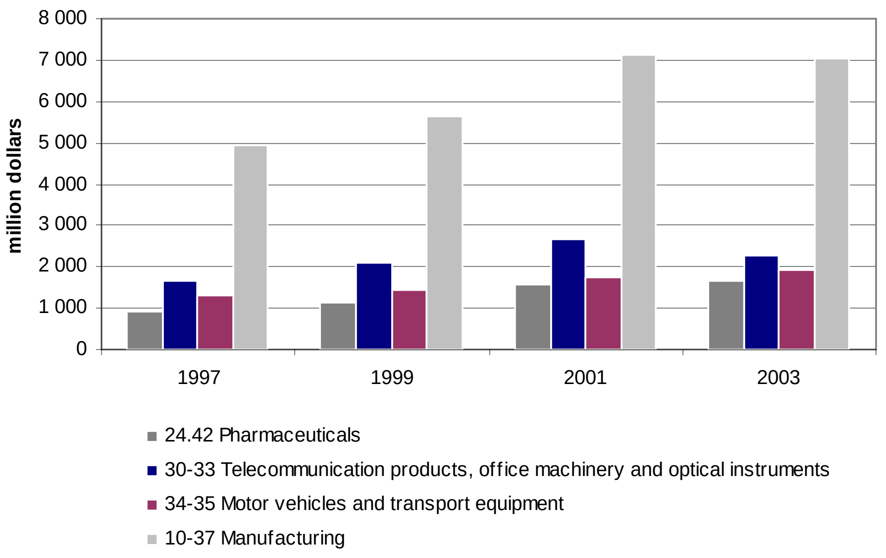
Business R&D expenditures in Sweden have increased since the early 1990s, with a peak in 2001. The manufacturing sector accounted for over 80 percent of total expenditures in 2003 (see Figure 4-2).

If we consider R&D performed by companies in Sweden at industry-sector[7] level, the investments are mainly in three sectors (SCB 2004):

- Telecommunication products, office machinery and optical instruments (25 percent of total business R&D)
- Motor vehicles and transport equipment (22 percent)
- Pharmaceuticals (18 percent)

Together these industry sectors represent almost 70 percent of total corporate R&D performed in 2003.

Figure 4-3 R&D expenditure in the manufacturing sector, 1997–2003.



Note: The industry sectors are defined according to the ISIC Rev. 3 standard.

Source: SCB 2004 and calculations performed for this study.

Companies in all three sectors (telecommunication products, office machinery and optical instruments; motor vehicles and transport equipment; and pharmaceuticals) have increased R&D investments in Sweden between 1997 and 2003 (see Figure 4-3). Pharmaceutical companies spent 80 percent more on R&D in 2003 compared to 1997 (not inflation-adjusted). R&D in the motor vehicle sector increased almost 50 percent and R&D performed in the telecommunications sector increased more than 30 percent.

[7] The industry sectors are defined according to the ISIC Rev. 3 standard.

The telecommunications sector is especially interesting, not only because the companies in this sector are the largest R&D performers, but also because the sector had a crisis in 2001 that forced companies to reduce costs, including R&D. Between 2001 and 2003, R&D expenditures in the Swedish telecommunications sector were reduced by about 15 percent. This reduction is also seen in the overall R&D expenditure pattern showed in Figure 4-2. The rise and fall of R&D expenditures between 1999 and 2003 can largely be attributed to the changes in R&D investments by the telecommunications company Ericsson. This demonstrates the magnitude of impact a single multinational company has upon overall R&D activity in Sweden.

4.4 The Internationalization of Swedish Corporate R&D

In this section, R&D is considered "international" if it represents either:

- Inward R&D investments. Foreign-owned companies performing R&D in Sweden.
- Outward R&D investments. Swedish-owned multinational companies performing R&D outside of Sweden.

Foreign-owned R&D increased dramatically during the late 1990s due to ownership changes. Many large, Swedish-owned multinational companies (including their R&D facilities) were acquired by foreign companies from Europe and the U.S. during this period. This is the main reason foreign-owned R&D expenditures (inward) increased by almost 60 percent between 1999 and 2003 (see Figure 4-4).

Figure 4-4 R&D expenditures by Swedish multinational companies abroad and by foreign-owned companies in Sweden,1999 and 2003.

	Inward (million dollars)		**Outward (million dollars)**	
R&D expenditure	**1999**	**2003**	**1999**	**2003**
EU-15[8] excl. Nordic countries	1,400	2,100	900	1,200
United States	800	1,400	700	700
Nordic countries	100	200	200	200
Rest of the world	300	400	500	700
Total	**2,600**	**4,100**	**2,400**	**2,600**

Note: Outward refers to 20 Swedish-controlled enterprise groups' R&D expenditure abroad. Inward refers to foreign-controlled companies' R&D expenditure in Sweden.

Source: ITPS 2005a and calculations performed for this study.

[8] The EU-15 countries are: Austria, Belgium, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom, Denmark, Finland and Sweden.

In year 2003, U.S. multinational companies spent 1.4 billion dollars on R&D performed in Sweden. U.S.-owned multinational companies accounted for about 16 percent of the total R&D performed in Sweden. European-owned (excluding the Nordic countries) accounted for about 24 percent, while multinational companies owned by a parent company from a Nordic country accounted for about 3 percent of the expenditure.

The 20 largest, Swedish-owned manufacturing companies spent about 2.6 billion dollars outside of Sweden in 2003. Swedish-owned companies spent 1.4 billion dollars related to R&D in the EU-15 and 0.7 billion dollars in the U.S. in 2003.

When interpreting these figures for inward and outward R&D performance, it is important to remember that change in ownership is the most common impetus for R&D investment to change origin. It is very seldom that a multinational company actually moves its R&D activities to a new region.

4.4.1 Foreign-Owned Companies Performing R&D in Sweden

This section first discusses the recent empirical literature concerning inward R&D performance and then reviews inward R&D performance trends.

Studies Concerning Inward R&D

Bandick & Hanson (2006) examined whether advanced production and R&D tend to increase or move out of Sweden when Swedish companies become foreign-owned. They used ITPS data on total employment abroad and combined that data with financial account data from SCB, covering R&D expenditure in Sweden. They found no evidence that foreign-owned companies acquiring Swedish multinational companies removed R&D activity from Sweden. They found that the share of high-skilled workers seemed to increase when non-multinational[9] Swedish companies become foreign-owned, but not when Swedish multinational companies change ownership. This suggests that technology sourcing is an important motive behind the acquisitions of Swedish multinational companies.

Ebersberger & Lööf (2005) studied the innovation behavior and productivity performance of foreign-owned companies in the Nordic region. They used the internationally harmonized Community Innovation Survey III (CIS3) data to study whether foreign-owned companies differ systematically from domestic companies. The companies they studied were divided into six groups:

- Domestic-owned[10] multinational companies
- Nordic-owned[11] multinational companies

[9] Non-multinational companies are defined as companies without affiliates abroad.
[10] Domestic-owned companies are defined as companies with the majority ownership in some of the Nordic countries.

- Anglo-Saxon-owned multinational companies
- Continental European-owned multinational companies
- Other multinational companies
- Non-multinational companies.

Three types of possible differences were investigated between the six groups. The first difference considered R&D and innovation behavior, the second difference explored innovation output, and the third difference was labor productivity.

The results concerning R&D, innovation behavior and innovation output were:

1) The probability of engaging in R&D and innovation activity does not differ between the domestic-owned multinational companies and foreign-owned[12] multinational companies.

2) In Sweden, the R&D intensity of domestic-owned multinational companies is significantly higher compared to all other types of companies.

3) Domestic-owned multinational companies are much more embedded in their home countries' national innovation systems compared to Anglo-Saxon and continental European companies.

ITPS studied the implications of increasing foreign ownership on R&D investments in Sweden during the 1990s (ITPS 2004b). This study showed that foreign-owned manufacturing companies, controlling for other company characteristics, did not have a significantly lower R&D intensity in Sweden, compared to Swedish-owned manufacturing companies. The study also showed that multinational companies in Sweden (both Swedish-owned companies with affiliates abroad and foreign-owned companies in Sweden), had significantly higher R&D intensity compared to the companies without affiliates abroad (non-multinational companies). ITPS also suggested that some positive spillover occurred between foreign-owned multinational companies and Swedish non-multinational companies. The results were based on ITPS and SCB data covering the Swedish manufacturing industry from 1990–2000.

In a Nordic project called the Nordic FOTON-project (Nordic Innovation Centre 2005) there were two case studies about drivers behind foreign companies acquiring Nordic companies. Conducted in the pharmaceutical industry and in the software/ICT industry, the case studies determined that there are three important factors behind foreign companies buying Swedish companies:

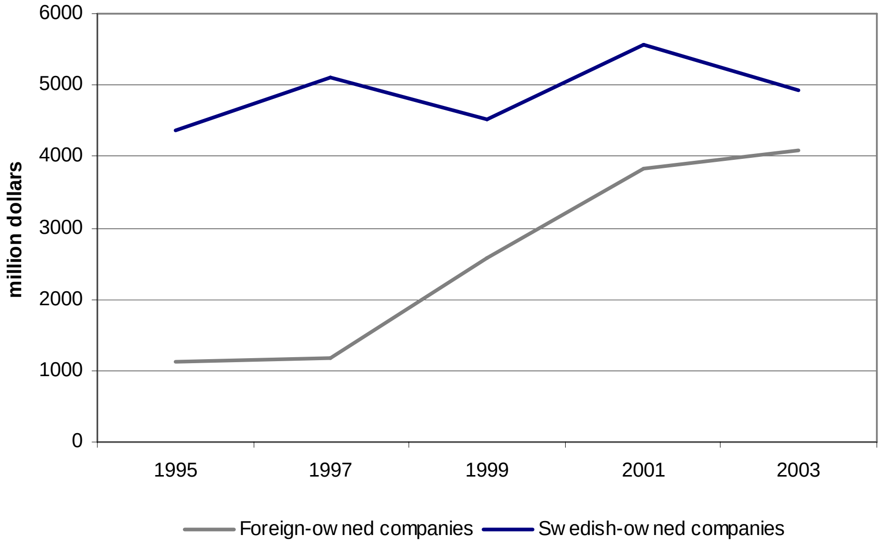
[11] Nordic-owned companies are foreign-owned companies with the majority ownership in a Nordic country but outside of the home country.
[12] All groups except non-multinational and domestic-owned multinationals are foreign-owned companies.

- Access to technology and competencies
- Access to new markets
- Access to new and complimentary products, platforms or production lines

Trends in Inward R&D

To understand the trend behind the inward internationalization of Swedish R&D, we have to start with the rapid increase in mergers and acquisitions (M&A) that took place during the second half of the 1990s, peaking in 2000 (UNCTAD 2005). In the late 1990s, a worldwide boom in mergers occurred that had dramatic effect on Sweden. The rapid increase in M&A has resulted in an exceptionally high level of foreign ownership in Sweden. As a result, foreign-owned R&D has increased rapidly.

Figure 4-5 R&D expenditure in foreign- and Swedish-owned companies.



Source: ITPS 2005a.

About 45 percent of R&D expenditures in 2003 were performed by foreign-owned companies in Sweden. This share has increased from about 10 percent in 1995 (see Figure 4-5). ITPS has studied the R&D activities in Sweden of eight foreign-owned, former Swedish-owned multinational companies (ITPS 2005a)[13].

[13] The multinational companies studied were: AstraZeneca, ABB, Volvo Personvagnar, AGA, Pharmacia, Stora Enso, BT Industries and Svedala Industri (Metso).

The main objectives behind performing R&D in Sweden were:

- R&D related to production in Sweden
- Access to research networks such as universities and research institutes in Sweden

Both of these answers are supported by the theories concerning internationalization of R&D (also see Chapter 3).

When the companies discussed above became foreign-owned, the majority were Swedish multinational companies who merged with, or were acquired by, other large multinational companies during the 1990s. The Swedish R&D activity is surely only one of many driving factors behind these ownership changes. There is not one simple answer to how the increase in foreign ownership will affect future R&D investments in Sweden. Research studies show that the increase in foreign ownership did not lead to a decrease in total corporate R&D expenditures in Sweden during the 1990s (see ITPS 2004b and Bandick & Hanson 2006), but we don't know how this will affect the R&D performed in Sweden in the future.

4.4.2 Swedish-Owned Multinational Companies Performing R&D Outside of Sweden

This section discusses the recent empirical literature concerning outward R&D performance and presents some outward R&D performance trends.

Studies Concerning Outward R&D

In 2005, ITPS presented a survey concerning the internationalization of R&D (ITPS 2005a). The study showed that the R&D investments in Sweden were highly connected to a few, large multinational manufacturing companies. The results from the survey also showed that the Swedish-owned multinational companies increased R&D investments both in Sweden and abroad during the late 1990s and early 2000.

IUI recently published a paper that documented another survey that was conducted on Swedish multinational companies in 2005 (Hakkala & Zimmermann 2005). The survey was a follow-up to surveys made by IUI since the 1970s, (Fors & Svensson 1994). The paper described the foreign direct investment trends of Swedish multinational companies in general, including R&D activities. The result of the survey suggested that the share of R&D conducted in Sweden by these companies declined during the late 1990s. In 2003, only about 60 percent of their R&D was invested in Sweden, a considerable drop from the 1990s investment levels of between 74 and 87 percent. The study also concluded that to large extent, the expansion of R&D expenditures of Swedish multinational companies during the late 1990s occurred outside of Sweden. IUI also found that the geographical distribution of R&D expenditures in foreign affiliates has changed. The share of R&D performed in Western Europe has decreased while that in North American has increased.

Ekholm & Hakkala (2003) published a paper concerning localization of R&D. They used a two-country, two-factor and two-good model to analyze location choices made by companies operating in the high-tech industry. Their result suggests that the high R&D intensity in Sweden correlates to the fact that Sweden is the home of many multinational companies operating in the high-tech sector. These multinational companies are conducting R&D at home, but conducting a substantial amount of their actual production in the large OECD economies.

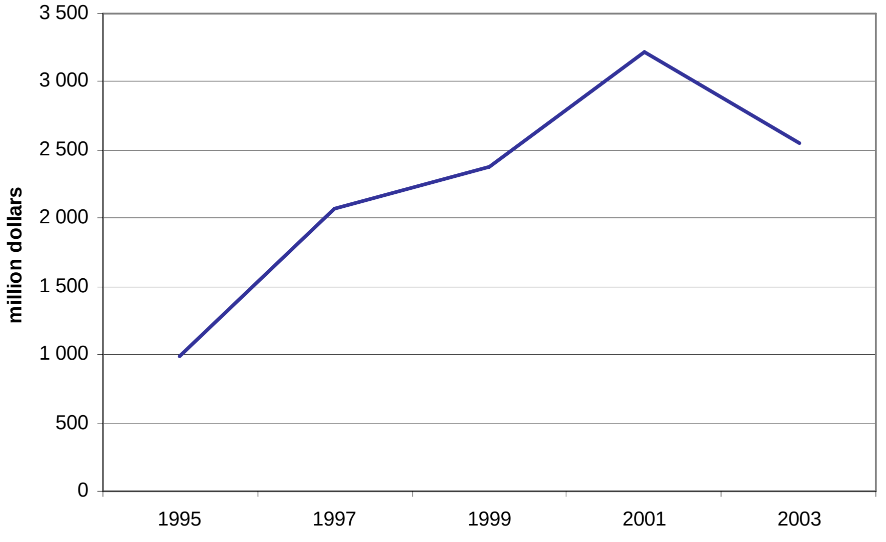
Norgren discussed the R&D activities of the Swedish manufacturing industries during the 1970s and 1980s (Norgren 1995). The paper showed that the R&D facilities established abroad by Swedish companies were mostly involved with adapting products and processes to foreign markets' demands. Another factor behind the internationalization of R&D in that time period was the outsourcing of component manufacturing, for example in the automotive industry, to foreign suppliers. This narrowed the base for R&D activities during the 1980s but did not lower the total R&D volume in Sweden, according to Norgren.

Fors & Svensson showed, using IUI data, that an increased internationalization of corporate R&D had occurred during the 1980s (Fors & Svensson 1994). The study also suggested a shift from directing foreign R&D solely to the adaptation of products and processes in the 1970s, toward more long-term and innovative R&D in the foreign affiliates in the 1980s.

Trends in Outward R&D

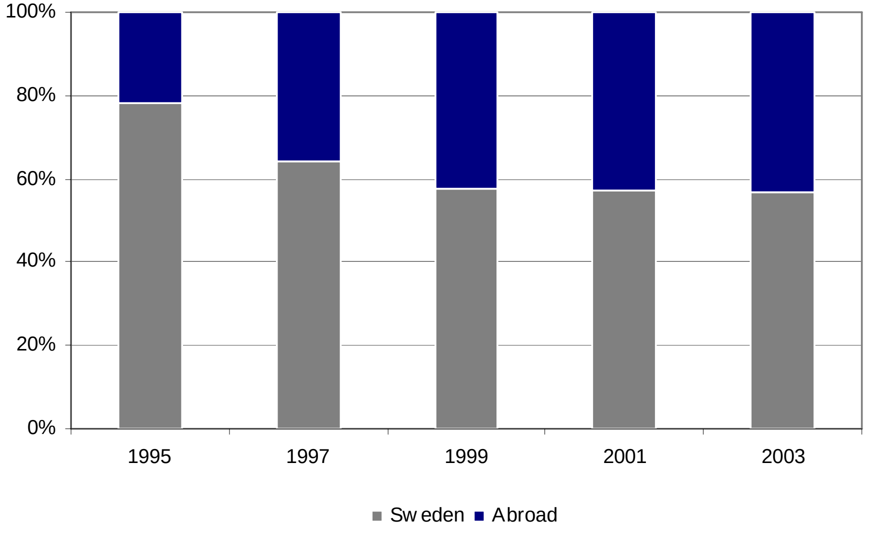
The 20 largest Swedish-owned enterprise groups have increased R&D investments abroad since the mid–1990s (see Figure 4-6). In 2003 the total R&D expenditure abroad was 2.6 billion dollars. Between 1995 and 2003 the Swedish-owned multinational companies increased R&D performed abroad from 20 percent to 40 percent of their total R&D expenditure (see Figure 4-7).

Figure 4-6 R&D expenditure by Swedish-owned multinational companies abroad.



Source: ITPS 2005a and calculations performed for this study.

Figure 4-7 Share of R&D performed in Sweden and abroad.



Source: ITPS 2005a and calculations performed for this study.

According to a study by ITPS, the main objective for Swedish-owned multinational companies to perform R&D abroad is to adapt products to specific customer demands (ITPS 2005a, also see Chapter 3). In the survey, 80 percent of the companies answered either that "adaptation of products and processes to customer demands" or "production related R&D" were the main drivers behind R&D-investments abroad in 2003.

The Research Institute of Industrial Economics has also surveyed Swedish multinational companies (Hakkala & Zimmermann 2005). Their results are similar to the findings by ITPS showing that the share of R&D conducted abroad has increased. The share of R&D conducted outside of Sweden has increased from between 15–25 percent in the 1990s to almost 40 percent in 2003.

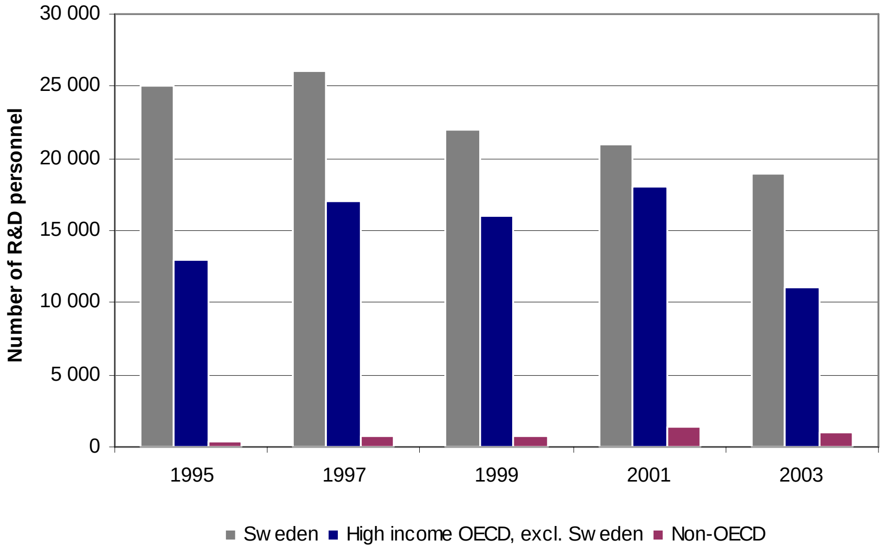
Data from Statistics Sweden (SCB) also suggests an increased share of foreign R&D (SCB 2004). If we examine R&D abroad that is funded by companies in Sweden, we find an increasing amount of R&D payments being spent abroad. About 1.5 billion dollars was used to fund R&D labs abroad in 2003. Behind the increased R&D funding abroad is the different investment pattern employed by the multinational companies in the Swedish telecommunications products sector.

4.5 Where Do Swedish Multinational Companies Employ R&D Personnel?

This section is based on data collected by ITPS covering Swedish-owned multinational companies (ITPS 2005a). ITPS collected the employment data and R&D personnel[14] data of 20 Swedish-owned enterprise groups from 1995 to 2003. In 2003, these groups accounted for almost 40 percent of the total corporate R&D expenditure in Sweden. The data can be divided into the three sub-regions: 1) Sweden, 2) high income OECD countries[15] (except Sweden) and 3) non-OECD countries.

[14] R&D personnel are defined as R&D person years.
[15] In this chapter, "High income OECD" is defined according to the definition used by the World Bank, which includes 24 countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Iceland, Italy, Japan, South Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, (Sweden), Switzerland, the United Kingdom and the United States. Non-OECD is defined as the rest of the world.

Figure 4-8 R&D personnel in Sweden, high-income OECD and non-OECD, 1995–2003.



Note: The 20 largest Swedish-controlled multinational companies.

Source: ITPS 2005a and calculations performed for this study.

Most of the R&D personnel within the Swedish-owned multinational companies are employed in Sweden (see Figure 4-8). The R&D personnel in Sweden have declined from 25,000 in 1997 to 19,000 in 2003. One reason for this is that many Swedish multinational companies became foreign-owned in the late 1990s and simply were excluded from the population. You can, however, also see a decrease in R&D personnel in Sweden that correlates to changes in ownership.[16]

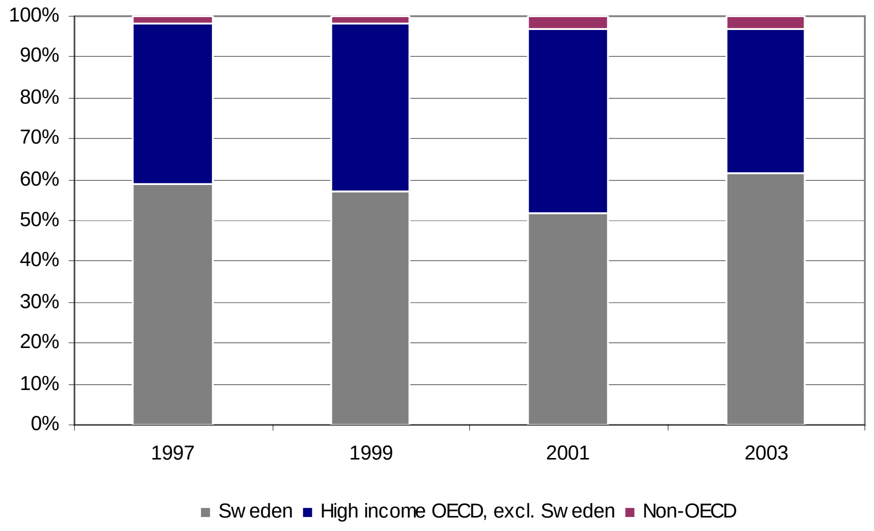
Within the high income OECD, the number of people working with R&D has decreased from 13,000 to 11,000 during the same period. The only region that has increased its volume of R&D personnel is the non-OECD region. The R&D personnel employed in non-OECD countries have increased from about 400 to 1,000 between 1995 and 2003.

Figure 4-9 shows the percentage of R&D personnel divided by the three regions. The majority of the R&D personnel of Swedish multinational companies are employed within the high income OECD, 62 percent in Sweden and 35 percent in the rest of high income OECD.

[16] Appendix Figure A-3 shows the time series without the ownership changes.

Non-OECD countries only employed about 3 percent of these companies' total R&D personnel in 2003. This share increased between 1997 and 2003 but is still very small[17].

Figure 4-9 Distribution of R&D personnel between Sweden, high-income OECD and non-OECD, 1997–2003.



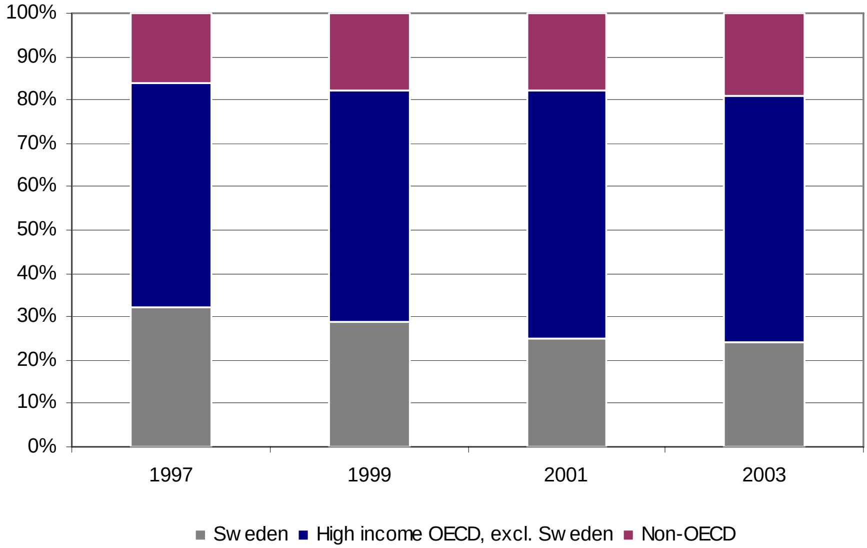
Note: The 20 largest Swedish-controlled multinational companies.

Source: ITPS 2005a and calculations performed for this study.

Figure 4-10 shows the total employment distribution among the regions used in Figure 4-9. About 75 percent of the total employment occurred abroad in 2003. This is much higher than the percentage of R&D personnel abroad. In 2003, the high-income OECD region employed about 55 percent of the Swedish multinational companies' personnel and non-OECD countries employed about 20 percent.

[17] These figures do not include outsourced R&D activities. There could be a difference in the level of outsourced R&D activities between high-income OECD and non-OECD countries that may result in underestimating the share of R&D activities in non-OECD countries.

Figure 4-10 Distribution of employment between Sweden, high-income OECD and non-OECD, 1997–2003.



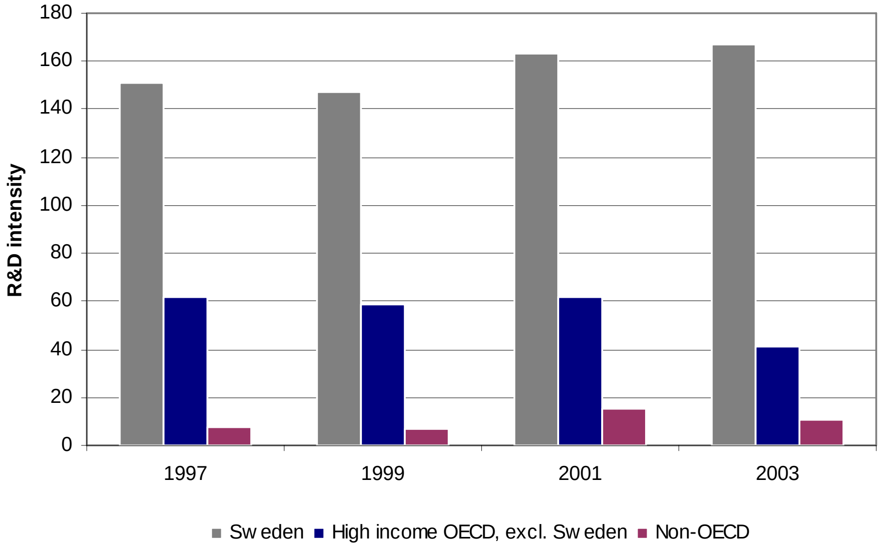
Note: The 20 largest Swedish-controlled multinational companies.

Source: ITPS 2005a and calculations performed for this study.

One interpretation of Figures 4-9 and 4-10 is that the Swedish-owned multinational companies have not internationalized R&D activities to the same extent as production and other business activities (approximated by total employment). Over 60 percent of the companies' R&D personnel were employed in Sweden, while only 25 percent of their total number of personnel were employed in Sweden in 2003. This suggests that the Swedish multinational companies' R&D is less internationalized compared to their production and other business activities.

It is also interesting to note that the total employment share in Sweden dropped while the share of R&D personnel is more stable between 1997 and 2003. This suggests that the internationalization process for R&D activity is much slower than the internationalization process of production. This aligns with the theory that R&D activities are to some extent embedded in the company's home environment. Research literature suggests that corporate R&D is connected to the home innovation system and to some extent "sticky" (see Chapter 3). The data in Figures 4-9 and 4-10 show that this seems to be true for Sweden as well.

Figure 4-11 Number of R&D personnel per 1000 employees in Sweden, high income OECD and non-OECD, 1997–2003.



Note: The 20 largest Swedish-controlled multinational companies. The R&D intensity is, in Figure 4-11, defined as the Swedish-owned multinational companies R&D personnel divided by the Swedish multinational companies' total employment in that region.

Source: ITPS 2005a, 2005b and calculations performed for this study.

The average R&D intensity[18] is about three times higher in Sweden than the average intensity of affiliate companies in high-income OECD countries; it is about 10 times higher in Sweden than that of affiliates in non-OECD countries (see Figure 4-11). This supports the implication suggested by Ekholm & Hakkala (2003) that Swedish multinational companies perform research in Sweden but produce products in the large OECD countries.

4.6 Conclusions and Forward Looking Perspective

The internationalization of R&D is often discussed in Swedish public debate but rarely expressed in figures. What can the data tell us about this phenomenon? The main purpose of this chapter is to investigate the recent trends concerning the internationalization of Swedish corporate R&D. The study mainly draws upon empirical studies of Swedish multinational companies but also presents new analysis of existing data.

[18] The average R&D intensity is calculated by dividing R&D personnel by total employment within the region.

4.6.1 Conclusions

Sweden has one of the highest corporate R&D intensities in the world. Sweden's business R&D expenditure as percent of GDP increased from under 2 percent in 1991 to almost 3 percent in 2003. A few large multinational companies account for almost all R&D performed in Sweden. These companies mainly exist in three sectors: the telecommunication products sector, motor vehicles sector and the pharmaceuticals sector.

For the purposes of this study, R&D is considered "international" under two circumstances: 1) R&D performed by Swedish-owned multinational companies outside of Sweden and 2) R&D performed by foreign-owned companies in Sweden.

R&D investments by Swedish multinational companies have increased both in Sweden and abroad during the 1990s and early 2000. At the same time there has been an increase in the share of R&D performed outside of Sweden. The 20 largest Swedish-owned enterprise groups increased their R&D performed abroad from 20 percent to 40 percent of their total R&D expenditure between 1995 and 2003. All data sources show an increase in R&D performed outside Sweden by Swedish multinational companies.

The 20 largest Swedish enterprise groups employed almost all the R&D personnel in the high-income OECD countries. 60 percent of these R&D personnel were employed in Sweden and over 30 percent in other high-income OECD countries. The non-OECD countries still (in 2003) only employed about 3 percent of the total R&D personnel. Swedish multinational companies in Sweden are also more R&D intensive (measured as R&D personnel per 1000 employees), compared to their affiliates in both high income OECD and non-OECD countries. These companies have internationalized production to a higher degree than R&D activity.

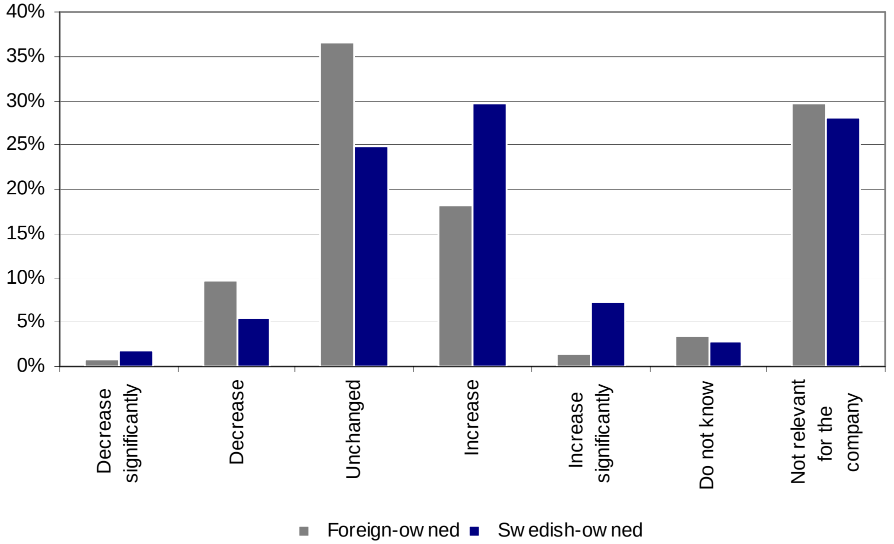
About 45 percent of corporate R&D in Sweden was performed by foreign-owned companies in 2003. This share has increased from 20 percent in 1997. The increase is explained by change in ownership; a few large, Swedish-owned, multinational companies were bought by foreign companies during the late 1990s. There is no evidence that foreign-owned companies acquiring Swedish multinational companies moved R&D activities from Sweden during the 1990s.

4.6.2 Forward Looking Perspective

R&D investments are becoming more international. Swedish multinational companies perform a high degree of R&D abroad and Sweden has an exceptionally high degree of foreign-owned R&D. Because the overall R&D performance in Sweden is very dependent on a small number of large, multinational companies, Sweden is vulnerable to the effects of globalization. If in the next 10 to 15 years Sweden cannot be an attractive host for the R&D investments of these large multinational companies, Sweden's overall R&D intensity will be dramatically reduced.

In 2004 ITPS surveyed 300 Swedish-owned and foreign-owned companies (representing 263,000 employees) in Sweden, about their R&D investment plans (see Figure 4-12) (ITPS 2004c). A majority in both groups planned to increase R&D investments in Sweden during the next five years. However, one interesting difference can be seen between survey response categories "increase the R&D investments" and "increase significantly." In these categories combined, 37 percent of the Swedish-owned companies said they were going to increase or significantly increase R&D investments over the next five years but only 20 percent of the foreign-owned stated the same.

Figure 4-12 Future R&D investments in Sweden.



Source: ITPS 2004c and calculations performed for this study.

Despite the many difficulties associated with interpreting business climate surveys, the results in the ITPS study could be an early warning. The future of R&D performed by foreign-owned companies in Sweden must be further studied.

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Appendix

Figure A-1 The ten leading economies in business R&D spending, 1996 and 2002.

Economy	1996 (billion dollars)	2002 (billion dollars)
World	376.3	449.8
United States	142.4	194.4
Japan	92.5	92.3
Germany	34.6	34.8
France	21.8	20.6
United Kingdom	14.5	19.6
Korea, Republic of	9.9	10.4
China	..	9.5
Canada	5.9	7.9
Sweden	6.6	7.3
Italy	6.7	6.6
Total	334.7	403.4
Share in the world	88.9	89.7

Source: UNCTAD 2005.

Figure A-2 Distribution of R&D personnel in Sweden, high-income OECD and non-OECD, 1997–2003, percent balanced.

	Sweden	High income OECD	Non-OECD
1997	61%	38%	2%
1999	56%	45%	2%
2001	53%	43%	4%
2003	63%	33%	3%

Note: The population used in Figure A-2 is 10 Swedish-controlled multinational companies.

Source: ITPS 2005a and calculations performed for this study.

Figure A-3 R&D personnel in Sweden, high-income OECD and non-OECD, 1997–2003, balanced.

	Sweden	High income OECD	Non-OECD
1997	21,000	13,000	600
1999	20,000	15,000	700
2001	21,000	17,000	1,400
2003	19,000	10,000	1,000

Note: The population used in Figure A-3 is 10 Swedish-controlled multinational companies.

Source: ITPS 2005a and calculations performed for this study.

Figure A-4 Distribution of employment in Sweden, high-income OECD and non-OECD, 1997–2003, percent balanced.

	Sweden	High income OECD	Non-OECD
1997	33%	50%	17%
1999	30%	52%	18%
2001	29%	53%	19%
2003	28%	55%	18%

Note: The population used in Figure A-4 is 10 Swedish-controlled multinational companies.

Source: ITPS 2005b and calculations performed for this study.

5 Swedish ICT Competitiveness and the Globalization of R&D

Göran Marklund

5.1 Introduction

National economic competitiveness is the foundation of economic growth and thus the material basis of national welfare developments. In accordance with the World Economic Forum, it is here defined as: "The ability of a country to achieve sustained high rates of growth in GDP per capita" (WEF 1996, p. 19).

GDP per capita is based on the economic value generating capacity of different industries. The contributions of different industries to GDP are basically measured in terms of value added.

In addition to value added, industrial contribution to national economic wealth, particularly in the long-term, is strongly connected to the job-creation impacts of production. Employment growth and its sustainability are key to the long-term growth of household consumption, tax payments and competence developments.

Technological capabilities are critical for long-term economic competitiveness, and are therefore essential sources of national wealth, employment and welfare. In recent decades, the accelerating globalization has generated fundamental changes in business models and innovation systems. Research and development (R&D) and other innovation-related investments have increasingly become geographically mobile. As a consequence, these processes have rapidly and fundamentally changed the opportunities and challenges for national technological capabilities. The benefits of innovation investments, in terms of economic value and employment, have become less tied to national borders. In addition, the decision to geographically co-locate technological and production activities has become less self-evident.

Globalization changes the playing field and rules-of-the-game for a country's generation of technological and business capabilities, as well as for the recouping of economic and technological benefits. Depending on the dynamics of different economic and innovation systems, these global changes generate important challenges and opportunities for countries.

The technological and industrial history of Information and Communication Technologies (ICT) represents one of the most significant chapters in the transformation of industries and societies in modern times. It is therefore adequate to refer to this transformation as the ICT revolution. This has taken place on several societal levels, and has been as much a technological and economic revolution as a social revolution.

The purpose of this study is to contribute to the discussion of Swedish ICT policy challenges generated by the most recent wave of globalization, starting around 1980. We will compare the development of Swedish technological performance in the ICT industrial system with that of other countries. By relating this to major features of globalization and the key dynamics of the Swedish ICT industry competitiveness, we will identify critical policy challenges for Sweden.

The ICT industrial system[1] should be broadly understood as all companies and other organizations that are directly or indirectly contributing to value generation related to goods and services, with the primary functions of receiving, transmitting or processing information. This covers three general ICT production categories[2]: 1) ICT Manufacturing Production[3], 2) ICT Service Production[4] and 3) ICT Trade Services[5]. However, in this study we will take a more limited focus on the ICT system, by focusing exclusively on technological investments and outcomes related to business-sector research and development (R&D). Our study will primarily address activities and processes of direct relevance for ICT industry manufacturing.

Because the focus of our study is relatively narrow, we will not be able to address all, or even most, of the important issues related to ICT industry competitiveness. However, the study rests on the assumption that this limited focus will contribute to our general purpose for three reasons. First, R&D investments and outcomes play key roles in the overall technological performance of industrial systems. Second, Swedish ICT competitiveness, technological and economic, has to a high extent been based on large industrial R&D investments. Third, the R&D-related technological dynamics and performance of companies and countries would be of critical importance for the overall innovation and economic performance of the entire ICT industrial system, as defined above.

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[1] We use the concept industrial system to denote the horizontal and vertical networks of all agents that add features to goods and services that are of importance for their value. The concept is close to clusters and value networks, but considerably broader than industries and value chains.

[2] Following the OECD definition established in 1998, which is based on the international industrial classifications ISIC and NACE.

[3] ISIC 3001, 3002, 3130, 3210, 3220, 3230, 3320, 3330, which represent the following industries: Computers, Office Machinery and Information Processing Equipment, Electronic Components, Electrical Wires and Cables, Telephones and Telephone Equipment, Radio and TV, Instruments for Control and Measurement.

[4] ISIC 6420, 7210, 7220, 7230, 7240, 7250, 7260, which represent the following industries: Telecommunication, ICT Hardware Consultancy, Software Production, Software and Systems Consultancy, Data Processing and Database Activities, Maintenance and Repair of Computing and Office Machinery, Other ICT Consultancy.

[5] ISIC 5143, 5164, 5165, 7133, which represent the following industries: Wholesale Trade with: a) Household Radio and TV apparatus, b) Office Machinery and Equipment, c) other Machinery for Industry, Trade and Shipment, Renting with Office Machinery and Equipment.

5.2 Economic Developments

As the global economic importance of ICT has risen rapidly in recent decades, so has the importance of ICT industrial competitiveness as a source of economic growth. The evolution of ICT applications and the ICT industry has continuously opened new and transformed old sources of economic value and growth. In turn, these developments have continuously changed the opportunities and conditions for national competitiveness in ICT production. In this section we will describe global and Swedish patterns of economic growth within the ICT manufacturing industry between 1980 and 2005.

5.2.1 Global Patterns

The ICT industrial system has for several decades been growing rapidly, globally as well as in Sweden. Moreover, as the use of ICT has played a revolutionary role in transforming virtually all other industries and sectors of society, it has become central to value generation in national economic systems. Therefore, ICT technologies, production and use are generally viewed as key drivers of economic growth.

Global demand for ICT goods has experienced exceptional growth during recent decades. A clear indication is that growth rates in ICT trade outpace that of total trade. ICT is also a central driving force in economic globalization (OECD 2004, p. 66) – global demand for ICT services has increased rapidly in recent decades. In fact, the growth rates of the global markets for ICT services have increased more rapidly than those of ICT goods, although the growth of ICT service markets started to accelerate later in the period 1980–2005.

As a consequence, industrial and technological policies of many countries have heightened emphasis on developing national ICT competitiveness. And, for countries with a highly competitive ICT manufacturing industry, the rapidly growing world market for ICT goods has opened new export opportunities.

Markets for ICT goods and services are highly interrelated and interdependent, since they are generally and increasingly intertwined at the stages of consumption and use. The connections between ICT goods and services generate technological and economic opportunities as well as challenges within the global and national ICT industries. Therefore, the evolution of specific, national characteristics and dynamics of national and international user-producer relationships – or more generally between supply-and-demand structures – are important factors contributing to the development of national industrial competitiveness. The history of ICT production clearly illustrates the critical, mutually reinforcing roles of market developments and technological investments in generating ICT industry competitiveness.

As a consequence of globalization, competitive industries and nations may expect increasing value generation from investments in ICT technology and production. However, international competition in the industry is rapidly increasing; the numbers of companies and nations entering ICT are experiencing rapid growth driven by the promising prospects for value generation. Therefore, the challenges to staying competitive are also mounting, as well as changing considerably in character.

The strong development of the ICT industry in China and India has already increasingly changed the competitive balance within the global ICT industry, as described in other chapters of this report. This development follows the successful ICT development by other Asian countries, such as Japan, Korea, Taiwan and Singapore. As with their Asian forerunners, China's and India's recent ICT growth has been fuelled by huge public investments and clear policy targeting technological development. As a consequence, and as noted elsewhere in other chapters this report, the sheer volume of ICT-related competence in Asia has already surpassed that of the U.S. and Europe. Moreover, because China and India are still developing countries, the relative costs of using these technological resources are still considerably lower than in the developed countries.

The combination of the relative size and acceleration of market growth with the availability of competitive technological resources strongly influences the localization patterns in the ICT industry. In this respect Asian growth, led by China and India, far outpaces that of all other countries. The policy measures taken to attract foreign direct investment (FDI) represent a formidable force in determining the flow of global investments in the ICT industry.

5.2.2 Swedish ICT Competitiveness

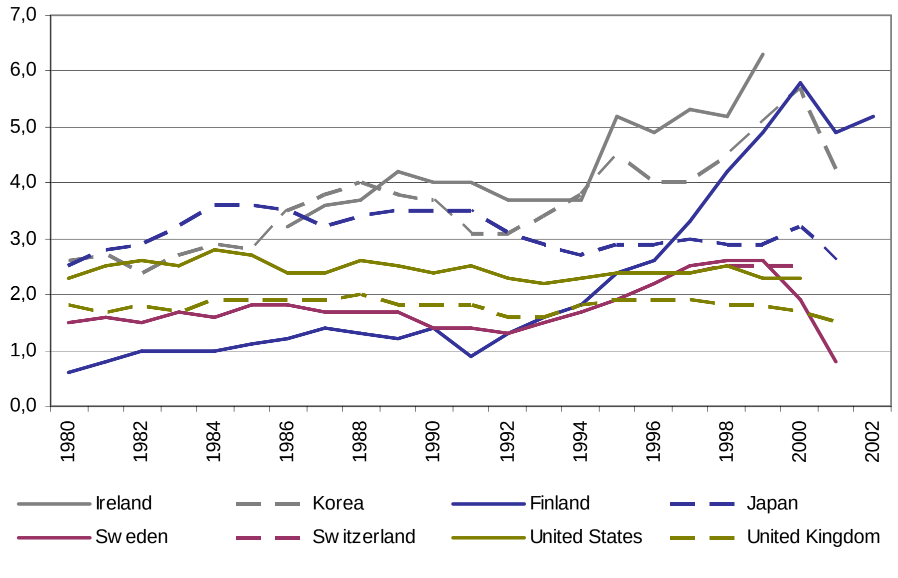
There are considerable differences between countries both in terms of the overall importance of ICT production in the economy, and of the relative specialization in different parts of the ICT industry. As a consequence, the shifts in global-market demand for ICT goods and services, in general and within different segments, have generated substantial differences in growth rates and growth patterns between countries. And, since the value generation trajectories have been quite different across ICT segments, the differences in national specialization patterns have substantially influenced the contributions of ICT industries to national economic growth.

In Sweden and Finland, ICT manufacturing didn't start to grow rapidly in terms of value added until the early 1990s. However, Swedish ICT manufacturing was fairly competitive in a European comparison during the 1980s, with a 1.8 percent share of ICT manufacturing of GDP in the mid–1980s. In Finland on the other hand, ICT manufacturing represented only about 0.6 percent of GDP in the early 1980s.

During the 1980s, the Finnish ICT manufacturing industry experienced stable growth, which only paused in the deep economic recession in the early 1990s. By then, Swedish and Finnish ICT manufacturing was about the same size, in relation to the national GDP of the two countries.

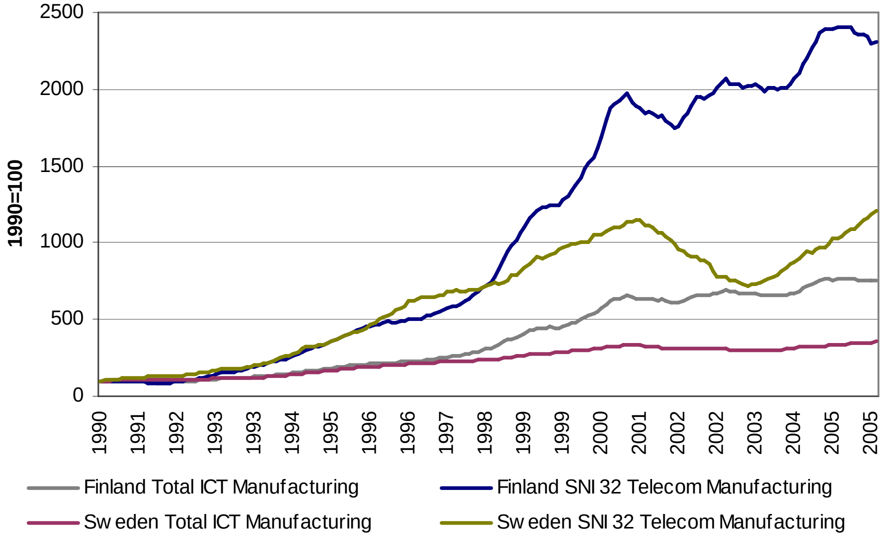
After the recession of the early 1990s, Swedish and particularly Finnish ICT manufacturing value added grew very rapidly compared to most other countries in the world. By year 2000, Finnish ICT manufacturing represented as much as 5.8 percent of GDP, an amazing increase from the 0.6 percent in 1980. In comparison, Swedish ICT manufacturing represented 1.5 percent of GDP in 1980, reached a peak of about 2.6 percent in 1999, but dropped considerably in the early 2000s. As a consequence of the rapid, global growth in telecommunications and strong Swedish competitiveness in telecom manufacturing, the Swedish ICT industry emerged as one of the most profitable in the world, particularly during the 1990s. In the process, ICT industry productivity growth increased considerably, as did its share of exports, value added and employment (see Figure 5-1).

Figure 5-1 Total ICT manufacturing value added as a share of GDP, 1980–2002.



Source: OECD, STAN 2005.

Figure 5-2 Production index for ICT manufacturing in Sweden and Finland.



Source: Reuters EcoWin.

The ICT industry crisis of the early 2000s lead to a severe downturn in value added in most countries. In particular, the manufacturing side of the ICT sector experienced a considerable decrease in value generating terms in almost all OECD countries. As the crisis was closely related to telecom manufacturing, the Swedish and Finnish ICT sectors were hit hard by the deep drop in market demand for telecom equipment. Korean and Japanese ICT sectors also experienced considerable downturns, from high levels of value added in the early 2000s.

Of all countries, Swedish ICT manufacturing experienced the most significant, negative impact of the telecom manufacturing crisis. The extraordinarily deep Swedish crisis was closely connected to the dominating company in the Swedish ICT sector, Ericsson, which teetered close to bankruptcy in 2003. By this point, Swedish ICT manufacturing had virtually lost its economic competitiveness and ranked lower than most other OECD countries in terms of value added as a share of national GDP. In most recent years, Swedish ICT manufacturing has recovered considerably, as global telecom demand has recovered from the deep recession (Figure 5-2).

Now, there are critical questions concerning the key issues and driving forces required to sustain this growth trajectory. Swedish ICT growth has been largely based on technological capabilities, and primarily in the telecommunications arena. This means that key issues and driving forces related to future technological capabilities within ICT fields should be major concerns for Sweden.

5.3 Technological Developments

Innovation is essential to a company's competitiveness. R&D investments are critical to developing technological capabilities and innovating.[6] As the ICT industry is heavily based on technological development, R&D investments have been – and continue to be – vital to company competitiveness, as well as to national innovation and economic competitiveness in the ICT industry.

In this section we address the development of Swedish technological performance in terms of R&D investments and patenting. Patenting admittedly represents a limited component of technological performance. In fact, because it mirrors invention, it is not a measure of economic value generating innovation.

Inventions, in a broad sense, are ideas and results with potential for commercialization and exploitation for different kinds of production. Innovation refers to the introduction of inventions in practical and economic value generating use, such as goods, services or production processes. Business-sector R&D represents key investment in inventions and innovation capabilities.

Although patenting is not a good technological-performance indicator in all industries, it is an important vehicle in the innovation processes of certain industries, such as ICT manufacturing. It is also closely related to R&D investments. Therefore, there is strong reason to believe that ICT patenting is one of the important indicators of technological capabilities related to ICT manufacturing.

5.3.1 Global Patterns

Several co-evolving trends are important to determining the conditions and challenges for national technological performance. Here, we will consider two major trends. The first trend relates to global developments in technological investments. The second trend relates to general developments in the industrial organization of R&D investments. Both trends, and particularly in combination, have important effects on the nature and dynamics of geographic distribution of technological capabilities within the ICT industry.

The technological requirements for smaller countries, such as Sweden, are highly determined by the different and combined trends in the development of ICT R&D investments within the five, major techno-economic regions: the U.S., the European Union, Japan, China and India. Historically, the largest volumes of R&D investment in the

[6] It should be noted that, as the R&D concept is generally understood in surveys and in regular annual reporting, R&D is not of equal importance for innovation processes across different industries. Particularly service companies, also within the ICT industry, have traditionally reported considerably smaller shares of their innovation activities as R&D.

ICT industry have been made in the largest developed economies in the world: the U.S., Japan, U.K., Germany and France. However in recent years, large investments in China and India have brought these countries to second and sixth place, respectively in terms of total volumes of ICT-related R&D investments. And, as discussed elsewhere in this report, the R&D investments and innovation initiatives are rapidly increasing in China and India, which will strongly influence global technological competition within the ICT industry.

At the company level, there has been a simultaneous development toward increasing R&D investments while decreasing the percentage of those investments allocated to in-house research. Therefore, we see growing dependence on external sourcing of technologies and innovations; recent decades have witnessed rapid increase in the outsourcing of R&D activities, although outsourced R&D still represents a small share of total R&D investments. Consequently, there are strong trends towards restructuring the organizational R&D regimes of several industries, including the ICT industry.

A related trend exists in the decreasing share of business R&D directed to more basic, in-house research activities; many companies have sought external sources of basic scientific competence. While the primary force behind private investments in R&D is company competitiveness and profits, corporate R&D tends to focus mainly on development activities close to commercialization and production. And, due to rapid technological development, increasing technological complexity and increasing competition, (all highly related to globalization), this tendency seems to have strengthened during recent decades.

A parallel development is the increasing need for many technologies and industries, including ICT, to address fundamental scientific challenges. Academic or semi-academic research is generally more important to generating science capabilities and competences than is corporate R&D. And, as the science base of most technologies and innovations (including those in the ICT industry) has tended to increase, the importance of research to technological capabilities and innovation has increased. Therefore, there is a growing need to tap into scientific research in order to stay industrially competitive. Companies place more strategic importance on investments in research relationships with academic and semi-academic institutions to access critical research competence. This is also the case in the ICT industry, where investments in academic research relationships have become an increasingly important driving force for patterns of geographical locations and flows of corporate R&D and R&D financing.

A country's long-term technological performance is strongly connected to the capabilities of the national research system, as nations face the increasing mobility of industrial production and R&D, in combination with increased importance of the science base for technological development. Technological capabilities are thus associated with the scientific performance of domestic research systems and to their "openness" to two-way interactions with industry. They are also associated with leading, international centers of excellence in R&D. Such centers may serve as important attractors of foreign and domestic R&D investments, both fundamental and applied. Such R&D environments, or centers, are generally less geographically mobile than industry. As a consequence, there is a strong international trend in innovation policy to develop and sustain centers-of-excellence in R&D.

5.3.2 Swedish Technological Capabilities

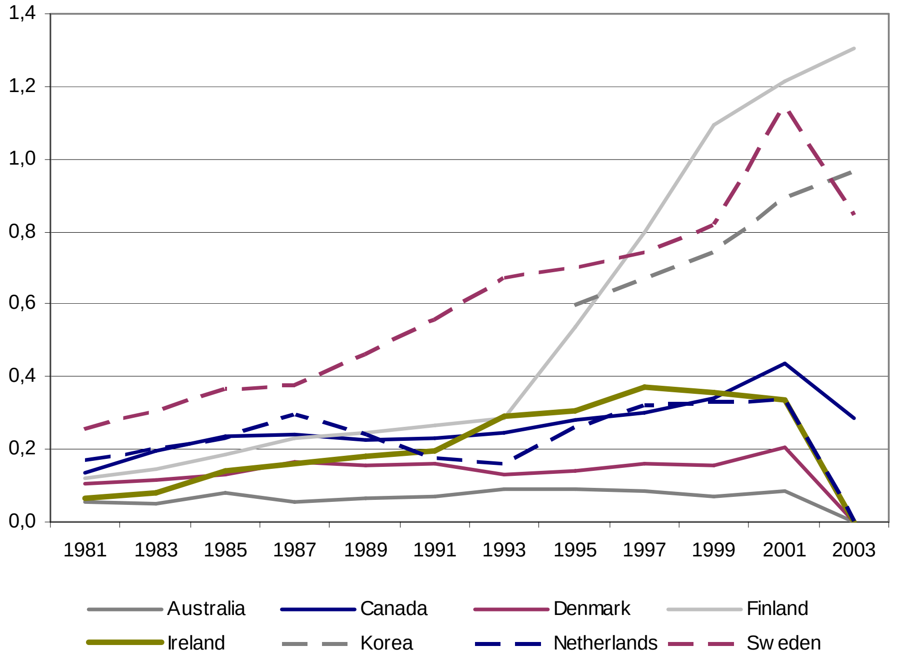
Comparing ICT-related business-sector R&D investments between countries reveals considerable national differences in terms of the evolution of both volume and specialization. In addition to the largest world economies, several smaller countries have generated highly competitive R&D investments in relation to country size. Four of these countries are northern European: Finland, Sweden, the Netherlands and Ireland. Four are Asian: Korea, Taiwan, Singapore and Hong Kong. Israel and Canada are two other ICT, R&D-intensive countries. In relation to GDP, most of these smaller countries show considerably higher R&D investments in the ICT industry than do the larger world economies.[7]

From 1980–2005, R&D investments of the global ICT industry increased considerably. A remarkable growth in ICT industry R&D investments took place in Finland and Israel during the 1990s. Sweden, Taiwan, Korea and Singapore also showed rapid growth in ICT industry R&D in the 1990s. For Sweden, the ICT crisis in the early 2000s resulted in a rapid decrease in R&D investments. The decrease was in fact starkest in Sweden; investments dropped substantially. This can be almost entirely explained by very large cuts in Ericsson's R&D budget, as Ericsson was the dominating R&D investor in the Swedish ICT industry, (see Figure 5-3).

Due to the considerable reductions, the Swedish ICT industry's world ranking in R&D investment as a percentage of GPD dropped from second to fifth place. The most recent trends indicate that Swedish R&D investments in the ICT industry have continued to decrease since 2003, though at a slower pace (Statistics Sweden 2005). Even if R&D investments stabilize at this new level, the decrease raises important questions about the future of Swedish technological capabilities in the ICT industry. In particular it raises questions about their long-term sustainability, especially when taking into account the increasing challenges of globalization.

[7] The picture doesn't change significantly if R&D investments are related to population size instead of GDP.

Figure 5-3 Corporate R&D investments in the ICT industry, 1981–2003.



Source: OECD, MSTI 2005.

Technological capabilities are fundamental to innovation processes, and R&D investments are critical to technological development. Inventions are major results of R&D investments. They thus represent important components of technological performance and economic competitiveness.

Exact measurements of the technological performance of an economy are impossible to obtain, since technology and knowledge are essentially intangible assets. However, important inventions often generate intellectual property that is protected in the form of patents. Patenting activity can thus be one important indicator of invention performance.[8] Patented inventions have a particularly strong correlation with R&D investments, as leading R&D-invested companies strongly dominate in terms of patenting (Marklund et al. 2004, p. 28).

[8] Comparable data on copyrights, trademarks and other important intellectual property rights measurements are very difficult to obtain, despite their increasing importance in service invention and innovation, which represent large and increasing shares of all innovations in modern economies.

By analyzing the growth and patterns of patenting, national technological performance is, to some extent, measurable and comparable. The U.S. patent system, administered by the United States Patent and Trademark Office (USPTO), is generally used for international comparisons of technological performance. [9]

Patenting in ICT fields represents a considerable share of total patenting in most countries. This share has increased considerably during the past two decades, particularly in the leading ICT-producing countries. Unlike several other countries, the Swedish ICT patenting didn't start to grow rapidly until the 1990s. This seems to be directly related to the rapid growth in R&D investments in the industry during that period, although changes in patenting strategies in Ericsson have probably contributed to this rapid growth in patenting.[10] Despite the rapid growth in Swedish ICT patenting during the 1990s, ICT patents as a share of total Swedish patenting remained the lowest of all leading ICT-producing countries. With ICT patents accounting for 31 percent of total patents in the USPTO in 2001, Sweden ranks ninth in the world in terms of technological specialization on ICT, with Singapore and Korea at the top.

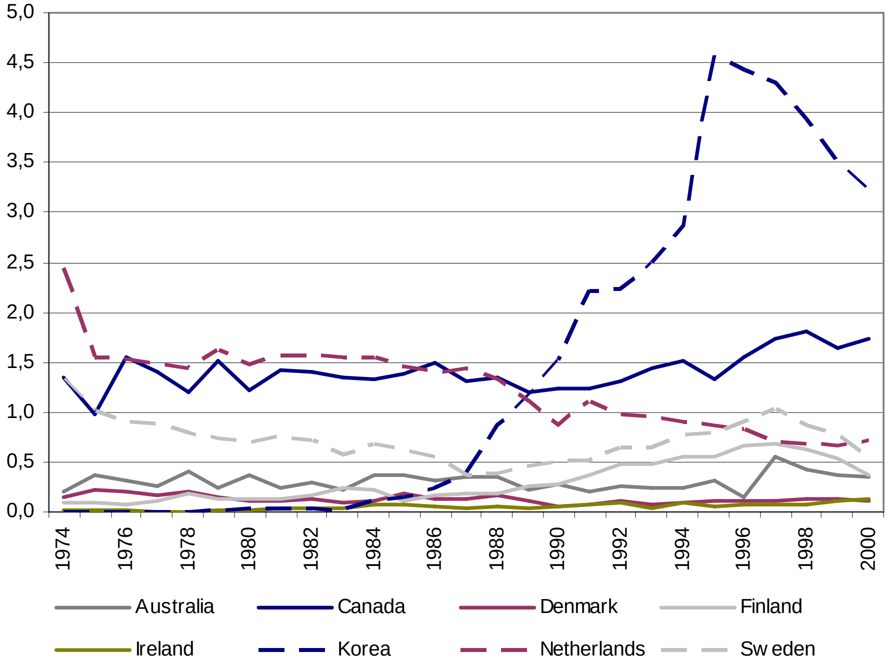
Although Sweden is not as technologically specialized in ICT as most other leading ICT-producing nations, Swedish ICT patenting per capita is among the highest in the world. The relatively low ICT patenting specialization primarily illustrates the relatively broad technological base in Sweden, compared to most other countries. Several of the other leading ICT-producing countries, such as Korea, Israel, Taiwan and Finland are strongly, specialized in ICT. It also seems clear that the economic growth of the ICT industries in the leading ICT-producing countries, including Finland and Sweden, were associated with a rapid upgrading of the technological capabilities of the ICT industry as a whole.

Swedish technological performance in the ICT industry improved rapidly during the 1990s, as measured in U.S. patenting. However, recent trends show stagnant development compared to other leading countries in the ICT industry (Figure 5-4). Although the figures are different if international comparisons are based on patenting at the European Patent Office (EPO), or in terms of so-called Triadic patents, the trend is similar for Sweden. This trend started before the recent downturns in ICT R&D investments. In combination with decreasing R&D investments, the downward trend in Swedish ICT patenting should be a major concern for the future of Swedish ICT competitiveness.

[9] For many countries, the U.S. is an important location for knowledge-intensive production. The costs for patenting in the U.S. are considerable, which is an important incentive to patent only relatively important inventions in the U.S.

[10] Because considerable and varying time lags often exist between R&D activities and patenting – especially patent-granting, as studied herein – it is difficult to establish the exact relationship between Swedish R&D investments in the ICT industry and Swedish ICT patenting in the U.S. The exact nature of this relationship requires further study.

Figure 5-4 World shares of USPTO ICT patenting, by priority and inventor.



Source: OECD Patent Database.

5.4 ICT Innovation System

Efficient innovation systems are of critical importance to national technological capabilities and long-term economic competitiveness. The innovation-systems perspective focuses on generally complex sets of relationships among actors, such as companies, universities and research institutes that develop technology and innovations. Innovation systems are understood in this study as:

> *The flows of technology and information among people, companies and other organizations in innovation processes, including the institutional incentives for and interactions between actors of importance in turning ideas into new value adding goods, services or processes* (OECD 1997).[11]

[11] Innovation systems have been defined slightly differently by different researchers and organizations. The definition used here is based on the OECD definition from 1997 in OECD (1997). It is not, however, identical to the OECD definition. The main difference is that our definition explicitly includes "institutions" as the "rules-of-the-game" generating incentives for different actors. Our definition also emphasizes the "value adding" aspect of innovation.

The innovation systems approach is a way of understanding the important actors in national technological performance and long-term economic competitiveness. It can assist in drawing attention to innovation-related strengths as well as mismatches within different systems, such as industries or countries.

Corporate R&D plays a major role in innovation systems. The characteristics, dynamics and performance of innovation systems have evolved over several decades; they are the result of interactions between specific industrial and public-sector structures and relationships. These have been formed both by interaction between the development of global and national demand and competition, and by interaction between private and public investments.

The challenges for all ICT-producing countries have increased substantially due to the recent global developments. For Sweden it is important to consider the following key, competitiveness policy concerns:

- Is the dynamic force of the traditional, Swedish ICT innovation system capable of generating continued competitive innovation and economic performance, or does it need renewal?
- How can the Swedish ICT industry be further strengthened to improve its capacity to profit from global growth and meet the challenges of global competition?
- What is the role of innovation policy, and what should be the major policy targets for strengthening Swedish ICT industry competitiveness?

In the following we attempt to describe the major characteristics of the Swedish ICT innovation system, both in relation to the historical technological performance of the Swedish ICT industry and in relation to globalization challenges.

5.4.1 Globalization Challenges

The growth of global markets for ICT production and technologies was both the *consequence* and a *cause* of increasing globalization from 1980. For the Swedish ICT innovation system, globalization has generated at least five kinds of pressures on Swedish technological performance, each with important innovation and economic implications.

First, globalization may result in a general narrowing of Swedish technological capabilities through the increasing business and technology specialization in Sweden-based multinational companies. Since these industrial companies lead Sweden in terms of technology, international markets and production, they significantly influence the overall performance of Swedish innovation systems.

Second, it is likely that an increasing share of the large R&D investments made by these industrial groups in Sweden, in general and particularly in the ICT industry, has not been transferred into innovations, since they decreasingly fit into narrower core businesses. However, considering the sharp reductions in Ericsson's R&D in Sweden and the associated, increased focus on development rather than research, this trend may weaken in coming years.

Third, production volume associated with corporate R&D in the ICT industry may decrease in Sweden, while expanding in countries with rapidly growing ICT industries, such as China, India and the Baltic countries. If so, R&D activities performed abroad and in Sweden that result in innovation and production may generate less and less economic value and employment in Sweden.

Fourth, the increasing mobility of multinational companies' production and technological activities increases the general pressure on industrial renewal through, for example, startups and small business growth. As younger, smaller companies generally demonstrate stronger ties to their original locations than larger, long-established ones, these dynamic elements of innovation systems should be of vital importance for the overall innovation performance.

Fifth, huge worldwide public investments in education and research, intended to improve the science and technology competence base of nations, are rapidly altering conditions for competence competition. A consequence of this global competence "upgrading" is that the field of opportunity to compete with an "abundance" of competent researchers and engineers (even within narrow niches) is rapidly narrowing. According to Thomas Friedman, this represents a leveling of the competitiveness conditions between countries (Friedman 2005). Therefore, attracting competence will increasingly require different kinds of "spikiness" or "uniqueness" (Florida 2005).

5.4.2 The Swedish ICT Innovation System

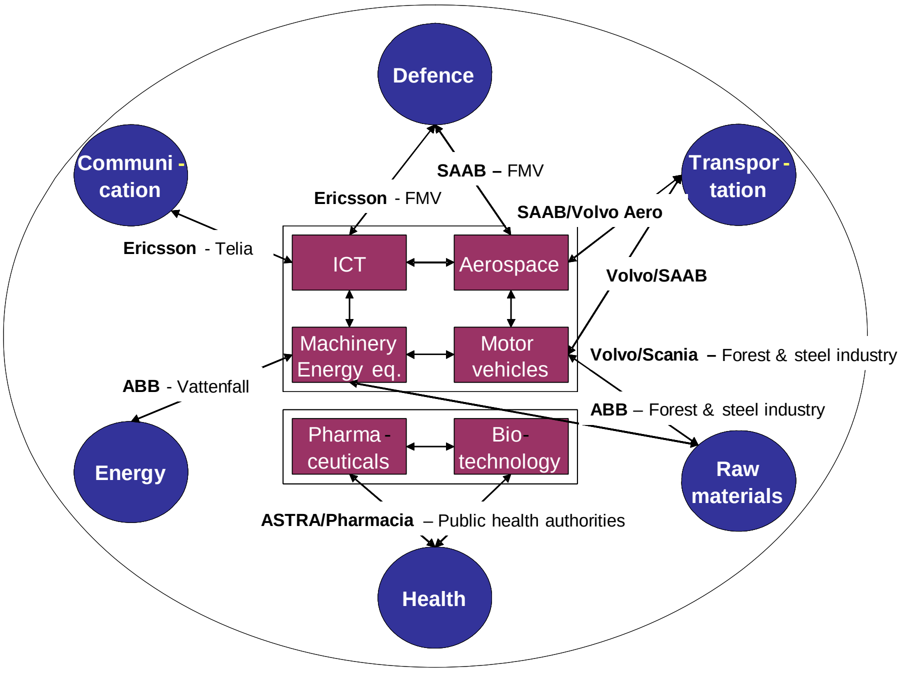
The beginning of the most recent wave of globalization could be dated around 1980, parallel with the strong growth of the Swedish ICT industry and its rapidly increasing international competitiveness. As Swedish industry in general, and the ICT industry in particular, have been highly dependent on international markets for value added, globalization has been of great importance for the Swedish ICT industry. The accelerating global demand for ICT goods has strongly fuelled the volume and value of Swedish ICT exports. In turn, the growth in global ICT demand has generated necessary capital for strong growth in technological investments. These developments have been of key importance for the growth of knowledge-intensive services such as R&D and ICT consultancy and telecommunication services. Thus far, globalization has been a major positive force behind the development of a highly competitive Swedish ICT industry.

As noted above, the economic competitiveness of the Swedish ICT industry has been strongly based on a highly competitive technological performance in the telecommunications field. This was based on an international comparison of very large corporate R&D investments in telecommunication technologies. As telecommunications was one of the most rapidly growing global industrial segments of the 1990s, the Swedish ICT industry strongly benefited from the growth of global markets for ICT goods and services.

In Sweden, as in all the other major ICT-producing countries in the world, public-private partnerships and public investments in ICT R&D and education has played an important role in the fostering of national ICT competitiveness. However, the public-private relationships in the evolution of ICT competitiveness are based on unique and important national features in the leading ICT-producing nations.

An important reason for the high corporate R&D investments in Sweden has been the development of long-term, public-private development blocks with a strong focus on technological development. At the core of these blocks have, in several cases, been a public procuring agency or company, and a private, nationally-owned industrial group developing and delivering technological solutions. These development blocks have been highly driven by public needs of varying kinds, particularly within different infrastructural areas (Figure 5-5).

Figure 5-5 Important public-private R&D development blocks in Sweden.



Within the Swedish ICT sector, the major development block has been firmly based on the relationship between the public company Televerket, later Telia, and Ericsson. The R&D relationships between Ericsson and the internationally large, Swedish defense sector have also been important in contributing to the Swedish ICT industry R&D (Sörlin & Törnqvist 2000, p. 91).

We suggest that there are three important and interrelated Swedish, national economic system features that explain the qualified demand for ICT services in Sweden. First, it is a consequence of an internationally broad, high-technology and medium high-technology manufacturing industry, with high levels of demand for ICT goods and services, in combination with heavy outsourcing of such functions. Second, it is a consequence of the sizeable, technology-driving demand from the public sector for development of ICT-based public services. Third, Swedish households display strong demand and early-adopter behavior in relation to ICT technology that fuels continuous upgrading of ICT goods and services.

An important general feature of the Swedish public-private partnerships, including those in the ICT industry, is that they have generated high, long-term investments in industrial R&D. This has been possible largely because of the existence of a public monopoly or semi-monopoly procuring agent that has invested with a long-term perspective in R&D projects in Sweden. Generally speaking, the public procurer has been very demanding in terms of technical and functional requirements, which has been an important driving force for the quality of the R&D and product system design and functionality (Marklund et al. 2004).

We can, in general terms, conclude that the basis of the Swedish ICT competitiveness was the result of the evolution of strong user-producer-based development blocks, resulting in qualified demand and good conditions for long-term investments in technological excellence. Because Sweden is a small country, both in population and in geographical terms, export markets have always been the major source of value generation. Consequentially, the pressure generated by international competition has further reinforced the stimulation of continuous technological upgrading of the Swedish ICT industry.

As a consequence, the Swedish national innovation system has provided access to highly demanding and ambitiously investing public customers. It has also offered a fairly protected home market, primarily due to its small size, as well as open access to a large global market. Moreover, it has provided geographical proximity and often important technological relationships with other R&D-intensive groups in Sweden, combined with relatively easy access to an abundant supply of human talent.

It should be noted that the dominance of one (or a few) highly technologically competitive multinational companies in the ICT industry is not a feature unique to Sweden. As Ericsson in Sweden, Nokia in Finland, Philips in the Netherlands and Samsung in Korea are nationally founded, they are still primarily nationally owned and have long industrial histories in their respective countries. In fact, the technological performance of the ICT industry in these countries has a strong basis in public-private partnerships, which have been of key importance in stimulating high, long-term industrial R&D investments.

However, in the wake of the globalization processes and the associated deregulation of the ICT industries, the “dynamic force” of the dominant Swedish “technological regime” in the ICT industry is eroding. Perhaps somewhat ironically, this process accelerated at the very height of the ICT boom during the latter half of the 1990s, when global ICT markets boomed and ICT deregulation took place in many countries. As a result, new foundations need to be sought and developed in order to maintain technological performance (see IVA 2005). These foundations would have to address three general and integrated issues:

- The need for long-term partnerships that promote and sustain investments in research with radical industrial-renewal potential.
- The need for technologically advanced local demand that stimulates R&D-based innovation and production in Sweden.
- The need for triple helix risk-sharing and cooperation in generating the necessary resources and capabilities for such a regime.

5.5 Innovation Policy Challenges

Swedish innovation and growth policy is facing some critical challenges in both the short and long term. The Swedish National Innovation Strategy, presented by the Government in 2004, constitutes the strategic basis for such a policy (Regeringskansliet 2004).

As a part of the National Innovation Strategy, significant steps have been taken to increase and reform Swedish public R&D funding, both in terms of academically performed basic research, and in terms of mission-oriented research (Regeringskansliet 2005a). Moreover, the strategy has been the basis for new industry-focused programs for R&D and innovation in key Swedish industries. The programs have been generated and defined through a series of public-private dialogues. One of the programs addresses the Swedish ICT industry (Regeringskansliet 2005b). Finally, the strategy has generated ambitious initiatives to stimulate R&D-based startups and R&D in small and medium-sized enterprises (SMEs).

These policy developments are important and historically unique steps towards a coherent strategy for improved competitiveness of Swedish industry. And, as the challenges tend to vary considerably across different industries, the industry approach to competitiveness policy is sound. The aim of this section is to note critical points for further developing national strategies for improved technological performance and economic competitiveness of the Swedish ICT industry.

Both the size and the character of the challenges facing Sweden are very different from those that have faced Swedish industry and policy in past decades. The scale and scope of public stimulation and intervention have been increasing, which has generated a global race in providing attractive national conditions for investments in R&D and production.

5.5.1 Quest for a New Regime

As a consequence of the radically changing, global conditions, the future strength of Swedish ICT-related innovation policy cannot rely on repeating historically effective measures (Arnold & Deiaco 2002). Instead, the objectives and design of future competitiveness policies must be continuously informed by foresight and global intelligence in business, technology and policy developments. In the following section we address critical issues for Swedish ICT innovation policy, by focusing on key functions for innovation performance and the ways they have been working historically in Sweden. Given the large public sector in Sweden, public investments and regulations should continue to be of critical importance for the future competitiveness of the Swedish ICT industry. However, both the global and national conditions for such policy has changed considerably in nature, which means that the actual policy measures considered would need to be quite different from those adopted during previous decades.

In spite of the recent strengthening of Swedish innovation policy, there is need for a deeper review of the challenges facing the Swedish national innovation system as a whole, and for the ICT innovation system specifically. At both levels, Swedish innovation policy has to identify and develop new routes to replace previously dominant innovation system regimes, several of which have been quite efficient historically. The "old" regimes were, in important respects, based on strong user-producer relationships, most of which had a substantial public-private dimension.

5.5.2 ICT Policy Challenges

Based on the prospects of global and national demand and market growth for ICT goods and services, in combination with the industrially and technologically strong Swedish ICT industry, we argue that the ICT industry should be given substantial policy attention. The potential for continued, above-average value added and employment growth is promising.[12] However, these opportunities are identified by many companies and policy makers around the world, and thus the competition for these values and the competitiveness requirements for ICT-based growth are increasing. National ICT policy is an important part of this competition.

Public policy influences both the supply and demand of technological development in the ICT industry through:

- *Procurements* of ICT goods and services for public services. The volume and technological requirements of this demand are critical in stimulating R&D investments.
- *Investments* in the supply and development of human resources with specialist and generalist competence for both hardware and software ICT development and production.
- *Provision* of internationally competitive, technical infrastructures for ICT production and consumption, which is critical to generating technological capabilities.
- *Regulation* of technology and business activities that generate incentives, which affect the risk-reward ratio for industrial technology and business investments.

[12] As indicated by foresights and private and public R&D and production investments worldwide.

To generate competitive national conditions for ICT industry development in Sweden, the policy domains described below must be considered simultaneously, in integrated and mutually reinforcing ways.

Long-term, public-private R&D alliances are key to generating large R&D investments and internationally competitive flows of inventions and innovations. The development of "centers-of-excellence" in R&D within national borders is important in creating and sustaining the 'spikiness' that is necessary for attracting international and national investments. In contrast to the traditional Swedish public-private regime, such environments must remain open to a variety of exchanges, and need to attract a global influx of human talent, R&D resources and capital for commercialization. An integrated part of such a strategy should therefore be to connect Swedish centers-of-excellence to other leading centers internationally.

R&D-based entrepreneurship in startups and SMEs is increasingly important for innovation-system efficiency. For Sweden this has been a relatively weak part of the traditional ICT regime and thus needs particular attention and reform. As the large and globally-dominating companies are becoming mobile both in terms of production and R&D, the need for a vital local R&D-based business dynamics is increasing. In developing these environments, large industrial groups are still important, particularly since they have important customer relationships with SMEs. However, their interactions must be based on different relationships where ample consideration is given to the potential for SME growth. The roles of public procurement as a driving market force, and of universities as vital knowledge environments for startups and continuous SME interaction, should also be key components of such policy.

Basic research for "spikiness attraction" of investments in science excellence should be a fundamental basis of the long-term technological capabilities of Swedish innovation systems in general, and the ICT system in particular. Developing and sustaining international excellence in selected science and technology areas is also critical for the quality and sustainability of the private-public R&D-alliances discussed above. Sweden already has an internationally strong science and technology research base, and strength within ICT-related fields. However, recent performance trends are somewhat stagnant. The volume of Swedish engineering research in universities and in private, non-profit R&D institutes taken together are quite moderate in international comparison. As a result of decreasing external R&D funding from the most R&D-intensive industrial groups, and reductions in expenditures from the large research foundations, engineering research at universities and in R&D institutes is facing considerable resource challenges (Marklund et al. 2004).

Human resources for competitive R&D competence represent a fundamental challenge for all innovation systems. University and institute research, training and education generally have strong local development properties, since individuals tend to be relatively "sticky" geographically. Because individual competences and "competence teams" are critically important to industry, investment in public research and training is equally important. This is further accentuated by two interrelated global industrial trends: 1) the tendency to "outsource" research of a more "basic" kind, which generates an increasing dependence on external R&D sources in the innovation processes, and 2) the tendency to search systematically and globally for leading R&D competence and, if necessary, tap into such competence pools by locating and re-locating R&D activities to international centers-of-excellence. Consequently, Swedish innovation policy for ICT competitiveness should carefully consider efforts that generate internationally competitive levels of publicly-funded university and institute research and training.

Regional market developments in the Baltic region are probably of key importance to Swedish ICT competitiveness, as the relative geographical proximity, compared to regions such as China and India, and may improve both the export potentials and the R&D interactions for Swedish R&D. It is likely that Swedish attractiveness for locating production and for technology investments will become increasingly related to the market and capability developments in the greater area of Scandinavia and Northern Europe, including the developing Baltic region. Therefore, Swedish competitiveness policy should consider strategies to contribute to the cultivation of economic and technological capabilities in Europe in general, and Northern Europe and the Baltic region in particular. If successful, such strategies would be of substantial importance to generating mutually reinforcing supply-and-demand relationships between ICT innovation systems in Northern Europe.

5.6 Conclusion

Due to intensified globalization, multinational industrial groups are increasingly seeking locations with optimal conditions for exploitation and production activities. Historical and geographical roots have become less important determinants of locations of value adding industrial activities. This is primarily due to the internationally widening boundaries of the value generation within industrial systems, though it is also related to the rapidly increasing trans-national patterns of company ownerships.

The global and national deregulation or re-regulation of several industries, including the ICT industry, which previously were regulated through monopolistic or semi-monopolistic private-public partnerships, further reinforces these trends. As a result, globalization has simultaneously spurred global growth opportunities and intensified international competition due to the opening of global markets. The above-described impacts of globalization have generated notable challenges for Swedish ICT competitiveness. As this competitiveness has been firmly based on international excellence in technological capabilities, these challenges are directly related to the future dynamics of the Swedish ICT innovation system.

After an exceptionally severe crisis in the early 2000s, the Swedish ICT industry has recovered in recent years. However, business sector R&D investments and technological performance are stagnating, which should raise concerns about the long-term viability of Swedish ICT capabilities. Moreover, several structural conditions for ICT industry competitiveness have radically changed in the wake of globalization. As a result, the historically successful Swedish ICT innovation regime would probably be considerably less efficient in relation to the evolving future challenges of the ICT industry.

It is suggested that, as the Swedish National Innovation Strategy is further developed and deepened, it should include programs and resources to support the development of a new ICT innovation regime. Such a strategy should primarily focus on how to develop new long-term, public-private alliances that would ensure international ICT excellence, and how to generate sustainable flows of and growth in R&D-based SMEs.

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6 Open Innovation in the Pharmaceutical Industry

Anna S. Nilsson

6.1 Introduction

The pharmaceutical industry is not only a big industry in terms of revenue, it is also one of the most research-intensive industries (Gambardella 1995). It is therefore important to acquire a deeper understanding of the trends in localization of research and development (R&D) facilities. The general and worldwide focus is on the current trend of “big pharma” moving to low-cost countries such as India and China, and that is seems to be happening quickly.

There are great differences in the characteristics of activities performed by large pharmaceutical companies. Sales, manufacturing and R&D should therefore not be analyzed and discussed as one unit. This study focuses on R&D in an effort to increase the understanding of where companies locate those specific activities and why.

The benefits reaped by pharmaceutical companies from public research are well-known. This means that we could expect companies to locate laboratories across the world to capitalize on spillover at local universities and institutes. At the same time, there are organizational and cost benefits to centralizing research in a single location. Thus, we have an interesting case of both centralizing and decentralizing forces (Furman et al. 2004).

The hypothesis in this study is that the internationalization of corporate R&D is a slow-moving process, and that companies must take into account several factors regarding localization of R&D. The purpose of this study is to highlight data that puts the discussion of localization of R&D within the pharmaceutical industry into perspective, and to uncover some considerations behind decisions regarding localization of R&D laboratories within pharmaceutical companies.

The key questions discussed in this study are:

- To what extent do pharmaceutical companies locate R&D activities outside the U.S.?
- What are the rationales behind the localization of R&D laboratories within the pharmaceutical industry?
- What relevance does open innovation in the pharmaceutical industry have for Sweden?

The first question is approached through statistics from different sources. The second question is approached through interviews with executives (herein referred to as Executives I, II, and III) within the areas of global business operations, global discovery alliances and external research (both national and international) within three of the major pharmaceutical companies listed in Figure 6-1. All companies are not U.S.-owned, but they have substantial activities in the U.S. and are members of the Pharmaceutical Researchers and Manufacturers in America. Further interviews have been conducted with industry experts (herein referred to as Industry Experts I and II) who have experience working with a large number of pharmaceutical companies; these interviews offer additional perspective outside of the three selected companies.

The data collected from a limited number of interviews will not offer a definitive answer to the second question above, but will, through an exploratory approach, help identify key issues and behavioral patterns among a limited set of actors within the population.

6.2 Where Do Pharmaceutical Companies Conduct R&D?

The average large pharmaceutical company spends 3,348 million dollars on R&D per year. This amount represents, on average, 15 percent of total revenue. Figure 6-1 shows the specific numbers for the 13 largest pharmaceutical companies. These companies constitute 13 of the 34 main members in PhRMA, not counting daughter companies to the large pharmaceutical companies.

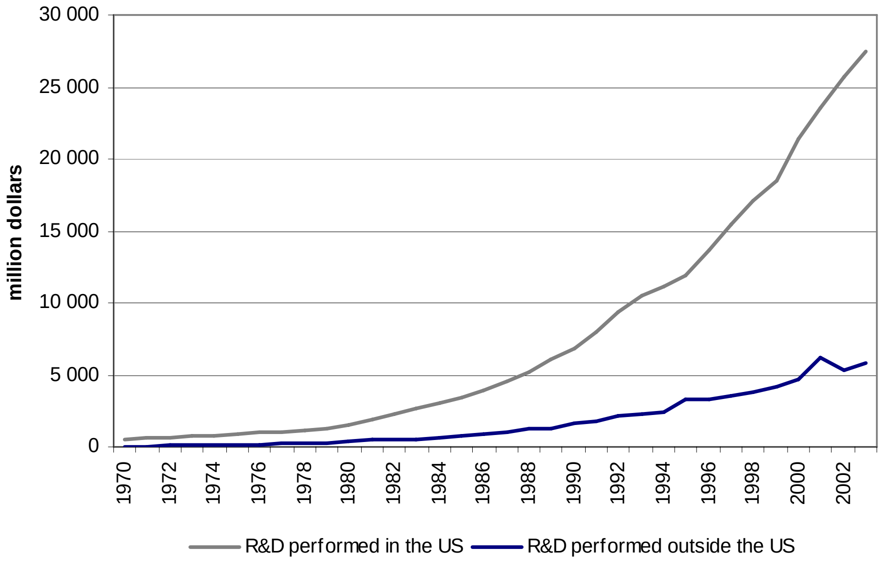
Figure 6-1 Research and development expenditure in pharmaceutical companies with revenue above 5 billion dollars in 2003.

Company Name	R&D Expenditure (million dollars)	R&D as a Share of Total Revenue (percent)	R&D Expenditure per Employee (U.S. dollars)
Abbott laboratories	1,830	9.3	25,404
Amgen	1,655	20.0	128,326
AstraZeneca	3,451	18.1	55,751
Aventis (Sanofi)	3,683	15.5	48,743
Bristol Myers Squibb	2,279	10.9	51,795
GlaxoSmithKline	4,942	12.9	47,906
Johnson & Johnson	5,602	13.4	50,651
Lilly (Eli) & Co	2,350	18.7	50,980
Merck & Co	3,280	14.6	51,897
Novartis	3,756	15.1	47,822
Pfizer	7,131	15.8	58,450
Schering-Plough	1,469	17.6	48,164
Wyeth	2,094	13.2	39,964
Group average	**3,348**	**15.0**	**50,193**

Source: RTEC 2004.

New-drug development costs have increased from 231 million dollars per drug in 1987 to 802 million dollars in 2000 (DiMasi et al. 2003). The total spending in R&D has increased, as reflected in Figure 6-2. The figure also shows the share of R&D performed within the U.S. versus the share performed outside the U.S.

Figure 6-2 R&D performed by member companies of the Pharmaceutical Researchers and Manufacturers in America (PhRMA), 1970–2003.



Source: PhRMA 2004.

The amount of money spent on R&D by pharmaceutical companies continues to increase. In 2004 members of PhRMA invested 38.8 billion dollars, which is 12.6 percent more than in 2003 and more than four times the investment made in 1990 (PhRMA 2005).

Figure 6-2 shows that the PhRMA companies spend most of their R&D budgets in the U.S. We find that PhRMA-member companies perform 84 percent of their R&D in the U.S., 13 percent in Europe, 2 percent in Japan and the remaining 1 percent divided in the rest of the world (PhRMA 2004).

If, however, we examine the number of R&D laboratories instead of absolute research dollars, we see a sharp increase in the internationalization of the companies. In 1960, most of the U.S. pharmaceutical companies performed their work within one U.S.-based laboratory. In 1997, the average company had two laboratories within the U.S. and two laboratories outside of the U.S. A major reason for the change was that new ways of performing drug discovery had emerged, and companies needed to find more sources of knowledge. Considering the combined resources of the 21 largest U.S.

pharmaceutical companies in 1960, there were a total of three laboratories operating outside of the U.S. By 1997 this number had risen to 25, which means that U.S. pharmaceutical companies had nearly as many R&D facilities within the U.S. as they did abroad (Chacar & Lieberman 2003).

There are, however, differences between the companies; some have centralized R&D-laboratories and some perform more R&D at sites in several countries. The reasons for differences in strategy, and the past and present thinking about where to locate these activities, are explored in the following section.

6.3 Rationale for Existing Locations of R&D Laboratories

Industry history should be kept in mind when seeking rationale in the big pharmaceutical companies´ localization of R&D. Having started as chemical companies, they located R&D laboratories in places that might not be considered hotbeds for life-science R&D today. As these companies grew into large multinational companies, investment in existing facilities increased.

Although history has an impact, the locations chosen for new corporate R&D investments are mostly based on careful planning (Chacar & Lieberman 2003). Creating a new facility is expensive not only in terms of direct cost, but also time. Companies therefore centralize their R&D activities around the original, large research site. There are also companies that have adopted a more decentralized strategy, establishing R&D sites in various countries with the aim of gaining access to local research ("access" refers not only to interaction, but also the recruitment of researchers).

Even companies that formally pursue centralized strategies have R&D sites in different parts of the world. It is interesting to question why the sites that are active today were initially chosen. You can divide the reasons into several categories: historic (related to company origin), cost (tax relief and subsidies offered by certain countries), research-strategic (close access to researchers in specific fields), and/or market opportunity. Figure 6-3 summarizes the rationale behind the locations of the majority of three companies' R&D sites, as provided by their executives. (The rationale for each area is specific to the three companies interviewed and is thus not representative for all companies).

Figure 6-3 Rationale for existing locations of R&D laboratories.

Location (state/country)	Rationale
New Jersey	Historic (strong internal research site)
Massachusetts (Boston)	Access to research
California (San Diego)	Access to research
Pennsylvania	Historic (strong internal research site)
Washington	Access to research (bioinformatics)
Canada	Access to research and cost
United Kingdom	Historic (strong internal research site) and access to research
Italy	Cost
Spain	Cost
France	Cost
Sweden	Historic (strong internal research site) and access to research
Japan	Market opportunity
India	Cost and market opportunity

Source: Interviews with executives in three pharmaceutical companies.

Mergers have been frequent within the pharmaceutical industry and have also affected the localization of R&D sites. As two companies merge, new management analyzes where the main strengths lie within the new organization and, as expected in a merger, streamlines inefficiencies by closing sites of less strategic importance. It should be noted that not all mergers have resulted in reduction of R&D sites; some result in a strengthening of existing sites. Generally, it is easier to focus on existing sites, rather than close some of them in order to build new sites in completely different regions of the world.

When looking for rationale in localization of R&D for pharmaceutical companies, each company's present economic situation must be considered, as expressed by this study's Industry Expert I:

> *Company X is doing well and has a good pipeline and can therefore set up new facilities. The other extreme is company Y, which has had problems that have put pressure on their stock value. That means that they have not had the luxury to think about new facilities. They are more concerned about making processes efficient in existing facilities.*

The present localization of R&D laboratories is thus the result of each company's history as well as an effect of the company's present economic situation. Keeping that in mind, along with the insight that there is not one strategy that all companies are following (Chacar & Lieberman 2003), we will focus on how executives and experts think about the localization of new R&D facilities today.

6.4 Strategies for Localization of New R&D Laboratories

Despite the high costs of reorganizing and relocating R&D facilities, pharmaceutical companies have actively done so in recent decades (Chacar & Lieberman 2003). According to Industry Expert I, some localizations by pharmaceutical companies were based on economic reasons – tax benefits, for example – but that is not necessarily the case anymore. Now, the strategic issues are prioritized. To present a snapshot of how decision makers in pharmaceutical companies prioritize today, the following five types of objectives were discussed with four of the interviewees[1]:

- Cost containment
- Speed-to-market
- R&D alignment with market needs
- R&D alignment with manufacturing
- Access to new technology and competence

The interviewees were asked to rank the five objectives above, according to which is presently most critical to selecting locations for R&D. Although the responses vary, which can be expected due to differences in company strategies, similarities in thinking do exist. These are described below.

The issue of placing R&D facilities close to manufacturing is not a priority. Proximity to manufacturing would be nice, as Industry Expert II expressed, but other issues are much more important: "There are some regional developers in the U.S. that have built the concept that if manufacturing is done here we can entice the pharmaceutical companies to move their headquarters and their research components to be near the manufacturing, and that is not necessarily so."

Cost containment also ranked at the lower end of priorities. R&D processes are costly and the risks high, which explains why pharmaceutical companies can not afford to compromise on quality. Many countries are offering R&D tax incentives in order to encourage business R&D spending and increase the presence of research-intensive companies[2]. Some pharmaceutical companies used to locate part of their activities in those countries, mainly to reap the cost benefits.

[1] List of objectives from RTEC 2004.
[2] OECD 2004 offers a good overview on which countries offer R&D tax incentives.

The present attitude expressed by the interviewees was summarized by Industry Expert II:

> *All things being equal, yes, cost will be a key determinant. However, the most important aspect is the quality of the clinical trials infrastructure and the competency of those administering the trials. You don't want to spend your money and find that you spent 600 million instead of 800 million, but the 600 million will not go anywhere, whereas the 800 may. It is that risk analysis that is conducted.*

The three objectives ranked most important to the company executives interviewed, regarding localization of R&D, were access to new technology and competence, speed-to-market and R&D alignment with market needs.

6.4.1 Access to New Technology and Competence

A centralized R&D strategy has benefits[3], but as mentioned initially, there is a trend toward dispersing R&D – and the issue of human capital is an important reason. If a company is expanding within a certain area of research and needs to add more competence, setting up a laboratory in close proximity to a critical mass of front-line researchers in that field is a common strategy. This is expressed by Executive III:

> *The one thing that we have very consciously decided, other than the recent conscious decision to place [research facilities] close to universities, is to have dispersed sites in different locations around the world. The primary reason is to take advantage of international diversity; we are able to attract the best scientists even if they want to stay close to home.*

The benefits of locating close to university research have been highlighted by scholars for some time (Jaffe 1989, Zucker et al. 1998), and in a study of the pharmaceutical industry, Kyle (2004) acknowledges the trend of companies relocating to areas with strong research universities and hospitals. In order to benefit from publicly funded research at various centers of competence, one would indeed expect companies to set up R&D laboratories at a number of locations – but that strategy is also very costly since there are productivity benefits to the co-location of research, as pointed out by scholars in organizational theory (Chacar & Lieberman 2003).

6.4.2 Speed-to-Market

It is not only the critical mass of basic researchers that attracts companies to locate new R&D facilities in certain areas. There is also the aspect of being close to other factors that may speed up the whole R&D process. Since the development of pharmaceuticals is a costly, long-term process, companies aim to decrease development time and get more patent-protected years of sales.

[3] Chacar & Lieberman 2003 provides a good overview of the benefits and costs of R&D centralization.

> *The location in Cambridge was chosen because company Y wanted to be close to research centers and leading hospital researchers. The pace of clinical trials is critical because they are very expensive and with a good infrastructure it is possible to save time at this phase, something that is not as easy in the earlier phases of research. It is important to be close to hospitals and clinical researchers (Industry Expert I).*

In short, locations that feature both high-quality research and an efficient infrastructure for clinical trials become very attractive R&D locations for pharmaceutical companies. One of those factors alone may not be sufficient.

6.4.3 R&D Alignment with Market Needs

The importance of keeping the development of new products close to particular medical needs in certain markets is highlighted by the interviewees. All interviewees pointed to India as a region that is becoming more and more interesting, partly due to the market and partly for economic reasons, since R&D can be performed at lower cost there. This does not include front-line research however, as Executive III explains:

> *When you contract with an Indian or Chinese company you have to provide a lot of supervision, as opposed to an independent researcher in Cambridge. Their communities are not quite to the point that they are truly independent. They do more routine activities, operated by standard operating procedures (SOP). They are changing rapidly, learning from every SOP you send, but that is where they are by 2004: things that can be done by SOP.*

The Indian pharmaceutical industry accounts for a market of 2.5 billion dollars (14th largest in the world). The Indian companies produce and export generic drugs, which mean that they have expertise in reverse engineering processes and good knowledge in synthetic and organic chemistry. The domestic market has, however, been too weak to motivate innovative activities, and there is limited cutting-edge knowledge in medicinal chemistry and biology.

On December 26, 2004, a new patent law was passed in India. In becoming part of a patent regime, Indian companies have been challenged to develop R&D expertise in order to deliver patentable innovations. Some companies have started this process and are acquiring the expertise needed by recruiting Indian scientists working in pharmaceutical companies overseas. Moreover, the proactive Indian companies are initiating collaborations with Indian and overseas research institutes and universities (Kale 2005).

Foreign pharmaceutical companies are now expanding R&D operations in India and China. As a consequence, Indians and Chinese who are educated in the U.S. and have work experience with U.S. pharmaceutical companies become key players when they move back. That said, India still cannot compete with the U.S., according to Executive II. China is even further from competing with the U.S., since several pieces are missing in their system.

The new patent law in India is expected to motivate investments in basic research, but such activities are not prioritized in China, as Industry Expert II explains:

> *In China they are all looking at applications. They are not doing much basic research. They are doing applied research, which will provide some economic advancement in the near term. However, after that they will begin to say "Where are the next ideas coming from? Where are the new products coming from? They are going to have to get them from overseas more than they have and I think that is going to be a significant problem for them in the near future.*

It is not only increased research capability and lower costs that make India and China interesting. They also represent large market opportunities, and Executive II presents the rationale:

> *With a long-term perspective it seems reasonable that more R&D activities would be located closer to markets that are different from, for example, the U.S. market. Asians have different needs, react differently, with regards to medicine than Caucasians. It is important to keep the development of new products close to the particular needs in the target market. For attractive emerging markets like India, for example, it is likely that there will be a trend to expand the R&D activity being conducted in that country.*

But there are still obstacles regarding these countries, and the issue of intellectual property (IP) is frequently mentioned. There is always hesitancy when entering markets that do not have a strong, regulatory IP system. Industry Expert II claims that China now has and centralized IP process, but that it is enforced sporadically at best. Further weakening the system is implementation, which occurs on a province-by-province basis.

Pharmaceutical R&D interest in China and India is significant, but not primarily as locations for front-line research. Instead, these countries are considered to have good value in development activities for which there are standard operating procedures. The other strategic argument surrounding presence in India and China is whether their large market-sizes outweigh problems/risks related to intellectual property rights. The latter creates hesitancy.

In summary, it is clear that a number of factors go hand-in-hand when companies make decisions regarding localization of new R&D laboratories: ensuring an input in the product pipeline through internal research excellence and external collaborations, along with proximity to organizations that perform good clinical trials. Market alignment is a consideration, and tax incentives may play a role as long as there is no compromise on quality.

The following is a reaction from one of the executives, who is frequently approached by economic development officers from various countries, trying to attract big pharmaceutical companies to their regions:

> *…the magnet has to be the intellectual capital, rather than the financial capital. And to create that intellectual capital, the government needs to create an atmosphere that biotech companies can thrive in because they will then attract the big pharma. For that atmosphere you need proximity to academic institutions, all sorts of quality of life – actually a diversity of quality so you can attract different kinds of people (Executive III).*

6.5 The Pros and Cons of Open Innovation

The open innovation strategy, where companies' R&D crosses over corporate and national borders, is nothing new to the pharmaceutical industry. Rather than relying entirely on internal ideas to advance the business, an "open" approach to innovation leverages internal and external sources of ideas (Chesbrough 2003). Two of the executives whose companies work to intensify open innovation shared their thoughts on the pros and cons of the strategy. They expressed very similar thoughts, presented in Figure 6-4.

Figure 6-4 Pros and cons of an open innovation strategy for pharmaceutical companies.

Pros	**Cons**[4]
• Allows companies to capitalize upon the diversity of scientific excellence around the world, by providing access to new research ideas, personnel and collaborations with academia and companies. • Increased visibility in multiple locations increases opportunities for external collaborations. • If a problem arises at one location, other sites may be able to continue the work.	• Duplication of facilities and infrastructure at multiple locations is costly. (Basic infrastructure is needed for every site, whether supporting 60 or 200 researchers.) • Stresses need for constant communication. • Local interests may override the global interests of the company.

[4] There are general threats to the industry in terms of cost-containment, regulatory changes, etc., but here the focus is on threats to an open innovation strategy.

The benefits that executives experience with the open innovation strategy are supported by Chacar & Lieberman (2003) who, in a study of 21 pharmaceutical companies, found geographic organization to have a significant effect on research productivity. The key factor was to have laboratories dispersed across countries in order to access local research. Evidence further indicated that, within the U.S., a relatively centralized organization was most beneficial for research productivity. The finding can be related to the issue of cost, which the interviewed executives named as a challenge to the open-innovation strategy. An explanation as to why a company may have a centralized strategy within the U.S., but decentralized internationally, is that “international barriers to information flows are much greater than those that operate regionally within a given country” (Chacar & Lieberman 2003, p. 318).

A challenge experienced by the two interviewed pharmaceutical companies that are pursuing open-innovation strategies is the coordination of R&D sites. Both companies have systems where the sites are responsible for a specific disease area. For some large and prioritized disease areas, there may be several sites involved. For research that is dispersed across several sites, there are coordinating committees consisting of the heads of each involved site. Then, there is coordination at the next level, where the leaders of each area meet frequently as an established group, led by the company director of research. This group is responsible for ensuring collaboration across the organization to optimize the utilization of technologies, systems and processes (libraries of substances, informatics, etc.).

All research results should be accessible to all researchers in the company and a culture of sharing openly is encouraged. But as Executive III expressed, keeping a constant flow of information between the sites is easier said than done:

> *Apart from the cultural differences, just the time zone differences really put a stress on communication and make the importance of communication foremost in everybody’s minds. If we don’t work very hard at communication, then things fall between the cracks and problems arise. We try and take advantage of modern communication devices such as electronic repositories for information and communication. It just requires constant reinforcement.*

The problem of communication between R&D sites is acknowledged by scholars. Allen (1977) suggested that communication between researchers falls with the square of the distance between them. New ways of communicating have become available since his study, and although those have better enabled working across disparate sites, there are still big challenges in managing them (Cummings 2004).

6.6 Conclusion and Implications for Sweden

The leading research-based pharmaceutical and biotechnology companies in the United States spend an overwhelming percentage of R&D dollars in the U.S. At the same time, we find the number of R&D laboratories that these companies locate outside the U.S. to be increasing, along with their overall spending on R&D. The increased complexity of the science being used to develop today's medicines drives more pharmaceutical companies to establish laboratories close to research hotbeds around the world.

While acknowledging the need for an open-innovation strategy and the belief that this strategy will grow increasingly prevalent within the pharmaceutical industry, involved actors also point out that costs and coordination difficulties create constraints in implementing the strategy. Moreover, the time required getting a new laboratory up and running is considerable. There are therefore reasons to expect the process of establishing R&D facilities in new places to move slowly and to depend on the financial situation of the companies.

Pharmaceutical companies are often approached by actors (e.g. economic developers) promoting certain geographic regions of the world as prime choices for R&D localization. Based on this exploratory study regarding the R&D activities of pharmaceutical companies, human capital emerges as the key factor for the localization of laboratories. Companies cannot afford to locate in places other than where the best research is being performed. There are reasons to expect pharmaceutical companies to continue to locate research laboratories close to the strongest research clusters around the world. Clusters that manage to combine front-line research and clinical expertise are particularly attractive, as quality and speed in clinical trials are paramount.

Sweden is well-known for high-quality research. The research community, however, expresses concerns that the resources dedicated to research are lagging behind those that are implemented by other countries (Regeringskansliet 2005). If Sweden's aim is to continue to be an attractive country for life-science companies, resources to ensure continued research excellence must be secured. This is also a question of making Sweden an attractive work/life choice for the researchers themselves, by offering better working conditions than other countries and a high quality of life.

Regarding quality and speed in clinical trials, the system in Sweden has worked very well. Today, the interaction between hospitals and companies is challenged, in part due to the focus on cost containment on the part of the actors responsible for hospitals (Landstingen). A strategic document brought forward by policymakers, industry representatives and other involved actors highlights the need to implement a broader perspective regarding efficiency and value of new medical products (Regeringskansliet 2005). A smoother clinical-trial infrastructure will enhance Sweden's attractiveness to pharmaceutical companies. An advantage for Sweden is its number of highly qualified clinical researchers; because these human resources are vital in this system, efforts should be made to facilitate their work. Industry representatives have suggested that one way to facilitate the work of clinical researchers is to establish one responsible actor (instead of several with differing goals) for clinical trials. That would also facilitate contact with companies interested in performing clinical trials.

Other advantages include Sweden's unique databanks and patient registers, which are of great value when developing medicine. Offering companies pursuing R&D in Sweden access to the unique databanks may also be used as a competitive advantage.

These suggestions indicate that structural changes are essential in order for Sweden to retain its position as an attractive country for pharmaceutical companies to locate R&D.

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Interviews

Three executives from three publicly held multi-national pharmaceutical companies, December 2004 – February 2005.

Two industry experts, December 2004 – February 2005.

7 New Marketplaces for Problem Solving and Technologies

Eva Ohlin

7.1 Introduction

During the last few years many large international companies have been forced to reduce their investments in research and development (R&D). Companies had spent more money but for fewer R&D results. This has been particularly true in certain industries, including the pharmaceutical industry (Raynor & Panetta 2005). Downward economic trends and increased international competition have been the driving forces behind the development of strategies to get more innovation for the same amount of money. These strategies include measures to access research, technologies and human capital at lower costs. Additionally, in the U.S. as well as in Europe, fewer young people are studying science and engineering, and large groups of people born in the 1940s will retire in the near future. As a result, companies face great challenges in their approaches to innovation and renewal.

One step toward addressing these challenges has been to increase cooperation with external partners, i.e. subcontractors, other companies, institutes and universities. This has created growing external innovation markets for problem solving, research and technologies. In some areas, organizations are being established that specialize in conducting R&D on contract or in partnership with other companies. Examples include MIT Media Lab, Stanford Bio-X and SRI International. In addition, technology transfer and the commercialization of research results are becoming important activities at universities. For this purpose, many universities have established specialized departments, research parks and "knowledge broker" organizations. In Sweden, such an example is Uminova in Umeå.

Institute for the Future (IFTF) predicts that the number of actors on these innovation markets will increase considerably in the coming ten years. New forms of organizations will develop to support, for example, problem solving in global networks and the trading of knowledge in various forms (IFTF 2002).

A number of specialized organizations have started to develop specific R&D niches or marketplaces in the U.S. Four of them are discussed in this study: NineSigma, InnoCentive, YourEncore and yet2.com. With new business models, these companies are exploiting the markets for problem solving, problem solvers and technologies, and are becoming part of an open innovation model for an increasing number of companies.

7.1.1 Purpose and Questions

The purpose of this study is to describe the emerging trend of new marketplaces for problem solving and technologies, and to discuss their role in corporate R&D strategies. This chapter will address the following questions:

- What types of R&D challenges are the new marketplaces able to address?
- Which industry sectors are the main users of these new marketplaces?
- What are the potential limitations of the new marketplaces for problem solving and technologies?
- What are useful insights for the Swedish policy discussion?

This chapter describes four of the specialized organizations that are active in the new external innovation markets. They have been identified as the main actors and they are dominating the U.S. market in this field. InnoCentive and NineSigma are intermediary actors on a problem solving market and act as "brokers" who bring together a problem solution seeker with a global network of problem solvers. These companies are sometimes referred to as e-R&D networks. YourEncore is another intermediary actor that connects experienced, retired researchers and engineers with member companies for short-term assignments. yet2.com is an example of a web-based company that offers customers help with buying and selling technologies (intellectual property) on an open market.

These marketplaces are examples of how companies are using internet-based technologies to overcome traditional barriers and outsource some components of R&D operations. There might be great potential for these global networks to develop and grow. However, it is yet too early to say how large and effective they will become.

This study is limited to exploring the new marketplaces, and does not cover the broader and evolving phenomenon of external, corporate R&D. These marketplaces are only one tool that companies can use in their search of external knowledge. The study is based on interviews with the actors on the innovation marketplaces as well as a number of secondary sources, including news articles, literature and various internet sources. It is important to note that the study relies on a limited number of sources and interviews. Most of the information about the marketplaces has been made available by the "broker" companies themselves, which means that the views of their customers, along with other independent perspectives, might be underrepresented in this study.

7.2 New Sources for Corporate Innovation

When the demands of quicker access to new innovations increase, more companies realize that it is no longer cost-efficient to rely only on in-house R&D. Many companies have implemented an open innovation model where internal R&D is complemented with external innovation sourcing and different forms of external cooperation. "Open innovation" (Chesbrough 2003) is a term used to describe the new model in which the company's R&D process is integrated with an external flow of new ideas, knowledge and technologies (Karlsson 2004).

The open innovation model drives the development of a global innovation market where the trade of research projects, patents, licenses, technologies, knowledge and problem solving is carried out. Change to an open innovation model requires a change in corporate culture – a new thinking that will have to be enforced from the top to make an impact (Teresko 2004). Using global innovation networks resourcefully and finding a balance between internal and external R&D activities are challenges for multinational companies (see the discussion in Chapter 2).

Procter & Gamble is one multinational company that has developed the open innovation model, by utilizing external R&D networks and new marketplaces for problem solving and technologies.

7.2.1 Procter & Gamble

The consumer product company Procter & Gamble (P&G) has been a leading user of external R&D networks for some time and is among the first to use the new marketplaces for problem solving and technologies. P&G, founded in 1837 and headquartered in Cincinnati, Ohio, is a multinational company with 98,000 employees in over 80 countries worldwide. P&G has three product categories: global beauty care, global household care and global health, baby and family care. With brands like Pampers, Ariel, Tide, Pantene, Olay and Pringles, P&G had a net sale of over 51 billion dollars in 2005. The company's competitors include Unilever and Johnson & Johnson. P&G has a large, global R&D presence with twenty R&D facilities in nine countries on four continents. P&G is granted, on average, one U.S. patent per day, and has more than 28,000 active patents worldwide (P&G 2006).

P&G spent 1.8 billion dollars on R&D in fiscal year 2004–05. In comparison, Ericsson spent 2.5 billion dollars on R&D in 2004 (see Chapter 2). The CEO of P&G, Alan G. Lafley, decided in 2003 that the goal should be to have 50 percent of the company's ideas and innovations come from external sources – a significant increase from the 2000 goal set at 10 percent (Greene 2003). Today, P&G retrieves more than 35 percent of its innovations from outside the organization (Huston & Sakkab 2006). The company has 7,500 researchers employed in-house all over the world. According to Larry Huston, Vice President for Innovation and Knowledge at P&G, there are an additional 1.5 million researchers in the world with the same skill sets. P&G's strategy is to include them in its organization and expand their knowledge network.

The reason for searching for outside ideas is the need to develop products faster, without having to do everything in-house, but instead leveraging the skills and knowledge of others (Huston).

To manage and access this large number of external researchers and to emphasize the increased external focus, P&G has replaced the term R&D with C&D – Connect and Develop (Huston & Sakkab 2006). External R&D partners can be used for all of the 150 research areas within P&G. P&G's external innovation network includes individuals, academia, government laboratories and intermediary companies, and makes use of intranet, websites and search engines. Besides using InnoCentive, NineSigma, YourEncore and yet2.com, P&G has an internal network called InnovationNet. It is a web portal – a "global lunch room" – on P&G's intranet that connects 18,000 P&G innovators in R&D, engineering, market research, patents and purchasing (Anthes 2004).

According to the company, the new innovation model has contributed to many of its successes. For example, the electric toothbrush was developed by an entrepreneur in Florida and today generates more than 200 million dollars in annual profits. According to Huston, P&G considers C&D to be in-sourcing, not out-sourcing, and has actually grown its R&D internally by bringing more ideas into the organization. P&G has been successful in decreasing its costs for R&D in relation to revenue, and at the same time been able to increase the total innovation capability. P&G has not replaced its own labs, which are closely linked to its customers, because critical aspects regarding customers can never be completely understood by outside partners, according to Huston (Huston).

7.3 Marketplace for Problem Solving

InnoCentive and NineSigma are electronic marketplaces that bring companies with specific R&D problems together with researchers and problem solvers around the world. The business concept behind these companies is to save time and money for customers by providing them access to qualified researchers without having them on their payrolls. Problem owners can access a global network of problem solvers to find the solution to their technology need. Researchers and problem solvers can live and work anywhere in the world.

There are a number of examples of how a marketplace for problem solving can benefit companies. A research group at Eli Lilly posted a problem on InnoCentive's website since there was no time to work on the problem in-house. Three months later the problem was solved by a retired researcher from a large research organization who earned 25,000 dollars for his work. The solution, a part of a new pharmaceutical drug, saved time and money for Eli Lilly. The company believes it could not have solved the problem internally for the same amount of money (InnoCentive 2005).

Another American pharmaceutical company had spent a year and a half trying to solve a pathology problem affecting cell samples. Within a month after posting the problem on InnoCentive's website, the solution was supplied by an unemployed protein crystallographer in San Francisco who received 10,000 dollars for the solution (Cantrell 2004).

7.3.1 InnoCentive

InnoCentive was created in 2001 and is a spin-off from the pharmaceutical company Eli Lilly. Eli Lilly created the company because it needed to address the problem of increasing R&D costs. InnoCentive wanted to prove that the open innovation model works and that a company can expand its access to the world's talent. InnoCentive is today an independent company based in Andover, Massachusetts. According to company sources, InnoCentive has a network of 80,000 problem solvers in 175 countries. Most of them live in China, the U.S., India and Russia. The problem solvers have backgrounds from academia, companies or they are students, retirees, etc. Since InnoCentive was created by a pharmaceutical company, this industry initially became its main focus. However, today InnoCentive handles problem solving within biochemistry, biology, nanotechnology and material sciences, and plans to expand into other disciplines and technology areas.

InnoCentive works constantly to build its network community and the skill sets of its researchers. InnoCentive has no customers (seeker clients) in Sweden today, but Ali Hussein, Chief Marketing Officer and Vice President of Global Markets at InnoCentive, says that they are starting to look more closely at Scandinavia for new customers. However, Sweden is among the top 20 of 175 countries when it comes to the number of problem solvers.

Companies announce research problems anonymously on InnoCentive's website, along with the award amount for a solution. InnoCentive also assists with problem-formulation before it is posted on the website. The customer company itself decides which solutions are acceptable. The person who solves the problem has the right to the solution until a deal with the company is made. Reportedly, there have been no issues with intellectual property rights (Hussein).

Besides an annual fee of 80,000 dollars, InnoCentive gets a small posting fee and a commission on the rewards paid (Torode 2004). There are two different types of problems or challenges: paper (theory) and lab challenges. Awards for paper challenges average about 30,000 dollars, and lab challenges can be worth up to 100,000 dollars. The InnoCentive network typically solves problems that are part of bigger problems or research projects and therefore are short-term assignments. The model can not be used to solve extensive problems like finding the cure for breast cancer (Hussein). Since the business started, customers have awarded more than one million dollars for solutions to 75 problems. Compared to the total number of problems that have been posted from the start, this represents a solution rate of 35 percent (Swiatek 2005).

InnoCentive had fewer than 30 people on its staff in 2005. According to Darren Carroll, Chief Executive Officer at InnoCentive, the company has the potential to grow during the next five years to around 200 people (The Wall Street Transcript 2005). Today, the company has about 40 customers (all U.S. and European multinational Fortune 500 companies). Among them are Boeing, DuPont and Procter & Gamble. The current business model limits expansion as there are a limited number of potential customers that would be able to pay the cost for using the service. InnoCentive says it is not limited to any scientific discipline or industrial sector, but rather to what types of problems and challenges the customers post. More Asian companies are expressing interest in the business model.

InnoCentive is currently searching for external investors to finance its expansion into the mechanical- and electrical-engineering sectors (The Wall Street Transcript 2005). InnoCentive envisions becoming the “e-Bay of the R&D world” (Hussein).

7.3.2 NineSigma

NineSigma was created in 2000 by a university professor in Cleveland, Ohio. The company currently has a staff of 17 and expects to grow by more than 30 percent in the near future. The founder realized that companies, in contrast to government agencies, did not have good processes for producing requests for proposals (RFPs). The business idea of NineSigma is to work closely with customer companies and write “requests for solution proposals” that can be distributed globally. These RFPs are later sent per e-mail to between 5,000 and 20,000 selected problem solvers in North America, Europe, Asia and Australia. The problem solvers come back with a bid of a few pages, which could include a specific solution, which is reviewed by the company itself to see if it matches their criteria of cost, approach, time, etc. The idea is to identify researchers and engineers that can solve the problem on a contract basis.

Most problem solvers come from the U.S., Europe and Asia. NineSigma’s network of problem solvers is created by active networking, recommendations from other solvers, scouting of articles, websites, etc. NineSigma has invited one million problem solvers from universities, companies and various research organizations to join the network (Stupay).

When the company was founded, its business was mostly research-related. More and more work is now done in the development area, for example, packaging and material issues. NineSigma has about two hundred projects per year within various industry sectors. According to Paul Stupay, Vice President of Business Development at NineSigma, some industries are more mature than others when it comes to using an open-innovation model. Because the pharmaceutical and chemical industries are more mature, NineSigma does a greater proportion of its business within these two industries.

All problems are written in English and the RFP process averages approximately 2.5 months. Confidentiality is important and agreements regarding intellectual property rights (IPR), licensing etc. are negotiated exclusively between NineSigma's clients and the selected problem solvers (Brez). The IPR arrangements are not pre-determined but will be negotiated by the two parties. About 60 percent of the problems are advertised anonymously and the solvers do not know which company is searching for a solution. NineSigma charges a fixed rate as well as a transaction fee. About 45 percent of the advertised problems are solved (Stupay).

NineSigma has about 60 companies as customers. The customers are mainly large companies, often market leaders within their industries. Among their customers are companies that spend the most money on R&D. NineSigma has a wider customer base than InnoCentive, but the companies have several common customers. P&G, Unilever, Kraft and Dupont Chemicals are some examples of NineSigma customers. Since 2003, P&G has been an important customer and, in fact, NineSigma's CEO was recently recruited from P&G. NineSigma has no Swedish customers but does have a number of Swedish problem solvers in its network, including individuals from the Royal Institute of Technology.

7.4 Marketplace for Problem Solvers

The U.S., Japan and Europe each face the challenges presented by the decreasing number of students pursuing advanced degrees in math and science, and the increasing number of researchers and engineers approaching retirement. This is expected to become a large problem in the coming 20 years (Freeman 2005). This insight generated a business idea at P&G that resulted in a new marketplace for problem solvers. The company YourEncore offers customers in the U.S. a pool of experienced retirees to solve problems on short-term assignments.

7.4.1 YourEncore

YourEncore was initiated by P&G. P&G had an original concept of using retired high- level scientists as resources for innovation and issued a request for proposal for an organization to develop and commercialize the concept. The winning proposal came from a company in Indianapolis, Indiana in 2003. YourEncore has established a network of 800 retired scientific researchers, product developers and engineers who are recruited for short-term assignments at member companies. YourEncore's customers are companies like P&G, National Starch, Boeing, 3M and Eli Lilly.

The business idea of YourEncore is to offer companies quick access to skilled people who represent no liability or management responsibility. The company handles the hiring process and makes a short list of potential retirees, which the customer company itself uses to select candidates for interviews and final selection. Member companies pay an annual fee to YourEncore and are charged a service fee for each retiree placement (Kostrzewa).

The number of retirees in YourEncore's network has doubled during the last year. According to Mike Kostrzewa, Executive Vice President at YourEncore, retired researchers in the U.S. would like to stay productive and have much knowledge to contribute. All retirees at YourEncore live in the U.S. and 35 percent come from three member companies – P&G, Eli Lilly and Boeing. Initially, YourEncore's focus was in the chemical sector, but today more and more engineers from other areas join the network. The company actively recruits retirees in new fields and tries to identify industries that will be affected by large retirements.

YourEncore works with trade organizations and it believes that the company is growing at a good pace. Anyone can join the network, and they become an employee of YourEncore when they get an assignment. The retirees receive all benefits from YourEncore and are paid a professional fee based on their exit salary (Kostrzewa).

The retirees are mostly needed within development, commercialization and project management. YourEncore is not typically used for early stages of research. Retirees work either on-site or remotely, depending on the nature of the project, and they are primarily hired for short-term assignments that last an average of 21 days. Sometimes retirees will work for their previous employers. According to Kostrzewa, YourEncore has a 100 percent success rate of project deliverable accomplishment, which is explained by the fact that the retirees will not take the assignment if they are not sure that they can solve it. All solutions belong to the member company (Kostrzewa).

YourEncore has 12 full-time employees and is located in Indianapolis, Indiana. The company expects that demand will continue to grow during the coming years. YourEncore has no presence abroad.

7.5 Marketplace for Patents and Licenses

Trade with patents and licenses is another part of the new innovation market. The market value is estimated to be 100 billion dollars and is growing rapidly (yet2.com 2005). Transaction costs of this trade are normally high for companies but the internet allows lower cost and an easier search. Patents within a company may be licensed to other companies and generate incomes.

According to the General Patent Corporation International, only a small percentage of all patents in the U.S. are commercialized (Lerner). yet2.com is an intellectual property shop – an external organization that helps customer companies exploit their intellectual capital.

7.5.1 yet2.com

yet2.com was founded in 1999 and is established in the U.S., Japan and the UK with a total staff of 20 people. After two changes in ownership, today the company is owned by its management. yet2.com helps companies create value from their technology-based intellectual capital by finding third parties that can improve or launch products based on that technology, or even build a business around it. Its original business idea was focused on helping companies sell intellectual property, but the company has now added the business of acquiring patents, licenses and technology to offer its customers. yet2.com is a marketplace on the internet where buyers and sellers meet in a simple way and where the buyer can be anonymous.

The needs of yet2.com's customers vary; one company may look for a specific technology with certain requirements, price and licensing conditions, while another company is looking for potential investors. According to Phillip Stern, Chief Executive Officer at yet2.com, companies realize that there is no need to invent things themselves when there is already a solution. Apart from the online service, yet2.com helps customers to search for innovations through partner contacts, articles and databases.

yet2.com helps customer-companies draft their web postings after conducting a thorough background search and rigorous interview process (i.e. discussing with the company what they already have tried, what did not work, etc.). yet2.com screens responses before they are sent to the posting companies and can also assist with the process of setting up an agreement. The cost to advertise is 1,500 dollars and companies are also charged a professional service fee. There were a few agreements made in 2003, 10 in 2004 and 20 in 2005 (Stern).

According to yet2.com, they have 100,000 registered users and about 250 clients that advertise on the website, including DuPont, Dow, Boeing, Procter & Gamble, Agfa and Microsoft. On the selling side, there is a mix of small and large companies who list technologies, but on the buying side, the listings are dominated by large companies. The associated, smaller companies are typically U.S.-based. In contrast, customers from Asia include almost exclusively large companies. yet2.com has no Swedish customers but received interest from some business developers in Finland. There are hundreds of people from Sweden and Finland who have registered as users with yet2.com (Stern).

About 60 percent of yet2.com's business is related to helping customers sell technologies, and about 40 percent is acquisition-related work. It has about 3,000 listings on its website and works actively on about 40 projects. The market is broad and yet2.com works with industries such as pharmaceuticals, consumer products, telecommunications, etc.

In general, yet2.com’s business model works best for fundamental technologies and not so well when it comes to design-related technologies. According to Stern, it is hard to say how many of the projects are successful, but about half of the projects result in a formal agreement between two parties. According to him, there are no major competitors. Companies generally either decide to search for technologies themselves or contract with a smaller specialized company in a certain industry (Stern).

Trade with patents and licenses was previously done mainly through contacts within the same industry. Today, the market is wider and companies often need innovations outside of their own industries. As an example, an engine constructor was looking for a new technology for fuel infusion and found the solution from a rocket manufacturer through yet2.com. DuPont uses yet2.com to access technologies outside its own competence area. Also, Dow has used yet2.com to identify new customers for its own undeveloped technologies. It is worth noting that chemical companies traditionally gave away unused patents, but today intellectual capital is marketed and traded in a way similar to traditional products (Wood & Scott 2004).

7.6 Concluding Discussion

As in many other OECD countries, the open innovation model increasingly replaces the traditional R&D model in the U.S. The marketplaces discussed in this study are a part of, and augment, the open-innovation model. There are strong reasons to believe it is here to stay, but to what extent this model will dominate in the future is difficult to predict. According to Chesbrough, even if external R&D can help create value, internal R&D is necessary for the value to be fully appreciated (Teresko 2004). The external innovation markets described in this study are only one aspect of the emerging open innovation model.

What types of R&D challenges are the new marketplaces able to address?

The new marketplaces serve companies in different phases and aspects of the product development process. InnoCentive focuses on research work, whereas NineSigma focuses more on development. While InnoCentive and NineSigma address the need for a quick problem solution, YourEncore solves the problem of an unexpected need for a skilled researcher or engineer. yet2.com answers the need for technologies already invented and the ability to generate revenues from innovations not used within the company. YourEncore and yet2.com solve problems in the later part of the development process, while InnoCentive and NineSigma are used at an earlier stage.

The problem solving market works for specific and clearly defined problems. Moreover, companies need to be very precise in defining a problem that should be viewed by problem solvers with different nationalities and different backgrounds. InnoCentive and NineSigma work well for problems that are part of larger research projects. Problems that cannot be precisely and clearly articulated are still the work for in-house R&D staff (Raynor & Panetta 2005).

InnoCentive and NineSigma have realized that companies need business services to support their innovation programs in addition to the web-based service initially offered. Utilizing the internet alone is not sufficient. YourEncore assists with finding retirees that will help with management, development and commercialization. yet2.com is useful when searching for fundamental technologies, but does not work as well with design-related technologies. According to Luc Vanmaele, Manager Technology Scouting at Agfa-Gevaert, wide search criteria are necessary when you are looking for technologies. Too much specificity may not generate a result. The "Saved Search" option on yet2.com's website is particularly useful for users according to Vanmaele. Each time a technology is added to the yet2.com database fulfilling the criteria mentioned in the Saved Search, the user receives automatically an email with the newly added technology listing. On the technology selling side, it is also easier to sell a portfolio of patents than a single patent at yet2.com, according to Vanmaele.

Which industry sectors are the main users of these new marketplaces?

InnoCentive was initially affiliated with chemical and pharmaceutical companies and NineSigma has supported these companies as well. Since their beginnings, these industry sectors have therefore been the focus of a large part of their work. However, both companies have expanded and NineSigma, for example, has today customers from the automotive, aerospace and consumer goods sectors. YourEncore was created by Procter & Gamble and has naturally recruited retirees from P&G, but also from early customers like Eli Lilly and Boeing. According to representatives from these marketplaces, they see a shift from the chemical and pharmaceutical industries to other industries such as material science, aerospace and consumer products. P&G said that using external R&D partners works for all 150 research areas that are found within P&G. yet2.com was not established by another company and has a much broader customer base than the other networks. yet2.com handles intellectual property within various sectors, such as the telecommunications and pharmaceutical industries.

YourEncore is recruiting more engineers and new customers, and both InnoCentive and NineSigma are in an expansion phase. They are faced with the challenge of finding more customers beyond the large and leading companies. In addition, their business ideas are limited to large companies due to the current cost structure. Smaller companies may find it difficult to afford the cost for these services. Most users are still

American and European global companies, but the Asian market is growing. The business idea seems to work for different industries, but some industries are more mature than others. YourEncore is actively looking for industries that have a large population of researchers who will retire during the coming years.

What are the potential limitations of the new marketplaces for problem solving and technologies?

Some industries are more developed than others in incorporating open innovation into their overall corporate culture and innovation strategies. For the marketplaces to grow, more companies have to realize that the open-innovation model works. For P&G, the use of external R&D partners is a necessary tool to stay competitive and it is part of P&G's corporate culture, according to the company.

Furthermore, InnoCentive's and NineSigma's expansion depends on their capability to find new problem solvers in new disciplines and new fields of science. The problem solving marketplaces cannot expand if they do not have the skill set in their networks. This is true also for YourEncore, which is recruiting new retirees in new fields.

Companies need help to articulate a problem in a way that potential problem solvers will understand. Until the seekers are skilled at specifying the problems, the market will not grow to its potential. In addition, external R&D networks are limited to certain problems and stages of the development phase.

Another possible limitation to market growth may be perceived intellectual property issues. For some companies, intellectual property is very important and their internal guidelines may limit the number of persons who can work with specific and perhaps sensitive problems. However, according to these organizations, they have the appropriate arrangements for dealing with intellectual property rights agreements and other security issues.

Not everybody believes in the idea of trading patents and licenses in these marketplaces. For example, Paul Lerner, Vice President at General Patent Corporation, believes that buyers and sellers will find each other without such means. According to Lerner, neither can websites, which are practically free, stay in business (Lerner). Luc Vanmaele at Agfa-Gevaert has a different opinion and says that yet2.com has the additional advantage of being a great idea generator. Furthermore, Vanmaele believes that the need for licensing new technologies will always remain. So far, Agfa-Gevaert has been successful in selling technology (patents), as well as in finding R&D-solutions on yet2.com (Vanmaele).

Conclusion

Many companies still insist they will continue to do most of their critical R&D work in-house. Ross Armbrecht, former President of the Industrial Research Institute, says that companies realize that “if they want a sustainable competitive advantage, they will not get it from outsourcing.” Companies have to focus on core R&D in-house and outsource some parts of the development, according to Ambrecht (Engardio & Einhorn 2005).

Larry Huston at P&G also predicts that internal R&D can never be replaced by external sources. Understanding customers’ needs and defining new problems must always be done by the companies themselves. According to executives at Motorola, the key is “to guard some sustainable competitive advantages, whether it’s control over the latest technologies, the look and feel of new products, or the customer relationship.” Further, the CEO of Motorola has said that a company has to draw a line between core intellectual property and commodity technology. The CTO of Nokia has expressed similar thoughts, realizing that “nobody can master it all” and that companies need to focus on the core and not the context (Engardio & Einhorn 2005). To find a balance between internal and external R&D is a challenge for multinational companies today. To create and use external networks to maximize innovation will be a key competitive advantage for companies (IFTF 2003). The marketplaces described in this chapter are just a few resources among many.

In conclusion, economic trends and increased competition have been the driving forces for the development of new external R&D markets. In addition, in many developed countries, fewer people are studying science and large numbers of researchers and engineers are soon expected to retire. A network that is accessible based on need, has access to technologies across industries and geographies, and is less of a risk and financial investment is appealing to companies looking externally for new innovations. The fact that these marketplaces are internet-based allows for greater potential for development of global networks.

The external R&D market is growing and extends to more industries and different types of problems. However, since the organizations discussed in this study are newer marketplaces, it is unclear how large and effective they will become. Access to venture capital and finding the skill sets for their networks are some of the challenges these marketplaces are facing. In addition, intellectual property, management, export control and national issues may be examples of challenges that could limit the market’s growth potential. According to the Institute for the Future, it is expected that during the next ten years, an experiment with different internal and external R&D forms will take place. Some will develop and survive, others will disappear.

Implications for Sweden

It is still too early to tell how important these forms of external innovation markets are as a part of corporate R&D strategies and company competitiveness. The evidence so far suggests that they might help to reduce cost, risk and time-to-solution for a set of limited and clearly-defined R&D problems. As of today, none of these new market-places have Swedish customers but three of them do have registered problem solvers in Sweden. The idea of using brokers for exchanging knowledge has been implemented in Sweden. However, these are initiatives on a smaller scale and with different approaches compared to the marketplaces discussed in this chapter.

It is likely that Swedish companies can also benefit from utilizing these networks. A low level of awareness may be one reason why Swedish companies are not active to-day. Going forward, companies will have to learn how to effectively integrate these external resources with in-house efforts before the full benefits can be realized. This learning process can take time and may also require a new corporate attitude toward exposing research problems to external actors.

Another opportunity exists for Sweden: to encourage researchers and problem solvers to join the global networks and compete for rewards and contracts. This would enable this critical community to gain experience from market-oriented R&D and create contacts with industry, while at the same time remaining within the academic research world.

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8 Silicon Valley: the Global R&D Hub?

Helena Jonsson Franchi

8.1 Introduction

Located in northern California, the Silicon Valley region is home to a large number of companies in the high-technology sectors of information technology, biotechnology and nanotechnology. To a great extent, these companies depend on successful research and development (R&D) for survival and to keep their competitive edge.

This region has been chosen as a case study for this chapter because it is considered to be one of the most dynamic and innovative high-technology regions in the world, and because it has consistently shown an ability to adjust rapidly to changes in the marketplace, while keeping its position as a leader of innovation and entrepreneurship. As the most R&D-intensive region in the U.S., Silicon Valley arguably has responded to the internationalization of corporate R&D in ways that could be of interest to other high-technology regions.

The purpose of this study is to examine the phenomenon of internationally distributed R&D, including offshoring, and identify new trends in Silicon Valley. The focus is on Silicon Valley companies establishing R&D activities in other countries and will not cover foreign R&D establishments in Silicon Valley.

Key questions:

- Has Silicon Valley been affected by internationalization, especially of corporate R&D?
- What are the driving forces behind this development?
- What are the impacts and effects of this development?
- What is the response from policymakers and others?
- What does the future of the region look like?
- What are the potential implications and findings of importance for Sweden?

This chapter is based on a review of the major findings from the most recent research, studies and media reporting, as well as interviews with researchers, think-tanks, venture capital firms, and small and large companies in Silicon Valley. Because of the complex nature of measuring the international distribution of R&D activities, there are no comprehensive data available showing the extent of corporate R&D moving or being established abroad from Silicon Valley, or even from the state of California. In some parts, the term “Bay Area” will be used instead of Silicon Valley. *The Bay Area is a region encompassing Silicon Valley and other areas in close proximity.*

8.2 A Dynamic High-Technology State and Region

8.2.1 What Is Silicon Valley?

Silicon Valley, as defined by the *Joint Venture Silicon Valley Network*, encompasses a region of the Santa Clara County and adjacent parts of San Mateo, Alameda and Santa Cruz Counties in northern California (part of the Bay Area). Often referred to as an "industry cluster," this area is well-known for having commercialized many of the important electronics and biotechnologies developed during the last 50 years.

The region has a population of 2.4 million, of which 40 percent is foreign-born (JVSV 2005). One-third of Silicon Valley's high-skilled workforce consists of immigrants, and more than half of these immigrant professionals have founded or work in startup companies (Saxenian 1999, Saxenian 2005).

The Bay Area hosts a large number of world-class public and private universities and research institutions, including Stanford University, University of California, Berkeley, University of California, Davis and University of California, San Francisco. It is also home to a number of interdisciplinary research centers, including Stanford's Bio-X, the Center for Information Technology Research in the Interest of Society (CITRIS) and the Center for Quantitative Biomedical Research (QB^3).

Silicon Valley has the largest concentration of information technology and biotechnology companies in the U.S.[1] (Zhang 2003). More than 25 percent of the software industry and 40 percent of the biotechnology industry in the U.S. is located in California. Some of these companies have grown to become industry leaders, including Hewlett Packard, Cisco, Sun Microsystems, Intel, e-Bay, Yahoo and Google (BAEF 2005).

In terms of percentage of sales, Silicon Valley companies have invested about three and a half times more in R&D (11 percent) than the national average (3 percent) (JVSV 2005). Six percent of the employment in the Bay Area is involved in research, development and innovation. This is two and a half times more than the national average (BJSA 2004). The dominance of large and small high-technology and research-intensive companies in Silicon Valley is one reason that the effects of internationalization of corporate R&D are more noticeable in this region.

8.2.2 Success Factors and Signs of Recovery

California is the seventh-largest economy in the world in terms of GDP (LAEDC 2005). About 45 percent of all venture capital in the U.S. is invested in California companies[2] and approximately 80 percent of that money ends up in the Bay Area and/or

[1] In 2001, 26,000 biotechnology companies were concentrated in Silicon Valley.
[2] Venture capital firms invested 9.3 billion dollars in California companies in 2004.

Silicon Valley. According to the *California Labor and Workforce Development Agency*, California, which invested 50 billion dollars in industrial and academic R&D in 2004, devotes more resources to R&D than any other state.

There are many different theories to explain the success of Silicon Valley. In the book *"Understanding Silicon Valley,"* for example, Martin Kenney presented three different perspectives. In the first perspective, Silicon Valley is considered an eco-system composed of interacting institutions, individuals and a culture that nurtures and encourages entrepreneurship. In the second perspective it is argued that in Silicon Valley, relationships are based on trust, which is based on performance, which in turn creates a nurturing environment for new ideas and talented individuals. And finally, in the third perspective it is argued that institutions specializing in creation of new companies are responsible for Silicon Valley's unique ability to foster technological advances (Kenney 2000).

Despite major economic success in the late 1990s, in 2001 the region entered a deep recession that lasted until late 2003, losing approximately 20 percent of its employment base. Starting in 2004, however, there were signs of businesses thriving again, entrepreneurs re-emerging, and increased venture capital investments in the region. This recovery has come after what renowned economist Joseph Schumpeter would describe as a period of "creative destruction" (Schumpeter 1942/1975).

8.2.3 The Next Big Thing

Even though Silicon Valley is recovering, there are new challenges facing the region. The technology industry has become more global and competitive since 2000 (BAEF 2005). The region's economic structure is shifting. The industry cluster that once consisted of semiconductor and software companies is transforming and new clusters (e.g. clusters of biotechnology companies) emerge.

Over the previous decades, as the region has gone through different "waves" of innovation, it has shown an ability to constantly innovate and create new businesses. "Silicon Valley has been shaped by past waves of innovation, including the commercialization of the integrated circuit (1960s–70s), the development of the microprocessor and personal computer (1980s), and the application of the Internet (1990s). Each time, these waves of innovation produced the 'next' Silicon Valley economy and changed the structure and mix of industries in the region*"* (JVSV 2002).

Many analysts consider the convergence of biotechnology, information technology and nanotechnology to be the "Next Big Thing" in Silicon Valley that will create new technological breakthroughs and new high-paying jobs for the region.

8.3 Internationalization: Dynamics and Driving Forces

8.3.1 A Globalized Economy

The California economy is one of the most globalized in the U.S. The reason for this has been summarized in five points: California has strong connections with Asia; high levels of service and manufactured exports; airports that serve as important nodes in global goods movement; and companies that engage in production sharing (Shatz 2003).

California was the second largest export state (after Texas) in the U.S. 2004. The same year, the state was responsible for 14 percent of U.S. exports, and international trade accounted for approximately one-quarter of its economy. The gap between California and the third most exporting state, New York, was 65.5 billion dollars in 2004 (MI 2005). Nearly 45 percent of California exports in 2004 went to Asia, 27 percent to Mexico and Canada, and 22 percent to the E.U. (IT 2005). California accounts for approximately 13 percent of total U.S. exports to the E.U. (22.8 billion dollars in 2004). In 2002, California's export value to Sweden reached 630 million dollars. Computers, electronic products and transportation equipment account for about 40 percent of total state exports (MI 2004, MI 2005).

California receives most foreign direct investment (FDI) in the U.S., with Europe as its largest investor (Figure 8-1). Inbound FDI from Europe into California reached more than 39 billion dollars in 2002, nearly 43 percent of the state's total FDI.

Figure 8-1 Foreign direct investment in California by country, 2000.

Property, Plant and Equipment			**Employment**		
Rank	**Country**	**Billion dollars**	**Rank**	**Country**	**Thousands**
1	Japan	31.3	1	Japan	149.4
2	United Kingdom	24.0	2	United Kingdom	138.2
3	Netherlands	14.0	3	Switzerland	82.8
4	Canada	8.6	4	Canada	67.8
5	France	8.3	5	France	54.4
6	Germany	6.9	6	Germany	51.6
7	Switzerland	5.0	7	Netherlands	44.6
8	Australia	4.9	***8***	***Sweden***	***28.8***
9	South Korea	2.2	9	Bermuda	18.2
10	Taiwan	1.9	10	Australia	15.5
	All Countries	120.9		All Countries	737.6

Source: MI 2004, based on data from the U.S. Bureau of Economic Analysis.

California's outgoing direct investment mainly goes to European countries, for example the U.K., France and Germany (Figure 8-2).

Figure 8-2 California's outward direct investment by country, 2001.

Rank	Country	California Share (percent)
1	United Kingdom	10.4
2	Canada	7.0
3	France	6.2
4	Germany	5.6
5	Netherlands	5.2
6	Japan	4.5
7	Australia	4.1
8	Hong Kong	3.4
9	Singapore	3.0
10	Italy	2.9

Source: MI 2004, based on data from the U.S. Bureau of Economic Analysis.

8.3.2 Internationalization of Corporate Activities

High-technology companies value Silicon Valley because its proximity to financing, research, and a skilled labor force provides an excellent environment for startups to develop innovative ideas. However, when those companies become mature and move into mass production and provision of routine services, their concerns turn to reducing operating costs and creating sustainable business models. At that point, many successful Silicon Valley companies have set up branches of operation elsewhere.

The most common form of all kinds of outsourcing by companies in California still seems to be domestic outsourcing, mainly in production. According to Junfu Zhang, more high-technology companies are moving out of Silicon Valley than are moving in. For example, the yearly net effect on the labor market between 1990 and 2001 due to company migration was less than 0.2 percent of the total employment in the state. High-technology companies are more likely to move than non-technology companies and some high-technology companies are more likely to migrate than nanotechnology companies for example. Those moving out tend to be older companies, while those moving in tend to be younger. When companies do move out of Silicon Valley, the often settle in nearby California cities (BAEF 2005, Zang 2003).

Earlier, companies used to first outsource domestically, and perhaps later considering the foreign option. More recently, companies have shown tendencies to offshore business activities directly, bypassing the domestic option (Bardhan & Jaffee 2005). According to an interview-study, 94 percent of semiconductor and software companies in the Bay Area have used some offshore resources. While these high-technology sectors appear to be the most affected, biotechnology companies, financial institutions and other companies have used similar strategies (BJSA 2004).

As in many developed regions around the world, internationalization of companies in Silicon Valley has steadily been moving up the value chain and reached the R&D segment. As mentioned in Section 8.1, there are no comprehensive data available showing the extent of corporate R&D moving or being established abroad from either Silicon Valley or California as a whole. However, according to an interview with Ashok Bardhan at the University of California, Berkeley, the share of R&D established abroad is increasing, and practically every major company in Silicon Valley uses this option. This is also true for a number of a small companies and startups, but so far to a lesser extent.

The R&D activities located abroad are mostly performed by a company's foreign affiliates in order to protect proprietary business procedures and other intellectual property rights. Silicon Valley companies – particularly those specializing in biotechnology and pharmaceuticals, software, engineering design and development, animation and simulation, and basic research in physical sciences – tend to locate their foreign R&D in India, China, Taiwan, Korea, Singapore and Eastern Europe (Bardhan & Jaffee 2005).

A few examples of companies with origin or headquarters in Silicon Valley and their R&D establishments in emerging markets include:

- *Oracle.* Oracle was one of the first international companies to establish R&D centers in India, opening one in Bangalore in 1994, and one in Hyderabad in 1999. The R&D centers in India are Oracle's largest R&D operations outside the U.S. The centers mainly work on Oracle's database products, business intelligence products, applications and application development tools (Balachandra 2005).
- *Hewlett Packard (HP).* HP has established HP Labs in Bangalore in India 2002. The lab is dedicated to high-level research on futuristic technologies, with a focus on emerging markets (Balachandra 2005).
- *Sun Microsystems.* Sun has established four R&D centers around the world: Bangalore (India), Beijing (China), St. Petersburg (Russia) and Prague (Czech Republic). The facility in Bangalore employs 1,000 engineers, a number it expects to double in the next few years (CBR 2005).
- *Google Inc.* Google opened an R&D facility 2004 in Bangalore (India) where the employees will be involved in all aspects of the company's engineering work, including conception, research, implementation and deployment (Lemon & Thibodeau 2004).

8.3.3 Driving Forces

The two major driving forces for companies establishing R&D abroad are access to skilled labor and the need to reduce costs. This is true for both unaffiliated and affiliated offshoring of R&D (Bardhan & Jaffee 2005). Improvements in telecommunications, an emerging economy's entry in the global economy, and the growing ability of other countries to provide quality services and manufacturing are also important factors. Other drivers for internationalizing R&D are the fact that R&D has become an increasingly multidisciplinary and costly process over the years. For many companies, establishing R&D abroad also provides access to and knowledge about major emerging markets. This shift in focus has led to a changed business model, where companies draw on global pools of talented individuals, technologies and capital, reducing costs and increasing efficiency though outsourcing and offshoring (JVSV 2005). Many new companies no longer consider themselves to “Silicon Valley companies,” but think of themselves as “global companies.”

In order to reduce costs for startup companies, Silicon Valley venture capital firms are encouraging them to send production development work overseas, meaning that these companies become multinational more or less from the start (BJSA 2004, interviews). According to an article in *Computerworld*, most startup companies are as keen on lower wages as on talent as a reason for offshoring, even though the major company Google was more explicit about the latter (Lemon & Thibodeau 2004).

Venture capital firms are also extending their activities abroad. For example, the well-known venture capital firm Draper Fisher Jurvetson has partnered with 17 companies across five contents giving Draper access to a globally diversified deal flow. Draper calls this its “affiliated network.” This trend indicates that venture capital flows into high-technology startups now have gone trans-national (Red Herring 2006).

8.3.4 The Power of Immigrants

The large Asian population in California plays an important role in forming strong connections between California and Asia, especially with emerging economies like China and India. This fact is especially evident in Silicon Valley.

According to AnnaLee Saxenian, tens of thousands of immigrants from developing countries came to the U.S. in the late 1970’s for graduate engineering education and decided to stay in Silicon Valley to work. In 2000, more than half (53 percent) of the scientists and engineers in Silicon Valley were foreign-born, with immigrants from India and China accounting for more than one quarter of all scientists and engineers (Saxenian 2005).

Saxenian argues that the same individuals who once left their home countries for a better lifestyle are now returning, reversing the “brain drain” and transforming it into “brain circulation” while maintaining social and professional ties to the U.S. The return of these individuals prompts knowledge-transfer from the U.S. to their home countries (Saxenian 2005). These ties have also proven to have measurable economic benefits. Researchers from the University of California-Berkeley argue that “for every one percent increase in the number of first-generation immigrants from a given country, exports from California have gone up nearly 0.5 percent” (Bardhan & Howe 1998).

Companies have begun capitalizing on the increasing desires of foreign-born, U.S.-trained workers to return home. A *BusinessWeek* article stated that hundreds of Indians have returned to India from Silicon Valley since 2000 to start their own businesses or help expand R&D laboratories for Cisco Systems, Oracle, Intel and other companies. Major companies like Microsoft and Intel have even organized job fairs in Silicon Valley for foreign-born, U.S.-trained high-technology workers willing to return to their homeland (Hof 2003). This phenomenon is sometimes characterized as “the new B2B – Back to Bangalore” movement, and is considered a relatively new and important trend in Silicon Valley. Some experts also consider this trend to be one of the drivers for offshoring of different business segments from Silicon Valley to India and China.

According to several of the interviews made for this study, as well as AnnaLee Saxenian’s research, this connection between Silicon Valley and emerging Asian markets of India and China is considered to be an important benefit for the region in terms of global competition (Saxenian 1999, Saxenian 2005, interviews).

8.4 Impact and Effects

There are many different views on how Silicon Valley has been, or will be, impacted by the internationalization of corporate R&D.

Most scholars studying Silicon Valley and the Bay Area believe that the internationalization of R&D is not a threat to the regional economy. Instead, they argue, given Silicon Valley’s demonstrated adaptability, this trend provides opportunities to create a stronger economy for the future.

However, there are also concerns among some analysts that offshoring R&D will cause heavy job losses, leading to high unemployment in the region and a hollowed-out economy. More investments abroad might mean fewer investments at home or even the closing of existing R&D facilities. Another concern is that certain occupations will disappear, causing the region to lose its leadership in many areas.

Some studies show that offshoring is only one factor behind the job creation and job losses in the Bay Area and appears to be less important than other factors such as technological change and outsourcing of jobs within the U.S. (BJSA 2004). However, as this section discusses, it is clear that Silicon Valley and the Bay Area have has been affected by offshoring of corporate R&D.

8.4.1 Small, Innovative Companies Stay

While more R&D jobs are being sent offshore, there are also R&D gains to the region. Results from a survey of 48 technology companies in California show that it is mostly large companies that establish or relocate R&D abroad (Bardhan & Jaffee 2005).

According to some studies, there is clear evidence that smaller and more innovative companies also internationalize some of their business activities. These smaller companies tend to keep their more advanced R&D in the region.

Some findings also show that new, small businesses will keep most of their jobs in the Bay Area until their business processes and products mature. To a greater extent than in the past, these companies create most of the innovation and new jobs in the region. When Bay Area companies expand, they will start creating more jobs and relocate existing jobs outside the region (BJSA 2004).

The fact that venture capital firms encourage the companies they invest in to consider internationalization of certain business segments is affecting the Bay Area job market. According to experts, R&D connected to product customization and development will continue to go elsewhere, including to other parts of the U.S.

8.4.2 The Importance of Capitalizing on Regional Strengths

The rapid growth of markets outside the U.S. is driving Bay Area and Silicon Valley companies to locate some of their activities closer to their customers. Companies today must identify which functions to move closer to important markets and which to keep in the region. The companies also need to find new ways to collaborate, complement and compete with companies abroad.

The Bay Area's regional strengths will play a larger role than before. Business segments that are aligned to the region's strengths are more likely to create new jobs and growth, such as research, marketing and headquarter functions. Design and development segments are likely to be increasingly distributed as companies move them closer to manufacturing facilities and customers (BJSA 2004). Examples of initiatives targeted toward improving state and regional competitive strengths are mentioned in Section 8.5.2.

One likely result of these trends is that ideas and funding will come from the U.S., while more of the R&D work needed to bring products to markets will be done abroad.

8.4.3 Change in Employee Structures

Some of the experts interviewed for this study mentioned that one impact of offshoring from Silicon Valley is that the R&D skill level in the region is moving up the value chain and the mid-range skill level shows tendencies of being "hollowed out." The Bay Area has shown tendencies to lose out to other regions in engineering jobs associated with cost-reduction, fine-tuning processes and expanding product features. These engineering jobs are expected to decline further.

Widespread offshoring of research and engineering work might lead to fewer job opportunities, and discourage students from pursuing careers in these areas. This in turn could weaken U.S. leadership in technology and innovation, and, according to some analysts, could lead to serious repercussions for national security and economic competitiveness (BJSA 2004).

According to Martin Kenney and Rafiq Dossani, U.S. engineers are now in competition with engineers in developing countries whose wages are 40–80 percent lower than the U.S. Due to technological advancements “increasing portions of engineering work can be done without close proximity to particular persons, places or other processes.”

For the most highly-educated and talented engineers in the U.S., offshoring will likely have little impact. There will always be a demand for them and they will always be rewarded financially for the value they create. The concern is for the other 90 percent who will have to compete internationally (Kenney & Dossani 2005, and interviews).

The requirements for existing occupations are also changing. For example, the ability to manage remote projects and teams and bring multinational experience to an organization, are now more requested skills, compared to before (interviews).

8.5 Policy Response and Recommendations

8.5.1 Anti-Offshoring Bills

Offshoring in general was a hot topic in the U.S. about two years ago. According to several experts the debate has since quieted, mainly due to a stronger economy that has created more jobs, and further research that has been conducted on the subject.

On the one hand, there are many policy issues connected to offshoring that are controlled by federal policymakers, including H1-B visas (which allow skilled foreign labor to work in the U.S.), tax policy, intellectual property controls, and region-specific trade restrictions. The states are, on the other hand, self-governed to a certain extent, and have the power to introduce legislation restricting certain aspects of offshoring. However, most policy makers in the U.S. act with caution when it comes to regulating the private industry.

According to the National Foundation for American Policy, only five anti-offshoring bills in the U.S. became law in 2004, and none of them were far-reaching. In 2005, 40 states introduced anti-offshoring bills, several of which were vetoed by Republican governors in California, Massachusetts, and Maryland.

Most state bills seeking to restrict offshoring fell into two categories: (1) restricting state contract work being performed abroad; and (2) limiting the use of offshore call centers. Several state legislators also are trying to prevent personal data from being sent outside the U.S. Existing federal law permits sharing of data among affiliate entities without regard to geography and provides for recourse against U.S. companies that fail to take appropriate safeguards to protect consumer privacy (NFAP 2005).

According to experts interviewed for this chapter, California legislators have taken no direct action to limit offshoring. Several bills that would have reduced offshoring were vetoed by California Governor Arnold Schwarzenegger, and, according to several analysts, he will veto any other anti-offshoring bills that come before him. In 2005 alone, nine anti-offshoring bills were presented in California; none of them have passed so far.

The lack of policy response is mainly due to the fact that company re-location is not considered to be a serious problem in California, mostly because it does not occur at significant levels (Zhang 2003).

8.5.2 Indirect Responses

There are a number of indirect responses by California policymakers and others that can be looked upon as responses to pressure from global competition and internationalization. These measures are not aimed at limiting offshoring as such, but instead build on improving the state's existing strength and preparing for future technological breakthroughs.

In the case of California, indirect responses have mainly focused on creating a more favorable R&D environment in the state, and promoting programs targeting certain high-technology areas. The aim is to promote economic growth by supporting industries that are expected to generate high-paying jobs.

Centers of Excellence

As a step toward keeping California and Silicon Valley competitive in the global marketplace, the former Governor of California, Gray Davis, initiated the creation of four Centers of Excellence in 2000, also referred to as California Institutes of Science and Innovation (CISI).

These four institutes represent a billion-dollar, multidisciplinary effort built upon a public-private partnership focusing on research areas considered critical to sustaining California's economic growth and global competitiveness. Governor Davis has expressed that he expects new technological breakthroughs to occur at these institutes and that it is important for California that these activities were kept within the state.

The four institutes are: the California Nanosystems Institute (CNSI), California Institute for Telecommunications and Information Technology (Cal-IT^2); California Institute for Bioengineering, Biotechnology and Quantative Biomedicine (QB^3); and the Center for Information Technology Research in the Interest of Society (CITRIS) (UCOP 2006).

Nanotechnology Blue Ribbon Task Force

California has a leading position in many growing markets, particularly in the semiconductor and biotechnology industries. Nanotechnology is considered to play a critical role as an “innovator” in these markets. Nanotechnology is also considered to have a major market potential, by some analysts expected to exceed the market value of information technology in the future.

To ensure California’s leadership within the field of nanotechnology, a Blue Ribbon Task Force was appointed by State Controller Steve Westly and Congressman Mike Honda in 2004. The 48-member panel is comprised of nanotechnology experts from industry, academia, government and venture capital firms from across the state. The objectives were to evaluate the status and what actions were needed from state and federal policymakers to make the nanotechnology industry a state success.

The Task Force suggested launching a “California Innovation Initiative” as a step toward taking advantage of the convergence of the strong base of nanotechnology, information technology and biotechnology assets in the state. These emerging technologies are extremely disruptive and California is aiming at becoming a leader through a strategic and coordinated effort (BRTSN 2005).

Stem Cells Initiative – Proposition 71

In the 2004 November election in California, voters approved a three-billion dollar bond to fund embryonic stem cell research over 10 years. The California Stem Cell Research and Cures Initiative (Proposition 71) will give California the “potential to emerge as a global leader in the development of stem cell therapies, create high-wage jobs and foster the establishment of new biotechnology companies” (MI 2005).

Already, top-level researchers and stem cell companies from other states and countries are establishing themselves in California to take advantage of these funding opportunities. This is an example of inward affiliated offshoring that could contribute to improving the R&D environment in California.

On the other hand, some experts interviewed for this study question whether the state government really should allow voters to select technological winners, claiming that California is more likely to find big winners in IT and biotechnology generally, rather than in one single area.

R&D Tax Credit

Many countries offer a number of tax incentives for attracting foreign companies and their R&D activities. Part of the effort to reduce offshoring of R&D, is to make the R&D environment in the U.S. more favorable, and several major multinational companies (some from Silicon Valley) have lobbied federal legislators to update and extend the existing R&D tax credit.

The present federal tax credit expired in December 2005. Congress is expected to announce an extension soon which will include a major increase in tax credits calculated by a new formula more favorable to growing companies. The new formula is calculated on R&D spending over the last three years and the tax credit can reach up to 20 percent (Puzzanghera 2005). President Bush also recently proposed to work with the Congress to make a new R&D tax credit permanent (ACI 2006).

The state of California offers all companies that conduct R&D in the state a tax credit. The tax credit is 24 percent for basic research and 12 percent for other types of research on the state corporate income tax (FTB 2006).

8.5.3 Policy Recommendations

According to a report by the Government Accountability Office (GAO), proposed policy responses on the federal level in the U.S. can be divided into four categories: 1) improving U.S. global competitiveness; 2) addressing effects on the U.S. workforce; 3) addressing security concerns; and 4) reducing the extent of offshoring (GAO 2005).

Examples of proposals to improve U.S. competitiveness include increasing government support for R&D and improving education and training of U.S. workers (GAO 2005).

There have also been some proposals to limit the effects of offshoring on U.S. workers. On a federal level, some of the measures have the aim to limit the effects of displaced workers from production being offshored.

For example, the Trade Adjustment Assistance (TAA) program, established in 1974, provides financial assistance to individuals who lose their manufacturing jobs due to foreign imports or shifts in production to foreign countries. Services available for qualified workers include weekly income assistance, training, and job search and relocation services. Analysts have suggested that the U.S. Congress expand the coverage of the TAA to include service workers (Brainard & Litan 2004).

Another proposal for addressing effects on the U.S. workforce, that has received attention, is to introduce wage insurance. This wage insurance, combined with subsidies for health insurance, would be available to workers who lose their jobs through "no fault of their own." The insurance would take effect only after the laid-off person finds a new job: if the new position pays less than the previous job, the worker would receive half the salary difference for up to two years (Kletzer & Litan 2001).

This program can be seen as a reaction to the fact that not only manufacturing jobs are being offshored but also other business segments, including services and R&D.

Proposals to address security concerns are mainly targeted towards national security, critical infrastructure or privacy of personal data. Some proposals are aimed at restricting work that can be conducted in foreign locations and others are aimed at strengthening requirements for governing security and data protection (GAO 2005).

Proposals to reduce the extent of offshoring include prohibiting or limiting offshoring in government procurement, and improving tax provisions or incentives for companies to locate work in the U.S. (GAO 2005).

In northern California, regional organizations like the Joint Venture Silicon Valley Network, Bay Area Economic Forum, Public Policy Institute of California, and California Council of Science and Technology, are closely monitoring internationalization of the Bay Area and Silicon Valley's R&D, and making recommendations to policymakers at the state and federal level to maintain Silicon Valley's position as one of the most innovative regions in the world.

Some of these recommendations are:

- Promote technological innovation by securing federal R&D dollars.
- Encourage business development through tax breaks, industrial parks, high-technology incubators, capital for commercialization of research and improved quality of life in the region.
- Consider each region a connected economy that interacts with other regions.
- Maintain a dynamic labor pool by upgrading the skills of the existing labor force, recruiting new talents from universities and hiring qualified immigrants (Zhang 2003).

8.6 The Future of the Region

8.6.1 In Good Shape

Silicon Valley is in good shape to meet the challenges of internationalization, including the challenges of R&D offshoring. California still has one of the largest markets, the most venture capital, an "infrastructure of innovation," and a diverse labor pool. These and other strengths will continue to be persuasive reasons for companies to establish themselves in the region.

An emerging strength in the Bay Area is its proven ability to manage and integrate business relationships across companies and international borders (BJSA 2004). According to experts, the ability to manage and coordinate external relationships and global distributed functions will be a very important competitive advantage in the future.

Globalization of R&D brings both opportunities and challenges, for example companies need be able to coordinate R&D efforts across national boundaries. As pointed out in an article: "Increases in R&D cost forces specialization. Then put together an assembly of specialists. The problem is that they are everywhere. Therefore being able to put them together becomes the differentiator" (SPRIE 2005). According to several analysts, it is predicted that Silicon Valley will become a, if not the, nexus of global R&D networks. Ross De Vol, Director of Regional Economics at the Milken Institute, recently expressed the same thought: "The Valley is becoming a node for an international network, probably the leading node on the network" (Said 2005).

8.6.2 Trends and Developments

This section summarizes some trends and developments in Silicon Valley, based on interviews conducted for this study (see the list of interviews). This is to give the reader a feeling of what is going on in Silicon Valley, even though there is little or no published data available to confirm some of these statements. However, these findings could be of importance to other innovative regions experiencing similar developments now or in the future.

Small companies go global earlier. Small high-technology companies are "going global" much earlier than they have in the past. At the same time, Silicon Valley is predicted to depend more heavily on such companies in the future, partly because they will conduct most of their advanced R&D and create most of the new jobs in the region. Large companies are expected to have most of their employees in other countries.

Top level of R&D stays in the region. The "Cisco Model" for internationalization of R&D is predicted to be used by companies to a greater extent in the future. According to the model, the most innovative work will stay in the region, while non-innovative work such as production development and customization will be moved elsewhere, mainly to affiliated offices. (There are signs that that this may no longer be true for India, however.) If R&D (or other business activities) can be done elsewhere to lower cost and to equal or better quality, it will be.

Venture capital firms drive offshoring. The trend seems to be for venture capital firms to drive their portfolio companies to offshore parts of their business activities, and that companies in some cases must justify not offshoring all segments of their businesses. Venture capital firms also are requesting workers and management teams with more global experience. Consequently, some universities, such as Stanford, are shifting their programs to become more global (global management and global knowledge-oriented) to meet market demands. According to interviews, Silicon Valley venture capital firms are trying to include at least one Chinese and one Indian employer or manager in their company (mainly in the information technology sector). Presumably, these managers have strong language skills, specialized knowledge about their home markets and the U.S. market, and can serve to connect the two.

Silicon Valley: a world hub for venture-capital? In the past, Silicon Valley venture capital firms have invested only in local companies. The current trend is to go regional, national and global; more venture capital firms now invest outside Silicon Valley and even overseas, and some analysts have predicted that this development may transform Silicon Valley into a world hub for venture capital, as New York is a world hub for financial markets or Chicago is for commodities.

Some venture capital firms and investment banks in Silicon Valley have set up branches in Asia. For example, Silicon Valley Bank, which lends capital to high-tech startups, opened a branch in Bangalore, India, in September 2004.

The role of government could expand. It will be important for political and educational systems to respond earlier to new market demands, especially in providing a skilled or retrained workforce. The government's role in business could become more important in the coming years; the government must prepare the nation and its innovative regions to be more competitive in the global marketplace. For example, the government will have to provide high-class education, a skilled workforce, and attractive infrastructure, as well as find ways of attracting foreign talent.

Skill levels are on the rise. The R&D skill level of researchers and engineers has gone up in Silicon Valley in the last five years, and is expected to continue to rise. There are concerns that the mid–range level skilled labor could be hollowed out as the market for middle engineers shrinks due to offshoring and outsourcing to other regions and countries.

Employee structures and career patterns are expected to change in Silicon Valley because of offshoring and outsourcing.

Coordination of skills will be a competitive advantage. The ability to coordinate all business activities (local, outsourced and offshored) in a timely and efficient manner across different time zones will be a much more needed skill in the future. Also, the ability to manage cultural differences between staff at the R&D centers and Silicon Valley headquarters is becoming even more important.

8.7 Conclusions and Implications

8.7.1 Conclusions: Main Findings

Some of the most interesting findings from internationalization of corporate R&D in Silicon Valley are described below.

Has Silicon Valley been affected by internationalization, especially of corporate R&D?

As in many developed regions around the world, internationalization by Silicon Valley companies has steadily been climbing up the value chain and reached the R&D segment. It is mostly the large company strategy to establish R&D activities abroad. This is expected to change during the next few years. This kind of offshoring is primarily affiliated, due to intellectual property (IP) protection and security reasons. However, smaller and more innovative companies, driven by venture capital firms trying to encourage cost reduction, are also beginning to engage in internationalization. Both large and small Silicon Valley companies are also showing tendencies to offshore directly, bypassing the domestic option.

What are the driving forces behind this development?

The most significant forces driving the offshoring of corporate R&D to foreign countries are: the need to reduce costs and the increased access to skilled labor overseas. In addition, companies also use offshoring of R&D to gain access and knowledge about emerging markets. The large number of Asians in Silicon Valley play an important role for the regions connection with emerging markets such as China and India. Finally, another important driving force is the venture capital firms encouraging their portfolio companies to consider locating part of their business activities abroad in order to cut costs.

What are the impacts and effects of this development?

While the internationalization of corporate R&D has affected Silicon Valley to some extent, some studies show that offshoring is only one factor affecting job creation and job losses in the region, and is less important than other factors, including technological change and outsourcing within the U.S.

Some interesting findings show that small companies have increasingly established parts of their business functions abroad. At the same time, however, these same smaller companies will keep most of their jobs in the region (compared to the larger companies) and will create most of the innovation and new jobs in Silicon Valley. Those business segments that that are aligned to the region’s strength are most likely to create new jobs and growth. Another noticeable trend is that the skill level of researchers and engineers are moving up the value chain. Engineering-associated occupations are especially vulnerable to competition from other countries, and it is likely the region will see further job losses of this type in the future.

What is the response from policymakers and others?

There has been no direct response from California policymakers addressing the concerns of offshoring R&D. However, a number of indirect responses can be explained, at least in part, as responses to pressure from global competition and internationalization. These indirect responses in California are mainly directed towards creating a more favorable R&D climate in the state, and promoting programs that target those high-technology sectors in which Silicon Valley specializes.

What does the future of the region look like?

Silicon Valley seems to be prepared to meet the challenges of internationalization of corporate R&D. The region's ability to manage and integrate business relationships across company and country borders is a competitive advantage in a globalized economy. The Bay Area and Silicon Valley region is poised to become a global nexus for R&D networks.

8.7.2 Implications for Sweden

There are some similarities between Silicon Valley and Sweden. For example, both economies are high technology-driven with similar industries, both are already heavily globalized and both already make large investments in R&D. What can Sweden learn from Silicon Valley's experience with internationalizing R&D activities? This section will describe some potential implications and issues for Swedish policymakers to consider.

Continue Monitoring Developments

It is important for Sweden to monitor those developments driven by internationalization in successful, innovative, high technology-driven regional economies like Silicon Valley, and to learn about these developments in general and to identify possible implications for Sweden at an early stage. Early detection can lead to early and proactive responses from policy makers.

Attract Foreign Talent

In Silicon Valley, immigrants with connections to their home countries play an important role in developing the region's economy, including the internationalization of corporate R&D. Sweden could take advantage of similar possibilities. Attracting foreign talent from nearby emerging economies, like Russia and Eastern Europe, could add new talent to the Swedish universities and to the labor pool (in particular in science and technology). This in turn would create better network linkages to these emerging markets.

How Do Small Swedish Innovative Companies Grow and Go Global?

The small innovative companies in Silicon Valley are expected to grow the most, to generate most of the new jobs and to create most of the new products. There are also signs that small and startup companies go global very early often through initiative from investors. These trends should be further explored and the associated policy implications carefully considered.

Does the Educational Structure Require Adjustment?

Are the R&D skill levels in Sweden, like in Silicon Valley, climbing up the value chain? Does Sweden need to adjust its educational structure to meet new market demands and to keep its workforce competitive in the global marketplace?

Market Swedish Strengths in the Global Economy

The ability to manage and coordinate external relationships and global distributed functions will be a very important competitive advantage in the future. Sweden has major strengths in this area that could be used, marketed and perhaps further developed to a greater extent.

Assess Sweden's Potential to Become Active Player – or Nexus – in Global R&D Networks

It has been argued that Silicon Valley has the potential to become a nexus of global R&D networks, which will orchestrate networks of global research projects. In a globalized economy it is of great importance for Sweden to monitor, and be an active player in, these networks. In some areas, Sweden may be well-positioned to serve as a nexus of internationally distributed R&D activities.

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Venture Capital Company A.*

Venture Capital Company B.*

Major IT Company A.*

Small IT Company A.*

Small IT Company B.*

** Wished to remain anonymous*

9 Japan: Internationalization of Corporate R&D

Kyoko Nakazato & Bogumil Hausman

9.1 Introduction

Japanese companies have a tendency to conduct R&D in-house and have a much lower share of R&D in foreign units than other developed countries (see Chapter 2). In 2001 the share of manufacturing R&D under the control of foreign affiliates was only 4 percent in Japan.

Historically the strength of Japanese manufacturing companies was believed to be based upon close interaction between the R&D division and manufacturing division, including suppliers (Odagiri 2005). To maintain this interaction, the functions were internationalized as part of an export-led strategy, which caused delay of full-fledged overseas production. The internationalization of R&D activities also started relatively late (Iwasa & Odagiri 2004).

The purpose of this chapter is to analyze the ongoing process of internationalization of corporate R&D in Japan and address the following key questions:

- How strong is trend to internationalize corporate R&D in Japan? How much inward and outward R&D investments and other forms of international collaboration are taking place?
- What driving forces and barriers are specific to Japan?
- What are the future trends and implications for Sweden and Swedish policymaking?

Material presented in this chapter is based on interviews with companies, policymakers and researchers and on the review of existing written resources.

9.2 Internationalization of Corporate R&D in Japan

9.2.1 Basic Concepts

The purpose of R&D activities conducted abroad by multinational companies can be divided into three basic categories (see UNCTAD 2005 and the discussion in Chapter 2):

- *Adaptive R&D*. These activities include basic production support and the modification and upgrading of the existing technologies and products for the local market.
- *Innovative R&D*. This includes development of new products for the local market and eventually for the global market.

- *Technology monitoring*. This is conducted primarily to assure access to the local innovation system and to follow the latest research and technology development.

Japan has long employed somewhat different concepts of the above categories. One concept is *sourcing*, understood as sourcing of local technological strength (e.g. through interaction with local researchers at universities and other companies). The sourcing category includes also the utilization of local R&D resources (e.g. researchers, research facilities, R&D performing services) as inputs (Odagiri 2005). The sourcing concept corresponds to the above categories of innovative R&D and technology monitoring.

The other concept is *support*, defined as support of local sales (e.g. the development of products suitable for local taste or performing clinical tests required for the local market). Following this definition, support would correspond to adaptive R&D.

9.2.2 Japanese R&D Expenditure

Japan's total expenditure on research and development during fiscal year 2003 was 168 billion U.S. dollars, an increase of 0.8 percent from the previous year. The amount has increased for four consecutive years. Compared to other big economies, Japan holds the third position after the U.S. (329 billion dollars) and the European Union (220 billion dollars) (MEXT 2004b).

The ratio of total R&D spending to GDP was 3.35 percent in year 2004. With this figure Japan maintains one of the highest ratios among the major advanced nations (after Israel, Sweden and Finland) (OECD 2005).

A breakdown by institutions shows that in 2003, the industry sector performed most of the R&D in Japan (117.5 billion dollars, which was 70 percent of the total expenditure). Universities were in second place (3.2 billion dollars, or 19.4 percent), followed by public institutions (1.2 billion dollars, or 10.6 percent) (MIC 2004). Compared to other countries, Japan relies more on the private sector than the U.S. and developed European countries. Japan shares this characteristic with Sweden.

Industry sector expenditures on research declined from 1992 to 1994, mainly due to the economic downturn, but rose again from 1995 to 1998. In 2000, the industry sector devoted on average the equivalent of 3.01 percent of total sales to R&D, a percentage that has not changed substantially since 1990. It is interesting to note that in 2000, 90 percent of industry sector R&D funds came from the manufacturing industry.

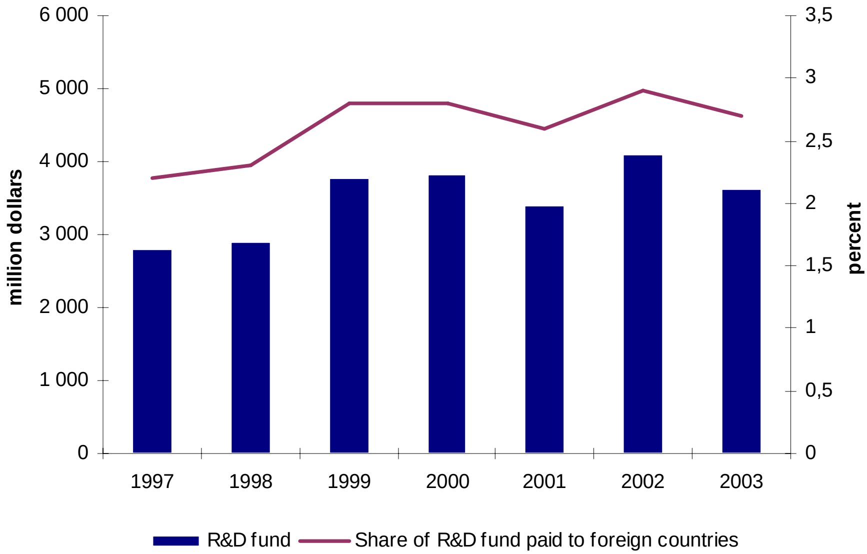
9.2.3 Japanese Corporate R&D in Foreign Countries

A Brief History

The Plaza Agreement between the U.S., France, Germany, Japan and the U.K. in 1985, with the purpose of working together on influencing exchange rates, resulted in forcing the Japanese yen to revalue. As a result, exporting became less profitable. This increased overseas manufacturing as well as R&D activities. During that period Japanese overseas R&D activities were mainly adaptive. According to a survey conducted by the Ministry of International Trade and Industry in 1990, the number of R&D units owned by Japanese subsidiaries totaled 222; 170 of those belonged to the manufacturing industry. In 1993, Japanese companies conducted 53 percent of total overseas R&D in the U.S., followed by Europe (38 percent) and Asia (6 percent) (Iwasa & Odagiri 2004).

Since the bursting of the bubble economy in the early 1990s, Japanese companies have reduced foreign investments and, in some cases, even closed overseas R&D sites. Since the late 1990s, Japanese companies have once again begun to invest in overseas R&D (see Figure 9-1). R&D investments in Asian countries, especially in China, have risen significantly. Overseas R&D activities are becoming more innovative and technology-monitoring activities are increasing. That is, overseas R&D is aimed at contributing to company-wide innovation by utilizing the local technological environment and local R&D resources.

Figure 9-1 The development of corporate R&D expenditures overseas as a share of total industry R&D expenditures in Japan (manufacturing industry).



Source: METI 2003.

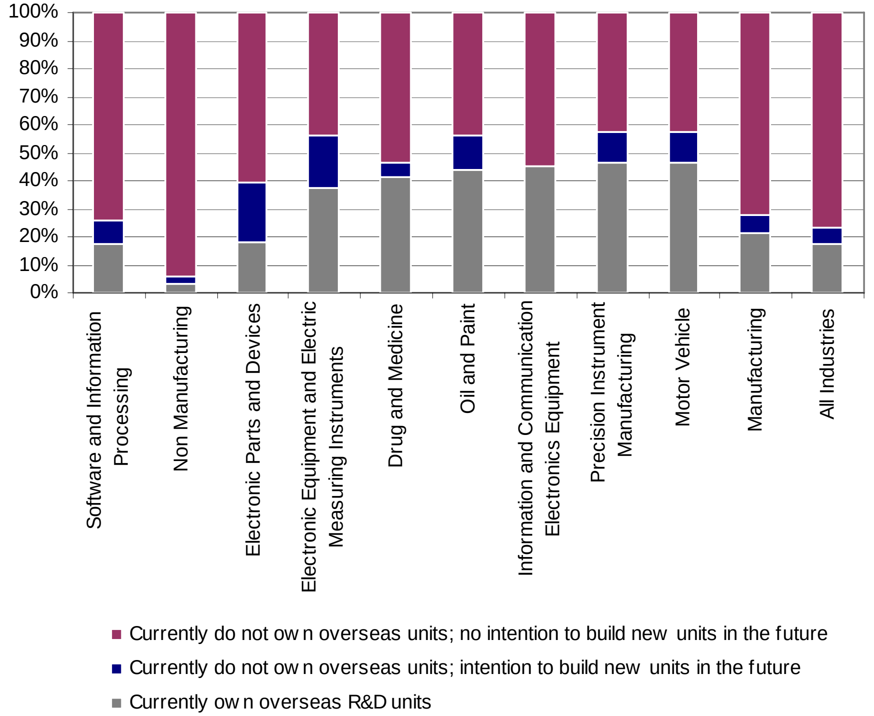
Current Status of Japanese Corporate R&D Overseas Activities

The data used hereafter is mainly based on questionnaire surveys by the Ministry of Economy, Trade and Industry (METI) and the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

METI's survey is titled "Survey of Overseas Business Activities (SOBA)." It has been conducted since 1972 among Japanese subsidiaries located in foreign countries (METI 2003). In 2003 the questionnaire was sent to 4,060 Japanese companies having subsidiaries abroad and the reply rate was 65 percent.

The survey by MEXT is titled "Survey of Research Activity of Private Sector in Japan" and has been conducted every year since 1968 (MEXT 2004a). The objective is to analyze trends and status of private R&D activities, expenditure, research personnel, collaboration with external organizations, corporate strategy, etc. The purpose of these analyses is to provide information to policymakers. In 2003, the survey was sent to 2,038 companies and 1,072 (53 percent) replied.

Figure 9-2 Percentage of Japanese companies having R&D expenditures abroad by industry.



Source: MEXT 2004a.

According to the survey on the growth of Japanese corporate R&D abroad from 1987 to 2003, the pharmaceutical industry has showed phenomenal growth since 1987 (MIC 2004). This is partly attributable to the clinical tests being carried out in foreign countries.

The percentage of Japanese companies having R&D expenditures abroad by industry is illustrated in Figure 9-2. According to the survey, 18 percent of the companies had R&D sites in overseas countries. For large companies with capital of 486 million dollars or more, the percentage is even higher (47 percent). By industry, a high percentage in the manufacturing sector is typical for automobile, precision machinery and information/communication equipment. In the non-manufacturing sector, the most internationalized is R&D in software and information processing.

Type of Operation and Host Countries

The Japanese companies' overseas subsidiaries, categorized by type of operation and by countries/regions where they are located, are depicted in Figure 9-3. The most common location for R&D sites of Japanese companies is the U.S., followed by E.U. and China. Production sites are concentrated in China and ASEAN4.

Figure 9-3 Number of overseas subsidiaries of Japanese companies by operation type and by country/areas in year 2004, Unit: Number of subsidiaries in foreign countries.

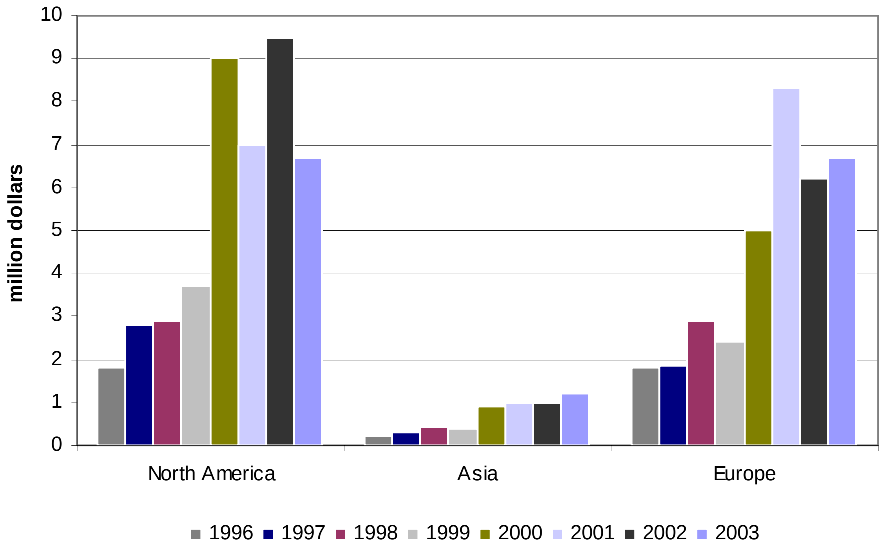
Type of overseas subsidiary	NIES	ASEAN4	China	other Asia	North America	Central and South America	EU-15	Central and East Europe	Oceania	TOTAL
Production	612	1190	1346	188	759	216	454	84	68	4917
Sales	830	383	463	52	637	177	969	101	141	3753
R&D	**25**	**29**	**67**	**6**	**108**	**4**	**60**	**3**	**8**	**310**
Other	107	89	122	15	244	53	161	5	26	822
TOTAL	1574	1691	1998	261	1748	450	1644	193	243	9802

Note: Definition of regions:
NIES (Korea, Taiwan, Singapore, Hong Kong)
ASEAN4 (Thailand, Indonesia, Malaysia, Philippines)
North America (United States, Canada)
EU-15 (United Kingdom, Germany, France, Italy, Netherlands, Belgium, Greece, Luxembourg, Denmark, Spain, Portugal, Austria, Finland, Sweden, Ireland)
Central and East Europe (Poland, Hungary, Czech Republic, Slovakia, Bulgaria, Romania, Slovenia, Albania, Croatia, Serbia and Montenegro, Bosnia and Herzegovina, the Former Yugoslav Republic of Macedonia)

Source: JBIC 2004a, JBIC 2004b.

Looking closer at Japanese R&D expenditure in North America, Asia and Europe from 1996 to 2003, the figures show a strong increase of investments after 2000 (Figure 9-4). Investments in Asia increased dramatically (up to four times) but stayed low in absolute figures compared to North America and Europe.

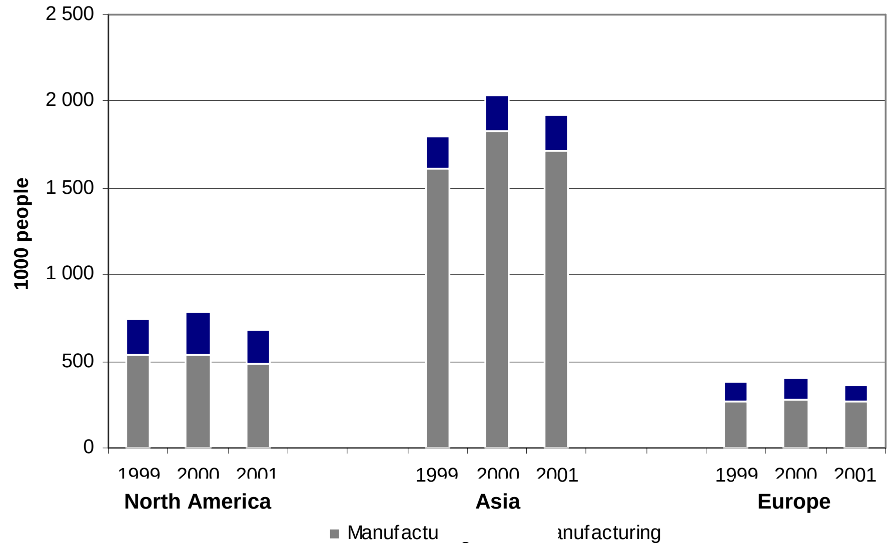
Figure 9-4 Japanese R&D expenditure in North America, Asia and Europe from 1996 to 2003 (in manufacturing industry).



Source: METI 2003.

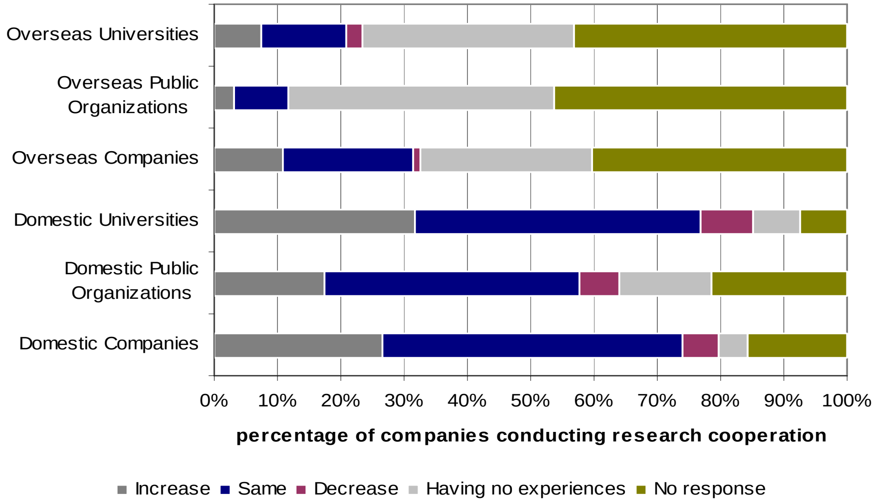
With regard to the total number of employees (including all categories, not just R&D) working at Japanese subsidiaries in North America, Asia and Europe, the proportions are opposite (see Figure 9-5). The number of employees in Asia is many times higher than the total number of employees in North America and Europe together. From a historical perspective, in the last ten years the number of employees has significantly increased in Asia. In 2003, 65 percent of the total number of employees in foreign subsidiaries worked in Asia. The number of employees in China has increased to one million in 2003, up by 26 percent from the previous year. The increase was driven by good revenues in transportation machinery (automobile) and information/communication equipment industries.

Figure 9-5 Comparison of the number of employees working at Japanese subsidiaries in manufacturing and non-manufacturing industries located in three major regions: North America, Asia and Europe.



Source: METI 2003.

Figure 9-6 Development of companies' R&D cooperation with external organizations.



Source: METI 2003.

R&D Cooperation with Overseas External Organizations

Another important practice is research cooperation with external organizations. According to the MEXT survey, 87 percent of companies have conducted research and development in collaboration with external organizations (both domestic and overseas) during the last five years (MEXT 2004a). The percentage is almost the same in manufacturing and non-manufacturing industries. This trend is even more salient for large companies with capital of 467 million dollars or more; almost all large companies are collaborating with domestic and overseas external organizations in their research and development activities.

Figure 9-6 shows different types of external R&D cooperation conducted by Japanese companies. The strongest trend is increasing cooperation with domestic universities, companies and public organizations. This might be the result of the recently implemented university reform in Japan giving universities more financial independence.

Japanese Corporate R&D Activities in Sweden

Many examples of Japanese corporate R&D activities in Sweden are in the area of biomedicine (see Figure 9-7). There are also some ongoing clinical trials and the expectation of extending the activities in the near future.

It should also be noted that some Japanese high-tech companies plan to initiate R&D activities in the area of bio-nano technology in 2006.

9.2.4 R&D Activities by Foreign Companies in Japan

Japanese Competitiveness

As discussed earlier, Japan ranked third in the world with regard to R&D investments in absolute terms, and fourth in the world by percentage of GDP. However, Japan holds only the 30th position in IMD’s overall competitiveness ranking. Furthermore, a study by the Mitsubishi Research Institute indicates that approximately 80 percent of the interviewed Japanese companies had technologies yet to be commercialized, and that approximately half of these companies consider the lag in commercialization a serious problem (JETRO 2004a). This demonstrates how many private companies fail to commercialize technologies despite the high, overall R&D spending seen in their annual balance sheets. It is believed that the recent lack of Japanese industrial competitiveness is primarily due to poor technology-management (JETRO 2004a). Consequently, establishing R&D in Japan by attracting overseas businesses could be one method of helping bolster the nation’s product development capabilities.

Figure 9-7 Examples of R&D activities in Sweden conducted by Japanese pharmaceutical companies.

Company	Partner	Type of Collaboration	Area	Year Started
Sumitomo	Karolinska	Basic research, drug discovery	Alzheimer disease	2000
Tanabe & Hamamatsu Photonics	Göteborg University Cellatis AB	Basic research on ES cells	ES cells for Parkinson disease	2003
Taisho	Karolinska	R&D	Diabetes II	2004
Sokai	TFS(CDC)	Clinical trials	Pain killer	2005
Astellas	Carlsson Research AB	Drug development	CNC	2004
Eisai	Göteborg University	Basic research using ES cells	Alzheimer disease	2004
Eisai	Bioactic AB	Drug development	Alzheimer disease	2005
Towser	Bioresonator in Umeå	R&D	Medical devices	2005

Efforts to Increase Foreign Direct Investment in Japan

It can be argued that flow of foreign direct investments (FDI) into a country is a good indicator of the future of foreign R&D activities.

With the goal of promoting foreign direct investment in Japan, the Japanese government established the Japan Investment Council (JIC) at the ministerial level in July 1994. The prime minister and the minister of state for economic and fiscal policy act as chairman and vice-chairman respectively.

The main purpose of JIC is to gather requests and opinions from foreign companies concerning the investment environment in Japan, thus influencing future government policy. The JIC also provides foreign companies with information on current FDI-related policy measures in Japan.

In a speech in January 2003, Prime Minister Koizumi announced the intention to double foreign investment in Japan in the next five years. He also appeared in newspaper and television advertisements advocating the increased presence of foreign companies in Japan. In the same year, JIC established a one-stop service center called Invest Japan Business Support Centre (IBSCs) within the Japan External Trade Organization (JETRO). The main purpose of this office was to support foreign companies and foreigner individuals who would like to invest in or start a business in Japan.

Historically Japan has been successful in attracting foreign direct investments. The total number of newly-established foreign companies increased from 237 (between 1976 and 1980) to 565 cases (1986–1990) (JETRO 2004b). However, between 1991 and 1995, Japan entered an economic recession and foreign investment plunged to 406 new companies. Then, between 1993 and 2003, numbers rose again to 897 new companies.

According to the METI survey, 42 percent (861) of foreign companies established in Japan between 1999–2003, were European. U.S. companies accounted for 38 percent (744) (METI 2004).

Foreign Companies Establishing R&D in Japan

The main type of activity performed by foreign companies established in Japan is sales. R&D activities remain minor with these companies (METI 2004).

The total R&D investment by foreign affiliates reached 7.2 billion dollars in fiscal year 2003, up by 16 percent from the previous year. R&D expenditures by the manufacturing industry were 7 billion dollars, which accounted for 97 percent of the total expenditure (METI 2004). The transport machinery industry accounted for 72 percent of the total expenditure. According to a study by the Cabinet Office, 51 percent of the 126 American- and European-affiliated companies in Japan in 2002 considered Japan to be a very attractive country for innovative R&D and technology monitoring.

Very few Swedish companies have established R&D activities in Japan. For this study we interviewed a large, well-established Swedish high-tech company in Japan. The company has an R&D group of ten researchers, eight of whom are Japanese; they plan to double staff in the coming years. The Swedish company's main reason for establishing R&D in Japan is to access advanced Japanese technology. Japan is believed to be five years ahead of other countries in this company's particular business area. The main goal of the group is to conduct innovative R&D to create new products, based on global standards, for the global market. In addition, the company expects that having R&D in Japan will help them penetrate the Japanese domestic market. As they phrase it, "selling from Japan to Japan is much easier than selling from outside Japan."

Generally, the main barriers to doing business in Japan are differences in business culture and low levels of English proficiency in the Japanese workforce. For this Swedish company, the future of R&D investments in Japan will depend heavily on the company's revenues in the near future. Surprisingly, they seem not to have encountered any issues with the internal mix of cultures (Western and Japanese). The company has its own global corporate culture and Japanese employees are expected to adapt.

9.3 Driving Forces and Barriers

9.3.1 Reasons for Internationalization of R&D

According to the MEXT survey on forces driving the establishment of overseas R&D sites, 54 percent of companies replied that they opened foreign R&D sites to conduct product development in response to the needs of local consumers (MEXT 2004a). The second most important driver was to secure access to excellent researchers; third was cost-effectiveness. The survey also indicated that companies with smaller capital (between 9.3 million and 46 million dollars) consider cost-effectiveness to be a stronger driver than do companies with larger capital. Also, according to the same survey, most of R&D was devoted to production technology followed by products specific to the local market.

In general there are several explanations for the increasing internationalization of corporate R&D in the world (UNCTAD 2005):

- Competitive pressure drives companies to innovate more in order to compete in high-tech areas (e.g. automobiles, electronics and pharmaceutics).
- There is need for greater flexibility in R&D activities, when rapid technology changes require quick access to existing expertise in other countries.
- Aging populations create insufficient pools of skilled, local workers to conduct required R&D.
- Developing countries, especially China and India, are increasing their own R&D capabilities and consequently supplanting some international R&D activities.
- A high level of foreign direct investment (FDI) can be an important indicator of future R&D activities abroad when initially-outsourced basic production, with time, takes on more complicated products and the accompanying adaptation requirements.

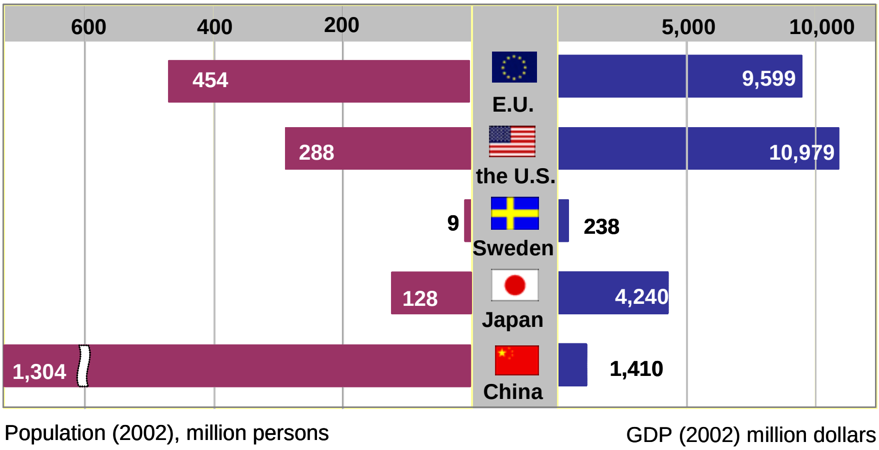
The level of internationalization of corporate R&D in Japan is much lower than in other developed countries. As mentioned in the introduction, the strength of Japanese manufacturing companies historically has been based on a close interaction between R&D and manufacturing divisions, including suppliers. To maintain this interaction, these companies' internationalization was part of an export-led strategy that caused delay of full-fledged, overseas production. The internationalization of R&D activities also started relatively late compared to other developed countries.

The following sections of this chapter discuss barriers to the process of R&D internationalization in Japan, along with new forces and conditions that might drive the process in the near future.

9.3.2 Competitive Pressure

Japan is the largest world economy after the U.S. (see Figure 9-8).

Figure 9-8 Japanese population and GDP (nominal) in comparison with E.U., Sweden, U.S. and China in year 2002.



Source: Asahi 2005.

Despite its position as the second largest world economy, Japan has recently lost its dominance in many cutting-edge industry areas due to increasing international competitive pressure (Nakagawa 2004). Some areas have been “taken over” by South Korea (e.g. Korean company Samsung is world-leader in the production of flat monitors based on the TFT LCD technology (Naito & Hausman 2005)). The Japanese economy has gone through several stages since the end of the WWII. First there was a recovery period during which Japan built its economy back up to the prewar level. Next came a high-growth period driven by chemical industry. Then, after the two oil crises, Japan saw a stable period driven by technology-intensive industries. In the 1990s there was a prolonged recession triggered by the expansion and contraction of an economic bubble in the latter half of the previous decade. Japan’s economic downturn was arguably caused by its 50-year-old postwar economic system, as well as an increasing inability to respond flexibly to internal and external changes.

After coming into power in April 2001, the Koizumi Cabinet has implemented policies covering regulatory reform, public company privatization (e.g. postal service privatization) and administrative reform. Economic revitalization is being promoted with policies to improve efficiency in areas like labor allocation, fund allocation and R&D. Major changes are also taking place in the corporate world as companies strive to increase competitiveness by moving away from traditional employment practices, such as lifetime employment and seniority-based wages (JETRO 2004a, Asahi 2005).

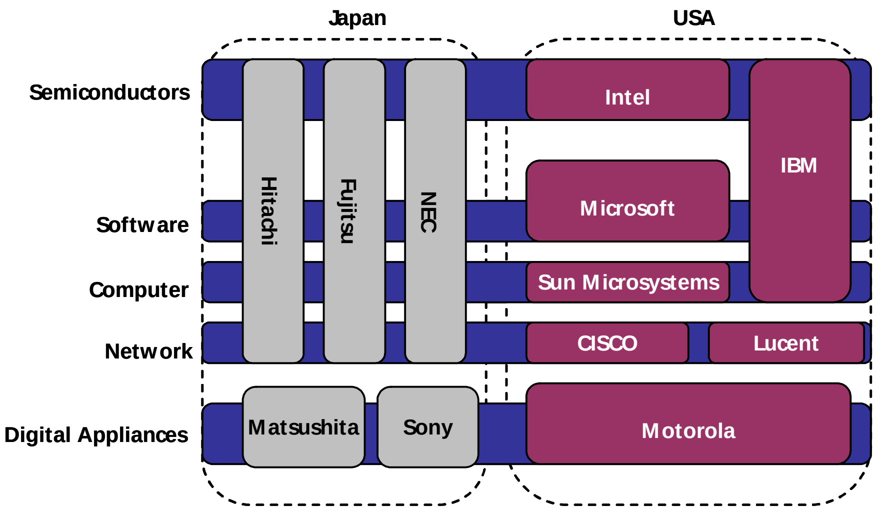
Competitive pressure can be perceived as one of the main forces driving the internationalization of Japanese corporate R&D today. At the same time, the internationalization process depends on a strong Japanese economy which full recovery remains to be seen.

9.3.3 Need for Greater R&D Flexibility

Japanese companies are extremely efficient in developing products that require technology integration (in Japanese suriawase). The automobile industry provides perfect example (Nakagawa 2004).

In response to the need for a greater flexibility in R&D, the Japanese trend is driven mainly by the concept of modularity. Modularity means that a product consists of many independently developed modules assembled in a specific, optimal architecture. Products from the Information and Communication Technologies (ICT) industry, in particular, are based on modularity. Japan has a long tradition of in-house product development which has created a corresponding, vertical industrial structure. This vertical structure has serious disadvantages compared to the much more efficient, modular and horizontally-oriented structure of western companies (see Figure 9-9). The vertical model's biggest drawback is that the same R&D efforts are duplicated by many companies.

Figure 9-9 Comparison of American and Japanese industry structures for ICT industry.



Source: METI 2003.

Since ICT is a vital part of the Japanese industry, the ongoing quest for modularity is expected to further drive internationalization of corporate R&D. However the long tradition of vertical industrial structure could significantly slow the process.

9.3.4 Aging Population and Lack of Skilled Workforce

Based on the current, low fertility rate of 1.29 in 2004, the population of Japan will decrease by 27 million by the year 2050 (Asahi 2005, NIPSSR 2002). The total fertility rate is the average number of children one woman gives birth to in her lifetime. By comparison the Swedish total fertility rate was 1.66 in 2004.

To meet the growing demand for skilled researchers and engineers, many Japanese universities are in the process of expanding abroad. For example, many Japanese universities have recently opened offices in China. The goal is to acquire top Chinese engineers for Japanese companies. In recent years companies have lost many top graduates from good schools to foreign competitors because the students rarely speak Japanese and have little familiarity with the Japanese culture.

The following list shows examples of recently open new offices in China:

- The Tokyo Institute of Technology now maintains an office inside Tsinghua University in Beijing. In September 2004 the two schools opened a joint program for graduate students in the fields of nanotechnology and biotechnology.
- Hitotsubashi University opened its first overseas office in Beijing in July 2004, in partnership with a Chinese national business association.
- In August 2004, Waseda University opened a joint research institute with Beijing University, and the two schools began mutual accreditation of their undergraduate students in late 2005.
- The University of Tokyo opened an office in Beijing in April 2005 to select exchange students and to handle other issues linking Japan and China.

The lack of familiarity with Japanese corporate culture and a high language barrier (low Japanese proficiency outside Japan and low English proficiency in Japan) can be viewed as one of the main obstacles in the process of internationalization of Japanese corporate R&D.

9.3.5 Pressure from Developing Countries

Due to its location in Northeast Asia, Japan is naturally exposed to the current developments taking place in China and India. As a result, Japan is trying to integrate more with neighboring Asian countries by signing, for example, the Economic Partnership Agreement (EPA). The EPA agreements have already been signed with Singapore (in effect from November 2002) and Philippines (to take effect in 2006). There are ongoing talks with Thailand, South Korea, India, Malaysia and other ASEAN countries (Brunei Darussalam, Cambodia, Indonesia, Laos, Myanmar and Vietnam) (NIKKEI

2005). The process is often complicated by the current Japanese attitude toward its history of having had political ambitions to dominate the neighboring area.

Another example of how Japan is responding to pressure from developing countries can be seen in their push for technology/industrial standards, especially in collaboration with China and South Korea. For example, the three Asian countries have agreed to jointly develop the next generation of mobile phone technology (4G). If their technology is selected for use around the globe, their telecommunications technologies and products will have a good chance of becoming the global standard. In addition, and as part of the process, the Japanese mobile telephone company, Docomo, has established an R&D center for 4G technology in China. Another example of collaboration is the agreement among technology ministers from China, South Korea and Japan to run a common project to develop a new computer operating system based on the open software platform Linux (NIKKEI 2005).

The pressure from developing Asian countries (viewed as a special case of global competitive pressure discussed earlier) is yet another very strong force driving the internationalization of Japanese corporate R&D today.

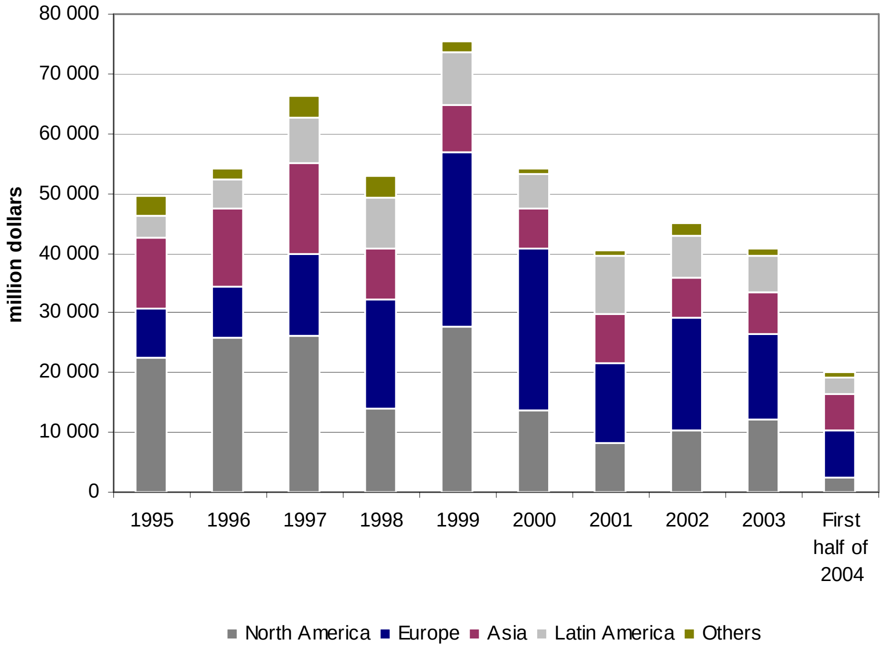
9.3.6 Foreign Direct Investment (FDI) Outflows

Another very important indicator of future R&D activities abroad is the level of foreign direct investment (FDI) outflows. In absolute figures, Japan holds the seventh position after the U.S., U.K., Luxemburg, Spain, France and Canada. This figure is not that impressive, considering that Japan is the second largest world economy. In 2004 the FDI outflows from Japan reached just 13 percent of the level of outflows from United States (UNCTAD 2005).

During the last ten years Japan invested heavily in North America and Europe (see Figure 9-10). However, over the last five years the total level of FDI outflows decreased considerably after a peak in 1999.

If this trend continues, the declining level of Japanese FDI outflows could jeopardize the process of internationalization of Japanese corporate R&D in the near future.

Figure 9-10 Development of Japanese FDI by country and areas over the years 1995–2003.



Source: METI 2003.

9.4 Conclusions

9.4.1 Summary of Findings

Japanese companies have a tendency to conduct R&D in-house and have a much lower share of R&D in foreign units than other developed countries. In 2001, the share of manufacturing R&D under the control of foreign affiliates was only 4 percent in Japan.

Japan's total expenditure on research and development (R&D) during fiscal year 2003 was 168 billion U.S. dollars, an increase of 0.8 percent from the previous year; the amount has been increasing for four consecutive years. Compared to other big economies, Japan holds the third position after the U.S. (308 billion dollars) and European Union (157 billion dollars).

Since the bursting of the bubble economy in the early 1990s, Japanese companies have reduced foreign investments and, in some cases, even closed overseas R&D sites. Since the late 1990s, Japanese companies have once again begun to invest in overseas R&D. R&D investments in Asian countries, especially in China, have risen significantly. The analysis of Japanese corporate R&D abroad by major manufacturing industries reveals that, since 1987, the pharmaceutical industry has showed phenomenal growth. This can be partly attributed to the clinical tests being carried out in foreign countries.

The most common location for R&D sites of Japanese companies is the U.S., followed by E.U. and China. Production sites are concentrated in China and ASEAN4 (Thailand, Indonesia, Singapore, Hong Kong). Looking at Japanese R&D expenditure in North America, Asia and Europe from 1996 to 2003, the figures show a strong increase in investments after 2000. Investments in Asia especially have increased dramatically (up to four times) but stayed low in absolute figures compared to North America and Europe.

The main type of activity performed by foreign companies established in Japan is sales. The R&D activities are still minor ones. The main barriers to doing business in Japan are differences in business culture and the low levels of English proficiency. It can be argued that a heavy flow of foreign direct investments (FDI) into a country is a good indicator of the future of foreign R&D activities. With the goal of promoting foreign direct investment in Japan, the Japanese government established the Japan Investment Council (JIC) at a ministerial level in July 1994.

The current Japanese level of internationalization of corporate R&D is much lower than in other developed countries. There are many reasons for this: close interaction between corporate R&D divisions and manufacturing in the past; old vertical industrial structure; lack of familiarity with Japanese corporate culture in overseas countries; and a high language barrier. There are also more direct economic factors like declining FDI caused by prolonged recession, along with an increasing inability to respond flexibly to internal and external changes.

Japan is forced to extend its participation in the R&D internationalization process due to growing competitive pressure, especially from other Asian countries. Other forces driving the internationalization process are an aging Japanese population and the country's lack of skilled workforce. A more efficient, horizontal structure of the Japanese industry is also required.

9.4.2 Future Trends

Assuming stability of the ongoing recovery of the Japanese economy, the level of internationalization of Japanese corporate R&D should increase significantly in the near future. Based on current trends, the Japanese pharmaceutical industry should lead the process. Based on the MEXT survey: nearly half of the companies plan to keep the current level of investment in R&D units overseas; 38 percent plan to expand the current overseas research base; and no company plans to decrease or close overseas R&D units (MEXT 2004a).

With regard to activities conducted by foreign corporations in Japan, the R&D function remains a marginal one. Sales comprise most of foreign corporations' activities, followed by the head-office function. Again, the main barriers to doing business in Japan are differences in business culture and low levels of English proficiency. Since overcoming those obstacles is a long-term process, the near-term outlook for heightened foreign R&D activities in Japan looks rather pessimistic.

9.4.3 Implications for Sweden

The increasing interest of Japanese companies in establishing more overseas R&D activities can be an opportunity for Sweden to attract Japanese technology-monitoring and innovative R&D. Due to its small consumer market, Sweden has little likelihood of attracting Japanese adaptive R&D. The exception could be when Japanese companies can use the Swedish market as an entry-point to the European market.

With 130 million people, Japan is a very large, homogenous and attractive consumer market. It can be more forcefully targeted by Swedish companies for adaptive R&D activities, especially following the latest Japanese effort to increase foreign direct investment in Japan. In 2002, the Swedish export to Japan was only 0.6 percent of the total Japanese import (the Swedish import from Japan was 0.34 percent of the total Japanese export) (MOFA 2004).

To meet the increasing interest of Japanese companies to establish more overseas R&D activities, the Swedish government should consider the following policy measures to promote the Swedish science and technology:

- Intensify the exchange of individual researchers, both from industry and academia, between Sweden and Japan. (Swedish researchers should be encouraged to use already-existing funds for conducing research in Japan.)
- Promote research collaboration between Sweden and Japan by providing financial means for running common scientific projects. (There are already some very good practices established by VINNOVA, SSF and the Japan Science and Technology Agency.)
- Encourage new collaboration agreements between Swedish and Japanese universities (including the exchange of individual students).

To promote new, direct corporate R&D investments (both Swedish investments in Japan and vice-versa), policies should include:

- Support for small Swedish private companies to approach the Japanese market;
- Intensified efforts to convince Japanese companies that Sweden is a good host-country for their R&D investments; and,
- Encouragement to work toward better understanding of Swedish and Japanese corporate cultures.

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10 China: From Shop Floor to Knowledge Factory?

Sylvia Schwaag Serger

10.1 Introduction

China's pace of economic development in the last 20 years is unprecedented. From being an essentially closed and planned economy in the 1970s, China has grown an average of 9 to 10 percent per year to become one of the most important trading nations and recipients of foreign direct investment (FDI) in the world (UNCTAD 2005a and 2005b).

Whereas previously FDI into China consisted mainly of acquisition or greenfield investments in production, extraction and distribution facilities, today increasing numbers of international companies are investing in research and development (R&D) in China (Gassmann & Han 2004).

In a recent survey of multinational companies, China was ranked as the most attractive country for future R&D investment, ahead of the U.S., India, Japan and the U.K. (UNCTAD 2005b). This development has led to growing concerns in many developed countries that multinational companies will increasingly set up R&D in China at the expense of Europe and the U.S. As American journalist Abe De Ramos eloquently posed the question in a 2003 issue of *CFO Magazine*, "U.S. companies are beginning to outsource technology research and development to India and China. Will a meltdown in tech jobs follow?" (De Ramos 2003).

This chapter examines foreign R&D operations in China and identifies the key forces driving China's rising importance as a location for such activities. The following questions will be addressed:

- What companies are locating R&D activities in China, and of what type?
- What are the main reasons foreign companies are establishing R&D in China?
- What is China's government policy on attracting foreign R&D?
- What factors may prevent companies from locating R&D in China?
- How are foreign companies' R&D activities likely to develop in the future?

While foreign companies are increasingly locating R&D in China, Chinese companies are just beginning to establish R&D facilities abroad. The determinants of this nascent trend are also examined.

The second section provides a brief overview over China's economic development and its national innovation system. Section 3 outlines principal policy developments and trends regarding FDI in China. In Section 4, we closely examine the R&D activities of foreign companies in China, and also emerging R&D activities of Chinese companies abroad. In addition to mapping current R&D activities, we identify drivers of R&D investment and localization decisions, and examine some of the challenges and opportunities related to these activities for China. Section 5 discusses the future of corporate R&D investments in China and draws some conclusions for Sweden.

Methodology

The dramatic pace of change in China, extreme regional differences, a lack of reliable and comparable statistics, and certain political control of the collection and dissemination of information make it difficult to gain a true picture of China's economic development. In order to assess China's economy today and predict its future, it is necessary to supplement official statistics with other information sources.

Some of the supplementary data used for this study has been published by the Energy Information Administration (EIA), the European Commission, the National Bureau of Statistics of China, the Organisation for Economic Development (OECD), the State Intellectual Property Office (SIPO), the United Nations Conference on Trade and Development (UNCTAD), the World Bank, and the World Intellectual Property Organisation (WIPO).

Other information sources include articles and books on foreign companies' R&D activities in China, such as Gassmann & Han 2004, von Zedtwitz 2004, and Walsh, 2003. And we gathered important, up-to-date information from periodicals and newspapers (e.g. *The Economist*, *BusinessWeek* and *China Daily*) to shed light on China's current economic development activity, and to reveal the issues considered critical in China right now.

A number of discussions and "half-structured" interviews[1] have also been conducted with representatives of approximately 20 companies in connection with the study. The companies varied in terms of size and industry. Representatives of chambers of commerce, employers' organizations, trade associations, universities and colleges, other government authorities, international organizations, academics, journalists, and other experts were also interviewed.

[1] By half-structured we mean that interviews were conducted based on a questionnaire. Interviewees were asked about their experiences with conducting, managing or analyzing foreign R&D in China, about factors speaking in favor or against establishing R&D in China, and about their assessment of how firms' R&D activities in China might develop in the future.

The aim of the interviews was to supplement the lack of reliable statistics on China, and to gain a realistic picture of the extent and drivers of foreign R&D operations in China. To assess how much innovative R&D is conducted by foreign companies in China, we have cross-referenced press clippings (e.g. on the establishment of a foreign R&D center in China with companies' annual reports and websites) and interviewed experts and company representatives.

10.2 Economic Development and National Innovation System

10.2.1 Introduction

The magnitude of economic change that China has experienced in the past 20 years cannot be overstated. After decades of isolation (particularly from the western world), the effects of cultural revolution, and the effects of a strongly Soviet-inspired model for economic planning and technology policy, Deng Xiaoping's "open door" strategy of the late 1970s ushered in a new era in China's economy. The strategy laid the foundation for an economic opening toward the world, in the form of trade, investments and personal mobility; for far-reaching, market-oriented legal reform; and for an explicit focus on improving China's scientific and technological competitiveness through increased cooperation with the Western world.[2] In the past two decades, China has successively liberalized and privatized sectors and companies, as well as opened its borders for trade. Its accession to the World Trade Organisation (WTO) in 2001 constitutes an important milestone in China's integration into the global economy.

The reform of China's science and technology system, begun in 1985, belongs to the principal policy decisions that have enabled China's progress in economics, technology and science in the past 20 years. Whereas China's science and technology resources had previously been closely connected to its military needs, the government formally acknowledged that these resources were of vital importance for economic development. Consequently, China made a deliberate decision to link science and technology to the productive sector (Walsh 2003).

China's economic reforms have been impressive, particularly when considering the results in terms of economic growth. A number of areas, however, require further reform in order to secure China's successful transition to a stable market economy. The government needs to continue restructuring and privatizing the approximately 150,000 state-owned enterprises (SOE). China's financial sector is still underdeveloped, inefficient, and too sheltered from market competition. Bad loans, which according to some estimates are equivalent to nearly half of China's GPD, constitute a significant threat to

[2] A good overview of China's technology policy since 1978 can be found in Walsh (2003).

financial stability and economic growth. Competition laws and the enforcement of Intellectual Property Rights (IPR) need to be strengthened. And the taxation system must be reformed to more effectively secure citizens' access to education, healthcare and other social services. For example, only approximately 24 million in China's population of 1.3 billion currently pay income taxes, and more than 90 percent of the rural Chinese population have no medical coverage (see for example WHO 2005). Growing corruption is a further potential threat to economic growth and political stability (OECD 2005a).

10.2.2 Economic Developments

Since its opening in the late 1970s, China's real GDP has grown, on average, by approximately 9 percent annually. Given relatively slow population growth, China's GDP per capita has also risen significantly, at an approximate average of 8 percent per year over the past two decades. However, the benefits of China's economic development have been unevenly distributed. On the one hand, we see the emergence of middle- and upper-classes, estimated to consist of around 250–300 million people whose purchasing power and wealth has increased dramatically in the past decade. On the other hand, nearly half of the population still live below or right above the international poverty line. These people have experienced little direct gain from their countries' rapid economic growth. Furthermore, the moderate income rises they may have enjoyed are often outweighed by drastically increased costs for healthcare and education (see Ljunggren 2004, WHO 2005, World Bank 2005).

China's economic growth is currently driven primarily by exports and investments; consumption plays a small role, in relative terms, and at 40 percent, the savings rate is among the highest in the world. International trade (calculated as the sum of exports and imports) accounts for approximately 75 percent of China's GDP, compared with around 30 percent in the U.S. and India and 20 percent in Japan. China is now the third-largest trading nation in the world, after Germany and the U.S.

China has become a key player in the world economy. The opening of China's economic boarders and its economic development in recent years have made it one of the largest and most important markets in the world (Schwaag Serger & Widman 2005). For example, China has been the largest market for mobile telephones since 2001. And the Chinese market continues to grow rapidly at a time when markets for goods and services in other countries are stagnating or even declining; passenger car sales in China increased by 24 percent in 2005 (*People's Daily* 2006b), compared with 3 percent in the U.S. (*Automotive News*). China has also become one of the biggest consumers and producers of raw materials, such as steel, coal, copper and aluminum, agricultural products, and energy (see for example Brown 2005).

With its growing importance in world markets, both on the demand and supply sides, China is increasingly determining world prices for goods, services and labor, as well as interest and exchange rates. China's expanding role in the world economy is not only affecting prices and wages. It is also shifting the geography of world trade by dramatically increasing the volume and value of trade between developing countries. This is sometimes referred to as South-South trade, which is increasing in relative importance to North-South or North-North trade (UNCTAD 2005a). In addition, China's growing economic role has repercussions in the international political order and balance of power (see for example Shambaugh 2005).

10.2.3 China's Innovation System

Rapidly Growing Knowledge Resources

China is far from being a knowledge-based economy. This is demonstrated by indicators both of knowledge inputs (R&D expenditure as a percentage of GDP) and knowledge outputs (scientific publications and patenting activity). Thus, China has few knowledge assets in relation to its size. Furthermore, China's knowledge resources are very unevenly distributed between regions, societal groups and sectors. Yet China has considerable knowledge resources, when compared with most other countries in the world.[3]

Even if China's R&D expenditure is difficult to assess and compare, it is clear that China invests more in R&D than most other countries in the world. According to the OECD, only the U.S. and Japan spend more on R&D, in absolute terms, than China. China has the second-highest number of researchers, after the U.S.[4] Between 1999 and 2003 China's R&D expenditure increased by approximately 130 percent (total), or an average of 24 percent per year. This can be compared with Germany, the U.S. or Japan, where expenditure increased by 15–20 percent in total or 3–5 percent on average per year (see Figure 10-1).

It is important to note that R&D figures in India, which is often compared with China, are considerably lower than China's, both in absolute terms – with total expenditure amounting to 19 billion purchasing power parity (PPP) dollars in 1999, compared with 36 billion PPP dollars in China in the same year – and as a share of GDP (0.8 percent in 2000). Since 1999, China's R&D expenditures have overtaken many countries, including the U.K., France and Germany. Furthermore, China's R&D expenditures have increased significantly in terms of share of GDP (from 0.6 percent of GDP in 1996 to 1.3 percent in 2003) at a time when

[3] A more in-depth analysis of China's innovation system can be found in Schwaag Serger & Widman (2005).

[4] It is difficult to gauge the accuracy and comparability of China's R&D statistics. When compared with other countries, China's R&D absolute expenditure differs considerably in size depending on whether one measures expenditure in nominal values or in purchasing power parity (PPP) values. Given the large differences in purchasing power between China and more developed countries, it makes sense to use PPP values. However, it must then be considered which PPP conversion rate to use (see for example Schaaper 2004).

GDP itself has grown by an approximate average of 9 percent per year. And overall, China's investments in knowledge have grown considerably in a relatively short time span, even though these resources remain unevenly distributed and strongly concentrated in a few regions, subject areas and social classes (von Zedtwitz 2004).

Figure 10-1 R&D expenditure in selected countries, 1999–2003 (share of GDP, current PPP dollars and increase).

	Share of GDP (percent)		**Current PPP Dollars (billion)**		**Increase (percent)**	
	1999	*2003*	*1999*	*2003*	*Total 1999–2003*	*Average Annual Increase*
United States	2.6	2.6	244	285	16.9%	4.0%
EU-15	1.9	1.9	163	204	25.5%	5.9%
Japan	3.0	3.2	95	114	20.4%	4.7%
Germany	2.5	2.5	48	54	14.3%	3.4%
China	1.0	1.3	36	85	134.4%	23.7%
France	2.2	2.2	32	38	17.9%	4.2%
United Kingdom	1.9	1.9	25	34	32.0%	7.2%
Sweden	3.7	4.0	8	10	34.6%	7.7%

Source: OECD, Eurostat, Germany Ministry for Education and Research (BMBF).

While China's R&D resources are increasing rapidly compared to developed countries, it still invests little in basic research, which plays a key role in determining a country's innovative capacity (OECD and Stipp 2005). Basic research in China currently accounts for less than 6 percent of total R&D expenditure, compared with nearly 20 percent in the U.S. and 13 percent in Japan (MST 2005). R&D also accounts for a considerably smaller share of total value added in high-tech industries such as aerospace, pharmaceuticals, computers and office equipment, and electronics and communications equipment, when compared with other countries (OECD and Chinese Ministry of Science and Technology). Finally, the private sector plays a smaller role in China's R&D, both in terms of expenditure and investment, than in, for example, the U.S., Japan, Germany or Sweden (Schaaper 2004 and European Commission 2005a).

In terms of human capital resources, China still lags behind the U.S. and E.U. But the gap is closing rapidly in terms of quantity and quality (Freeman 2005, Sigurdson 2004). With around 15 million students in tertiary education, China has approximately as many university students as the U.S. and the E.U., respectively, but these countries have considerably more students enrolled in advanced research programs (OECD 2005d, NBSC 2006, NSF 2006 and European Commission 2005b). The U.S. and the E.U. each have approximately 40 percent more R&D scientists and engineers in their labor forces than China (NRCSTD 2005). And, fewer researchers work in the Chinese private sector (only about half of the total) in comparison with the U.S. (80 percent) and Japan (63 percent). Interestingly, this is not the case with the E.U. (55 percent) (Schaaper 2004).[5]

Several experts expect China to catch up quickly in terms of science and technology (S&T) resources. Richard Freeman (2005), for example, estimates that China will have more Ph.Ds in S&T than the U.S. by 2010. The rapidly growing number of Chinese engineers is drawing attention, and raising concerns, in Europe and the U.S. (*BusinessWeek* 2005b). While the number of Chinese university graduates is large (2.4 million in 2004) and rising rapidly (growing an average of 50 percent per year for the past three years), according to a recent study, their skills levels are still comparatively low, and few Chinese university graduates are suited to work in large multinational companies (Farrell & Grant 2005). However, foreign managers of multinational companies' China operations interviewed for this study reported seeing rapid improvements in management and project leadership skills in their Chinese employees.

China's knowledge outputs have also increased rapidly in recent years, though not as fast as its inputs. Perhaps the most noteworthy change is the dramatic increase in Chinese scientific publications. In terms of share of total international scientific publications, China has advanced from around thirteenth place in the mid–1990s to sixth place in 2003 (Schwaag Serger & Widman 2005). Some experts go so far as to describe this development as "spectacular" (Leydesdorff & Ping 2005, p. 625; see also Zhou & Leydesdorff 2006).

In patenting, China still lags far behind the U.S., Europe and Japan. While Chinese patent applications have increased significantly in recent years, in 2004 they still only accounted for 1.4 percent of total international patent applications (website World Intellectual Property Organization, WIPO). In 2001, Chinese companies and organizations held only 0.3 percent of granted patents at the European Patent Office (EPO) and 0.1 percent at the U.S. Patent and Trademark Office (USPTO). Patenting activities in China are dominated to a much larger extent by foreign companies than in most other countries. Thus, between 1999 and 2001 nearly half of all domestic invention patents were foreign-owned (OECD Patent Database).[6]

At first glance, China performs well on another measurement of knowledge output: high-technology exports. High-technology products account for a high share – more than one fourth – of total exports in 2004 (MST 2005). However, a large share of China's high-tech exports are products, where the high-tech components are

[5] Researchers are defined as professionals engaged in the conception and creation of new knowledge, products, processes, methods and systems and are directly involved in the management of projects. The number of researchers is expressed in full-time equivalent (FTE) on R&D.

[6] China offers three categories of patents: design, utility and invention. Invention patents are the category most suitable for international comparison.

imported from abroad and merely assembled in China in order to be re-exported. This is the case in the computer industry, for example. Imports of high-technology products are larger than exports of high-technology products, confirming that much of China's exported high technology actually comes from abroad. Furthermore, foreign-owned companies in China accounted for close to 85 percent of China's high-tech exports in 2003 (Breidne 2004 and Schaaper 2004).

Considerable Weaknesses Remain in China's Innovation System

China's ability to create knowledge has grown rapidly in the past two decades. However, a number of factors hamper China's ability to use these resources efficiently and effectively. One such factor is the relatively underdeveloped service sector, particularly business services, which are an important source of innovation and future competitiveness. Services account for a relatively small share of GDP. Furthermore, services have been relatively neglected in China's innovation policy, which focuses primarily on manufacturing.

Insufficient protection of Intellectual Property Rights (IPR), particularly weaknesses regarding the enforcement of IPR law, presents a second impediment to strengthening China's innovative capacity (Zhang 2005 and OECD 2005c). While China's IPR legislation has improved in the past years, enforcement remains weak. Studies of China's life-science sector show that fear of intellectual property theft, mistrust of the patenting process and a lack of social capital – defined as "features of social organization such as networks, norms and social trust that facilitate coordination and cooperation for mutual benefit" (Putnam 1995, p. 67) – constitute significant barriers to the commercialization of research (Nilsson et al. 2006).

A third problem is the large gap between people, sectors and regions that generate or have access to knowledge, and the overwhelming majority of Chinese who reap no benefit whatsoever from investments in knowledge (Jefferson 2004, Schaaper 2004, and Schwaag Serger & Widman 2005). These knowledge gaps result in sub-optimal returns on knowledge investments and also pose potential threat to China's future political, social and economic stability.

A fourth weakness in China's innovation system is its underdeveloped financial sector (OECD 2005b and European Commission 2004). A conservative banking sector with a strong focus on large and state-owned enterprises and the lack of a functioning venture capital market explain the shortage of capital sources for small and medium-sized companies and for high-risk projects.

In addition to the above-mentioned weaknesses in China's innovation system, a number of challenges exist that are more difficult to quantify. These include the political system, which restricts critical and creative thinking, and a possible overemphasis on hard sciences in policy formulation at the expense of other sciences or research areas important to creativity, entrepreneurship and competitiveness (see Schwaag Serger & Widman 2005).[7]

Perhaps the most widely discussed weaknesses of China's innovation system are: its apparent over-reliance on foreign companies' R&D, and the inability of its domestic companies to develop high-tech products. According to Maximilian von Zedtwitz, in early 2004, there were approximately 200 foreign-owned R&D centers in China, and the number is likely to have increased since then (von Zedtwitz 2004).

Foreign companies' R&D activities can be seen as one of the biggest strengths and biggest weaknesses of China's innovation system. They are a key component of China's innovation system when measured by share of patenting and high-tech exports. At the same time, analysts question whether foreign companies' R&D activities in China actually increase or decrease the country's innovative capacity in the long term. Some observers argue that foreign companies' R&D activities offer few, significant spillover benefits for domestic companies' innovative capacity. Furthermore, some Chinese experts we interviewed expressed concerns that foreign R&D may actually undermine domestic innovative capacity by "crowding out" domestic companies in the labor market. As a result, there is growing criticism of the government's policy to attract foreign R&D by providing significant tax and other incentives.

China's Efforts to Address its Weaknesses

Chinese policymakers have identified a number of the weaknesses in China's innovation system and are addressing these with targeted policy measures. The government has identified innovation and a strong science and technology base as guarantors of future competitiveness and prosperity. The government also sees innovation, science and technology as the solution to many of the challenges facing China today, such as pollution, the threat of epidemics, water and energy shortages. As a result, innovation has high priority on their policy agenda (*People's Daily* 2005). When the Chinese government presented its medium- and long-range scientific and technological development program (also referred to as the "15-year plan") in January 2006, it emphasized the importance of strengthening "independent innovation." (SCPRC 2006) This term reflects the objective to reduce China's dependence on foreign companies' R&D activities by increasing the innovative strength of Chinese companies and researchers.

[7] Regarding the first-mentioned factor, recent studies have established that tolerance, diversity and openness are important determinants of innovative capacity and high-tech growth (see for example Florida 2001).

In the past decade, the Chinese government has identified a number of ways to enhance or supplement its domestic innovative capacity. First, China has implemented effective policies for attracting R&D activities by foreign companies (this will be discussed in greater detail in Section 4). And China's highly successful efforts to attract FDI are arguably driven by the desire to upgrade scientific, technological and innovative capabilities.

Second, and a very important element of the government's efforts to increase China's innovative capacity, are new incentive programs that encourage professionals of Chinese origin to return to China (see for example Saxenian 2005). This applies to scientists, but also people with management and other significant business experience. Thus, the Ministry of Education set up a "Fund for Returnees to Launch S&T Research" in 1990, which according to the Ministry's website, has provided financial support of more than 350 million RMB (approximately 45 million dollars) to 11,000 returnees. The "Program for Training Talents Toward the 21st Century" targets teachers returning from overseas studies. Started in 1993, it has granted 180 million RMB (23 million dollars) to 922 people. Other programs, aimed at attracting Chinese-national students and scholars, finance scholars of Chinese origin wishing to return temporarily to China for short-term visits, to conduct research, or to give lectures.

Another example is the National Science Fund for Distinguished Scholars (NSFC), which was established in 1994 with the explicit objective of attracting overseas scholars back to China. NSFC provides significant research grants of approximately 1 million RMB (around 125 million dollars) for Chinese scholars with foreign nationality (NSFC homepage). Scientists willing to return to China are also offered entire state-of-the-art research labs as well as prestigious titles and awards. Starting in the late 1980s, Chinese cities and High-Tech Development Zones began to offer tax breaks and other incentives, such as free office space, better housing and fast-track promotions, for Chinese returnees (*Asia Times* 2000).

Between 1978 and 2003 around 700,000 Chinese citizens from mainland China went abroad to study, mainly in the U.S., Japan and U.K.; approximately 170,000 are estimated to have returned (Ministry of Education website). These returnees have been a vital component of China's innovation system, playing a key role in many of the country's scientific and technological achievements, as well as its commercial success stories. Chinese returnees account for a high share of new-business launch and knowledge production, in terms of scientific publications, patenting and licensing. Many of them have been instrumental in setting up China-based R&D labs and institutes, both academic and corporate (*People's Daily* 2003).

Chinese professional overseas account for a significant portion of the FDI flowing into China, and they comprise a large number of the key personalities in China's scientific community, including national chief scientists. This group has also founded many of the country's high-tech companies, and they have "played a predominant role in all of China's prestige scientific projects such as the space programme and human genome mapping" (*Financial Express* 2005).

Overall, China's investments in knowledge (which have grown at an unprecedented rate during the past ten years), combined with its policies for attracting knowledge resources from abroad (both in terms of corporate R&D functions and human capital), reflect a clear and strong determination to strengthen China's innovative capacity. At the same time, China's innovation system suffers important shortcomings and China still lags behind more developed countries in terms of knowledge outputs. In the following sections we examine more closely two key instruments in China's pursuit to become an innovation country: FDI and R&D activities by foreign companies.

10.3 Foreign Direct Investment (FDI) in China

10.3.1 One of the Largest FDI Recipients

Attracting FDI has been a cornerstone of the Chinese open door policy, introduced in 1978, and has played an instrumental role in the transformation of the Chinese economy (see for example Long 2005 and OECD 2005b). While FDI inflows were relatively modest in the 1980s, they increased dramatically in the early 1990s. Since then, FDI has been pouring into China, attracted by stable macroeconomic conditions, as well as fiscal and other incentives, such as the provision of physical and institutional infrastructure, and the huge emerging domestic market.[8] Gradual liberalization of foreign investment and ownership restrictions have also contributed to a continued increase in FDI flows, thus briefly making China the largest FDI recipient in the world in 2002/2003.

In 2004, China attracted 61 billion dollars, or approximately 10 percent of total FDI inflows worldwide, making it the third-largest recipient after the U.S. and the U.K. (UNCTAD 2005b) (see Figure 10-2). According to *The Economist*, "[n]o other country attracts as much FDI as China," (*The Economist* 2005b).

China's FDI figures are likely to be overstated due to a practice known as "roundtripping," whereby significant sums of money are taken out of China and then brought in again as "foreign investment." Investors therefore benefit from China's preferential policies for FDI. According to some estimates, roundtripping accounts for around 20–30

[8] For an analysis of capital inflows into China, see Prasad & Wei (2005).

percent of total FDI to China.[9] However, even when accounting for this, the FDI flowing into China is still larger than for most other countries. Furthermore, roundtripping does not disprove the fact that both multinational companies and experts recently ranked China the most attractive investment location in the world (UNCTAD 2005b).

Figure 10-2 FDI inflows in selected countries, 1990–2004 (million dollars).

Country	1990	1995	2000	2001	2002	2003	2004
United States	48,422	58,772	314,007	159,461	71,331	56,834	95,859
United Kingdom	30,461	19,969	118,764	52,623	24,029	20,298	78,399
China	3,487	37,521	40,715	46,878	52,743	53,505	60,630
Australia	8,120	11,968	13,963	4,632	15,632	6,955	42,594
Brazil	989	4,405	32,779	22,457	16,590	10,144	18,166
Russian Federation	..	2,066	2,714	2,748	3,461	7,958	11,672
India	237	2,151	2,319	3,403	3,449	4,269	5,335

Source: UNCTAD 2005b.

It has also been pointed out that FDI to China is relatively small when examined in relation to the size of its population (OECD 2003). Thus, FDI inflows per capita into China in 2004 were only half as large as those into Brazil and Russia. At the same time, FDI inflows were still almost ten times larger for China than for India, the country with which China is most frequently compared.[10] The relatively small size of FDI inflows in relation to population may be a valid point when arguing that potential exists to attract more FDI to China. However, it should not distract from the fact that, in the past 15 years, China has experienced one of the most rapid and sustained increases of FDI inflows.

So far, foreign investments into China have been dominated by overseas Chinese communities and other Asian countries. Hong Kong alone accounted for 43 percent of total cumulative FDI inflows by 2004, although a significant share of these inflows is explained by "roundtripping" (see Figure 10-3).[11] E.U. countries only accounted for around 7 percent of total FDI inflows into China, as of 2004.

FDI inflows into China are strongly concentrated to the coastal regions. As of the end of 2003, 85 percent of all inflows had gone to the country's 12 coastal regions, autonomous provinces and municipalities (*China Statistical Yearbook 2004*).[12] The industrial sector is

[9] Research from 2004 estimates roundtripping to be as high as 30-50 percent of total FDI (Xiao 2004).

[10] While roundtripping results in an overestimation of China's FDI inflows, India's narrower definition of what constitutes FDI leads to an underestimation of India's FDI inflows. As a result, the gap between China's and India's FDI inflows is likely to be smaller but still significant.

[11] A further share of Hong Kong's large foreign investment into mainland China consists of Taiwanese investments which are rerouted through Hong Kong, as well as the Virgin Islands and Cayman Islands, to circumvent Taiwanese restrictions on investing in China (Long 2005).

[12] These are Beijing, Tianjin, Hebei, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong and Guangdong.

the primary focus of FDI into China, with more than three quarters of funds going to manufacturing, energy, construction or mining. Within the industrial sector, manufacturing accounted for 71 percent of total FDI in 2004. Around 23 percent of all inflows were directed at the service sector. The share of FDI in services has actually decreased, largely due to a significant drop in foreign investments in the Chinese real estate sector, which previously accounted for the largest share of FDI in the service sector.

Figure 10-3 Top investors in China, by country or region (as of 2004).

Country or Region	Percentage of Total
Hong Kong	43.0
United States	8.5
Japan	8.3
Taiwan	7.1
Virgin Islands	6.6
Republic of Korea	4.6
Singapore	4.5
United Kingdom	2.2
Germany	1.8
France	1.2

Source: Invest in China website.

Initially, equity or contractual joint ventures were the most common form of FDI in China, accounting for 61 percent of total inflows as of 2002 (Liang 2004). Since China removed the restrictions on the establishment of wholly foreign-owned enterprises in connection with its accession to the WTO, this type of FDI has replaced joint ventures. Thus, for 2004, wholly foreign-owned enterprises (WFOEs) accounted for 67 percent of FDI inflows, compared with 32 percent in joint enterprises (*Invest in China* website).

10.3.2 FDI a Cornerstone to China's Economic Policy

According to *The Economist* (2005b) "[t]he foreign-investment boom in China was started by overseas Chinese." The first wave of investors into China can be described as consisting of overseas Chinese, mainly from Hong Kong, Macau and Taiwan, many of whom had close personal ties to the mainland, and who invested primarily in labour-intensive manufacturing industries, such as toys and textiles (ibid and Liang 2004). Most of the initial investments flowed into Guangdong, because of its proximity to Hong Kong, and were aimed at either setting up or buying into low-cost, standardized production facilities for export. Up until the early 1990s, China's domestic market was largely closed to foreign companies, and this explains why initial FDI into China consisted largely of establishing export-oriented ventures.

Overseas Chinese investors, and the favorable treatment they received by the Chinese leaders, paved the way for the second wave of foreign investment, which accompanied the entry of big, multinational companies. In addition to seeking lower production costs for goods to be exported, these companies are increasingly attracted by the domestic Chinese market. The dramatic increase in FDI inflows in the early 1990s is partially explained by the opening of the Chinese market to foreign MNEs, which began around the same time (Hou 2004). Just a glance at Global Fortune 500 companies reveals that in certain sectors (e.g. motor vehicles and parts, pharmaceuticals, chemicals, electronics, computers, semiconductors, engineering, consumer food products, construction and industrial equipment), the largest companies have direct investments in China.[13]

Today, China's domestic market remains one of the major pull-factors for FDI inflows.[14] Its sheer size, together with unparalleled growth rates, makes China one of the most attractive markets for multinational companies in the world. For example, China's mobile telephone market, already the largest in the world, is growing by five million new mobile phone users each month. Measured according to sales in 2005, its market for passenger cars is the second largest in the world, after the U.S. (*People's Daily* 2006a). These and other examples – such as a 200 percent rise in chocolate imports in the past four years – reflect both a dramatic pace of economic development and a rapidly emerging middle class of between 100 and 300 million, with a pent-up desire to enjoy the comforts of wealth.

Overall, FDI inflows into China have been driven by a combination of preferential policies, a large domestic market, low production costs, and a number of favorable framework conditions, such as physical and institutional infrastructure, perceptions of economic and political stability and a generally FDI-friendly environment.[15] China has actively courted foreign companies because it has viewed FDI as a panacea, or quick fix, for many of its shortcomings. Thus, FDI is currently encouraged for purposes of increasing the productivity of China's agriculture, contributing to the development of China's western regions, strengthening China's export performance, improving the access to and efficient use of raw materials – to name just a few (Long 2005). However, perhaps the most important motivation behind China's preferential FDI policies has been to augment domestic innovative capacity and the competitiveness of its companies by "importing" knowledge, management skills and technologies from abroad (see Section 4 of this chapter).

[13] The Global Fortune 500 is a ranking of the 500 largest companies in the world by revenue. According to web searches and the homepages of the Global Fortune 500 companies, at least two thirds had some form of FDI in China.

[14] A survey conducted among Japanese and Korean companies found potential market size to be the most important reason for undertaking FDI in China (NIRA 2002).

[15] According to a recent survey by A.T. Kearney, the factors that make China more attractive to foreign investors than India include: the large domestic market, preferential FDI, low production costs, infrastructure, and macroeconomic stability. The survey is referred to in *India Chronicle*, No. 003, August 2005, www.sunmediaonline.com/indiachronicleaugust/bilateraltrade.html.

Recently, there has been growing criticism of China's strong focus on investment, including its policies for attracting FDI. China's FDI policies are seen to be effectively "tilting" the playing field in favor of foreign and foreign-funded companies (see for example *China Daily* 2004, and Prasad & Wei 2005). Some observers claim that India's less aggressive promotion of FDI, and its "favoring [of] domestic investment over foreign," has allowed the development of domestic companies that can now compete on the international market (*The Economist* 2005b). Economists are starting to question whether China's policies aimed at promoting investment are beneficial for China's long-term economic development and prosperity. The debate over the benefits of preferential investment policies is partially connected to concerns about growing inequalities and accusations that China's growth has benefited a small minority at the expense of the vast majority of people. Kuijs and Wang argue that:

> *...reducing subsidies to industry and investment, encouraging the development of the services industry, and reducing barriers to labor mobility would result in a more balanced growth and a substantial reduction in the income gap between rural and urban residents* (Kuijs & Wang 2006, p. 1).

China's dependence on foreign companies for production and export of high-technology products is also identified as an example of its "unhealthy" reliance on external technologies. Companies with either whole or partial foreign ownership accounted for 57 percent of China's total exports in 2004 and 58 percent of total imports, in value terms. Their share of national industrial outputs has increased from 2 percent in 1990 to 32 percent in 2004 (*Invest in China* website). Foreign companies also dominate exports of high-technology goods. In 2003, these companies accounted for approximately 80 percent of China's total high-tech exports (NRCSTD 2005).

10.3.3 Strategic Factors Drive Chinese Outward FDI

Outflows of FDI from China are still modest. According to UNCTAD, outflows only amounted to 1.8 billion dollars in 2004, or a mere 0.2 percent of total FDI outflows worldwide, and 2.2 percent of developing countries' outflows. Between 2001 and mid–2005, according to *China Daily* (2006), Chinese companies completed 103 outbound Mergers and Acquisitions (M&A), most of which were in minerals, natural resources and communications industries.

Chinese FDI outflows have been driven primarily by China's highly raw-material and energy-intensive economic growth and, consequently, by the need to secure access to natural resources and energy (see Zweig & Jianhai 2005 and *Financial Express* 2004). As a result, some of China's FDI outflows in recent years have been directed at countries rich in natural resources, (e.g. Africa, Latin America, Central Asia and the Middle East). Examples are Sinopec's one billion dollar deal with Brazil to build a gas pipeline, Shanghai Baosteel's 1.4 billion dollar joint venture with the Brazilian steel producer CVRD, and the purchase of Petro-Kazakhstan for 4.2 billion dollars by China National Petrol Corporation (CNPC). Securing access to natural resources and energy has become an important determinant of China's foreign policy, and outward FDI is one of its key instruments:

> *Beijing's access to foreign resources is necessary both for continued economic growth and, because growth is the cornerstone of China's social stability, for the survival of the Chinese Communist Party (CCP) /…/ Beijing has been encouraging representatives of state-controlled companies to secure exploration and supply agreements with states that produce oil, gas, and other resources. Meanwhile, it has been courting the governments of these states aggressively, building goodwill by strengthening bilateral trade relations, awarding aid, forgiving national debt, and helping build roads, bridges, stadiums, and harbors. In return, China has won access to key resources, from gold in Bolivia and coal in the Philippines to oil in Ecuador and natural gas in Australia* (Zweig & Jianhai 2005)

Beyond the need to secure natural resources, the government also views outward FDI as a means for generally increasing China's international political and economic influence (Accenture 2005). In 2002, the government launched its "go-global" policy, encouraging Chinese companies to increase their presence abroad. One clearly defined goal is to have 30–50 "national champions," or globally competitive Chinese companies, by 2010. In 2005, China had 15 companies among the Global Fortune 500, although to what extent they are globally competitive is questionable, since many of these are government-owned or protected monopolies (*The Economist* 2005a).

Gaining access to foreign markets and, perhaps even more importantly, to gaining access to technologies, are other factors driving Chinese outward FDI. According to von Zedtwitz (2005), technology sourcing is the primary reason for Chinese companies' direct investments in developed countries. Lenovo's purchase of IBM's PC business, TCL's joint venture with Thomson to create TTE Corporation, and Nanjing Automotive's acquisition of Rover are examples of Chinese companies seeking both access to foreign markets and to technologies. Instead of acquiring or merging with a foreign company, telecommunications manufacturers Huawei and ZTE have set up R&D centers in Sweden and the U.S., among other countries, as a way of increasing visibility and sourcing technologies.

In summary, the bulk of China's outward FDI has been closely linked to foreign policy objectives of securing access to raw materials and expanding economic and political influence. As a result, China's prospective "national champions" are targeting developing countries and transition economies, more so than developed countries, in their international cooperation and expansion efforts. China's strategies for going abroad were exemplified by ZTE's Chinese New Year reception held in Beijing in January 2006. This is the first time ZTE organized a formal reception tailored only to foreign diplomats. Of the 33 countries in which ZTE has activities, 27 are developing countries or transition economies.

10.4 Corporate R&D Activities in China

10.4.1 Number of Foreign R&D Centers is Growing Rapidly

As the previous section has shown, transferring knowledge and technologies to China through foreign companies has been a long-standing goal of China's FDI policies. However, foreign companies' establishment of R&D centers in China is a relatively recent phenomenon. A few pioneering companies, such as Microsoft, Nortel, Ericsson and Nokia, set up innovative R&D labs in China in the second half of the 1990s. Since 2000, the number of foreign R&D centers in China has increased dramatically.

While in the 1980s and 1990s most R&D activities by foreign companies in China consisted primarily of product development and adaptation to the Chinese market, now large multinational companies, many of whom are technology leaders in their fields, are increasingly locating innovative R&D in China. We use the term "innovative" to differentiate between R&D activities devoted merely to adapting products to the Chinese market (adaptive R&D), and operations with a scope and nature that exceeds the domestic Chinese market. Centers with innovative R&D functions are also sometimes referred to as "global R&D centers."

Examples of companies carrying out innovative R&D in China include Nokia, Microsoft, Ericsson, Intel and Motorola. For example, "Nokia shifted a significant part of its third-generation software development to Hangzhou, transferring technologies and people from the former competence centre in Finland" (von Zedtwitz 2004). Another example of an "early mover" locating innovative R&D activities in China is Microsoft. Microsoft China's R&D operations are an important part in Microsoft's global value chain. One of Microsoft's six research labs worldwide, Microsoft Research Asia (MSR Asia) established in 1998 and employing approximately 170 researchers, is based in northwest Beijing. In late 2003, Microsoft opened its Advanced Technology Center (ATC) in the same building (Buderi 2005).

The lab and the technology center are not only researching and developing products aimed at the Chinese market, but also expect to be the key technology transfer point for a host of new Microsoft products worldwide, such as web search and mobile technologies.

There are three ways for foreign companies to establish R&D operations in China: as wholly independent R&D labs; as R&D departments or activities within either a branch of a Chinese operation or a joint venture with Chinese partners; and, as cooperative R&D with Chinese research universities or institutes (von Zedtwitz 2004). According to Gassmann & Han (2004), the more sensitive the technology is for the company, the more likely that its Chinese operations are wholly foreign-owned. Foreign R&D centers are mainly greenfield establishments. There are indications of joint venture-based R&D labs becoming “more viable modes of entry into R&D in China” (e.g. Nissan with Dongfeng Motors) (von Zedtwitz 2004).

10.4.2 Not All Foreign R&D Centers are Operative

For several reasons, it is difficult to accurately assess R&D activities by foreign companies in China. The figures of R&D employees in foreign companies in China only reflect part of the actual R&D activity. Many foreign companies have R&D cooperation with, or buy R&D services from, Chinese companies. In addition, R&D is one of companies’ most strategic, and therefore sensitive, activities, which means that they are not always keen to disclose how much or what kind of R&D they have and where. A third reason it is difficult to gain a clear picture of foreign corporate R&D activities in China is that foreign companies are offered significant incentives (financial and otherwise) to establish R&D operations. Chinese authorities sometimes require companies to set up local R&D in return for being allowed to manufacture or sell in China. As one person interviewed by the author said, “The Chinese demanded [that we carry out R&D in China], so we hired a few engineers.” As a result, some R&D activities exist more on paper than in reality. Gassman & Han (2004) observe that preferential treatment and government incentives for foreign R&D facilities may induce some foreign companies to register their activities as R&D even if they would not otherwise be classified as such. Companies may do so to establish goodwill with Chinese authorities since they strongly encourage foreign technology transfer and because “local R&D activities are considered to be important evidence that a company is interested in developing long-term commitments in China” (Gassman & Han 2004). When examining foreign companies’ R&D operations more closely, we found a number of examples where companies publicly announce that they have an R&D center long before it is in operation, which sometimes never becomes operative.

The Chinese Ministry of Commerce stated that by late 2005 there were more than 750 foreign-established or foreign-invested R&D centers in China (MC 2005). For the reasons mentioned above, the number of centers actually carrying out R&D functions, performing R&D of relevance to the company’s China or global operations, is likely to be considerably smaller. According to Maximilian von Zedtwitz (2004), there were 199 foreign R&D facilities in China in the beginning of 2004. The number has increased since then, possibly amounting to 250–300 currently. Nearly all foreign companies that have innovative or adaptive R&D activities in China also have production or distribution facilities there.

It is even more difficult to assess how many of these companies are carrying out *innovative* R&D. This is partially semantics; where do we draw the line between innovative and adaptive R&D? For this study, we have examined and cross-referenced annual reports, company websites and news clippings of foreign companies' activities in China. We found a complicating factor in the discrepancy between R&D sites declared by a company or the Chinese press to be strategic, and the absence of these sites in the same company's listing, on its homepage, or in its annual report, of its global R&D centers. After correcting for this discrepancy, we found approximately 30 large multinational companies that currently have up to 60 facilities performing innovative R&D activities in China.

In summary, there exists a relatively new and clear upward trend for companies to establish R&D activities in China. In addition to establishing operations aimed at developing or adapting products solely for the Chinese market, a growing number of foreign companies are setting up innovative or global R&D operations in China.

10.4.3 R&D Centers Concentrated in a Few Cities

The vast majority of foreign R&D centers can be found in Beijing and Shanghai. Beijing appears to be a preferred R&D location for IT, telecommunications and electronics companies, while Shanghai attracts automotive, chemical companies, food, pharmaceutical and engineering companies (von Zedtwitz 2004). Maximilian von Zedtwitz finds clear indications of foreign R&D centers "clustering" with proximity to central government, academic institutions, design or fashion hubs, as well as with other R&D labs. While proximity to government seems to determine location in telecommunications, for example, in other sectors availability of graduates (e.g. engineering schools) and access to scientific, fashion or key consumer communities seem to be more important (von Zedtwitz 2004).

Foreign R&D activities focusing on product development or adaptation can be found outside Beijing and Shanghai, and are quite frequently located close to the companies' production facilities. However, when it comes to innovative R&D operations, with very few exceptions, they tend to be located in Beijing or Shanghai and not necessarily in close vicinity to companies' manufacturing plants. These two cities are the most popular destinations for foreign R&D activities because they offer a combination of highly qualified human resources, well-developed infrastructure, a concentration of industrial and science parks, as well as top-class universities and research institutes (Gassmann & Han 2004).

10.4.4 R&D Centers Also Concentrated in Certain Sectors

The extent to which foreign companies locate innovative R&D functions in China differs significantly according to industry. So far, telecommunications and IT or personal computer companies are at the forefront, whereas life-sciences companies have been less likely to locate such functions in China (Asakawa 2005 and Gassmann & Han 2004). A number of pharmaceutical companies have established, or make use of, clinical trial capabilities in China, but few have located innovative R&D there. Interestingly, some pharmaceuticals have recently announced plans to do so, (e.g. Novartis).

Given the dominance of telecommunications, software and personal computer companies in foreign companies' R&D operations in China, combined with the fact that in the 1980s and 1990s, R&D internationalization was largely limited to technology-based multinational companies, it is not surprising that the literature has focused on technology-intensive companies establishing R&D labs. Previous studies found R&D investments to be concentrated within high-technology industries and, quite often, to be pioneered by "high-tech companies operating in small markets that face a scarcity of resources in their home countries" (Gassmann & Han 2004, p. 424).

Lately, however, a number of companies in sectors which would not be considered high-tech are locating important R&D functions in China. In particular, a number of foreign-owned or foreign-invested product design centers have sprung up in the Shanghai area. Philips, Sony, GM, Electrolux and Motorola are examples of companies that have established design centers in China, and a number of companies report concrete plans to do so in the near future. For instance, Warner Brothers recently announced that it will move its global architecture and construction center from London to Shanghai (AFP). While many design centers set up by foreign companies in China are still primarily geared to service the domestic market, a growing number of companies with design operations are attracted to China because it offers good and inexpensive designers. Some are also starting to view the Chinese market as strategically important, not only because of its size, but because it is a dynamic and rapidly changing country that is assuming an increasingly significant role as global trendsetter.

10.4.5 Growing R&D Activities by Swedish Companies in China

So far, activities by Swedish companies in China have consisted mainly of production, purchasing and sales. In recent years, some Swedish companies have set up product development in China, and a few have set up research and design (see Figure 10-4). Ericsson, SonyEricsson, ABB, AstraZeneca and Electrolux are some of the Swedish or Swedish-related companies with at least one R&D facility in China. These four companies have also begun to locate parts of their innovative R&D operations in China. Ericsson, for example, has R&D centers in Beijing and Shanghai that carry out innovative R&D. SonyEricsson is developing mobile phones in their entirety at its facility in Beijing. ABB has several R&D facilities. These four companies employ a total of between 1,000 and 1,500 R&D staff in China. The figure is even higher if R&D employees contracted from wholly owned Chinese companies are included. Some companies, such as Ericsson, are also reportedly planning a substantial increase in R&D employees in China in coming years (*China Daily* 2005b). IKEA plans to locate a global design center in Shanghai.

About ten other Swedish companies (e.g. Volvo Penta, SKF and Sandvik) have product development for the Chinese market in China. So far, there is no clear indication that Swedish companies are closing down R&D operations in Sweden or in other countries in favor of locating R&D in China. A more important question, which is difficult to assess, is whether future expansion of R&D activities in China will occur at the expense of expanding similar activities in Sweden.

While Swedish small and medium-sized enterprises (SMEs) are increasing their activities and presence in China, R&D activities by Swedish companies are limited to large companies. This pattern is not surprising when considering that large multinational companies dominate international R&D activities in general (see for example ITPS 2005 and UNCTAD 2005b). At the same time, however, SMEs experience specific challenges when setting up operations in China (Schwaag Serger & Widman 2005). As a result, it is important to examine the extent to which absence of SMEs' R&D activities is a reflection of difficulties encountered in China, and whether this absence has consequences for their ability to participate in, and benefit from, the internationalization process in the long term.

10.4.6 Drivers of Foreign Corporate R&D Activities in China

As mentioned in Chapters 1 and 2, three key drivers determine companies' decision to locate R&D activities in a given country. The first is a supply of knowledge resources that may be better or cheaper in some countries than others, or may be unique to a specific country. The second factor is the intention to adapt products and services to the local market or to be near production facilities. A third reason companies might locate R&D to, for example China, is in response to political or institutional conditions (von Zedtwitz 2004). Examples of the third driving force include "local content" rules, laws concerning intellectual property rights. There are also national regulations that may require foreign companies interested in setting up production facilities to also set up R&D facilities. And there are fiscal incentives as well.

In the case of China, all three factors play a role in explaining foreign companies' R&D activities in China. However, the relative weight of each factor is changing over time. This section examines the driving factors by combining results from published studies with findings from interviews carried out with R&D managers and other experts between May 2005 and January 2006.

Figure 10-4 R&D activities in China by Swedish-owned or Swedish-related multinational companies.

Company	**R&D Centers, (place and year of establishment)**	**Type of R&D Activities**	**Number of Employees within R&D***	**Other Activities in China**	**Comments**
ABB	Beijing (2005), branch in Shanghai (2005)	Global R&D center (one of ten in the world)	20–50	Manufacturing, sales	China the third largest market. Total of approx. 8,000 employees in China
Astra Zeneca	Shanghai (2002)	Clinical research institute (East Asia Clinical Research Institute)	About 100	Manufacturing, sales	Biggest international company in China within prescription medicines. Growth of approx. 30 percent per year in China. A total of Approx. 1,800 employees in China. Cooperation with Shanghai Jiaotong University and others.
Electrolux	Shenzhen (2003) Shanghai (2004) Changsha (2004) Hangzhou	Electronic development center, global design center, some product development for the world market (fridge-freezers, hot goods)	About 50	Manufacturing, sales	Total of approx. 2,000 employees in China
Ericsson	Shanghai (1997) Beijing (1999) Chengdu (2004) Dalian (2005) Qingdao (2004) Guangzhou (2005) Nanjing (2005)	Seven R&D centers, some R&D for the world market	About 800 (approx. 20 percent of the total number of employees in China)	Manufacturing, sales	China is its second largest market. The leading supplier on the Chinese mobile market.
Sony Ericsson	Beijing (2002)	Global R&D center (one of four in the world)	About 100	Manufacturing, sales	China is the world's largest mobile telephone market.
IKEA	Shanghai (planned)	Global design center		Purchasing, sales	China is its largest purchasing source (18 percent)

Trelleborg	Shanghai (2004)	Technology center for Trelleborg Automotive; technology and development for China and the Far East		Manufacturing, sales	A total of approx. 400 employees in China
Assa Abloy		Some product development for the Chinese market.		Manufacturing, sales	
Atlas Copco		Some product development for the Chinese market.		Manufacturing, sales	Approx. 1,600 employees in China
Munters		Some product development for the Chinese market.		Manufacturing, sales	
Nolato		Some product development for the Chinese market.		Manufacturing, sales	Approx. 1,600 employees in China in 2004
Sandvik		Some product development for the Chinese market.		Manufacturing, sales	Approx. 850 employees in China
SKF		Some product development for the Chinese market.		Manufacturing, sales	Internship program with Shanghai Jiaotong University
Tetra Pak		Some product development for the Chinese market.		Processing, sales	China is its biggest market since 2002
Volvo Group		Some product development for the Chinese market (particularly market-adaptation within Volvo Penta)		Manufacturing, sales	China is the fastest growing market for Volvo cars (83 percent increase 2005)

Companies that currently have innovative R&D activities in China, i.e. R&D that consists of more than just product adaptation for the Chinese market.

Companies planning or about to establish innovative R&D activities in China.

Companies whose R&D activities in China consist mainly of product development or product adaptation for the Chinese market.

** It is very difficult to obtain reliable and comparable figures on R&D employees. The figures in the table are rough estimates and cover companies whose R&D activities in China consist of more than just product development and product-adaptation for the Chinese market.*

Source: Data has been compiled from annual reports, web pages and interviews.

Proximity to Market and Production

As has been pointed out in the previous section, multinational companies are drawn to establish production in China *both* because of low production costs and an attractive domestic market. Many foreign companies with production in China also have product development there. Activity, which usually consists of adapting existing products to the Chinese market (adaptive R&D), is often located in the same place as the production facility. In principle, all companies with R&D facilities in China had manufacturing, purchasing and/or distribution activities there before they set up research or product development. So far, adaptive R&D is the dominant form of R&D carried out by Swedish and most other foreign companies in China.

The desire to be close to the strategically important Chinese telecommunications market may be one explanation why telecommunications and IT companies have dominated foreign R&D activities in China. Dramatic growth rates in the number of PC and internet users make China an attractive market for companies such as Google and Hewlett Packard. Domestic technical requirements and standards give a further explanation why companies such as Motorola, Microsoft, Ericsson, SonyEricsson, Nokia, etc. were among the first to set up extensive R&D operations in China (von Zedtwitz 2004). Finally, "if the company's business requires local product adaptation and intensive customer cooperation, it is likely that local development units will be established" (Gassmann & Han 2004, p. 426).

Analyzing company-level data on science and technology activities, Motohashi (2006) finds that "the major motivation of foreign R&D in China is 'market driven' instead of 'technological driven' or 'human resource driven.'" However, he acknowledges that the motivations differ depending on where in China companies establish R&D. Thus, market-driven R&D is observed primarily in Guangdong, whereas foreign companies' R&D operations in Beijing are more technology driven, due largely to a concentration of scientific institutions in China's capital. He finds that "Shanghai, with both a large industrial as well as strong science sector, is in-between." We find that while market-driven motivations are important, human resource or technology driven motivations also play a significant role.

Human Capital

Human resources have grown significantly in China in recent years, both in quantity and quality. China's increasing research strength, combined with its well-equipped laboratories and a large supply of relatively inexpensive scientists and engineers, is attracting the attention and investments of many R&D intensive companies. Thus, for example, a growing number of pharmaceutical companies are choosing China as a location for carrying out clinical trials. The labor cost for a Ph.D-level researcher in

Shanghai is around one-fifth the cost for a similar resource in Silicon Valley, and the costs for conducting clinical trials in China are about one-fourth the costs in the U.S. (*BusinessWeek* 2005a).

Our interviews confirm that well-qualified, motivated and relatively inexpensive engineers, doctors and other scientists constitute an important pull factor in companies' considerations to establish R&D activities in China. As mentioned above, foreign companies' innovative R&D operations are strongly concentrated in the Beijing and Shanghai area. Both offer a large supply of highly skilled labor, which is explained by a concentration of internationally renowned universities and research institutions.

When asked to reflect upon their experiences carrying out R&D in China, R&D managers of two foreign firms indicated a high level of satisfaction with the quality available of human capital. They did acknowledge that Chinese employees, on average, currently still lack some management capabilities or the ability to think "out of the box" in comparison to their world counterparts. However, many executives also pointed out that they do not expect this will remain a shortcoming of Chinese employees. Evidence of this can be seen in the number of companies beginning to promote local Chinese employees to replace foreigners (hired initially to manage the new operation) in key management positions.

Policies and Government Incentives

Perhaps the most important reason foreign companies originally located R&D in China was because they had to. In addition to its abundant labor supply, low manufacturing and transport costs, and a large domestic market, foreign investors have been drawn to China by a combination of FDI-friendly policies and "persuasion."[16] Since China began to open to foreign companies, it has pursued a determined policy that requires companies interested in producing or selling goods and services in China to transfer technology (Gassmann & Han 2004). Officially, the "Decision on Amendments to the Implementation Rules of the Law on Wholly Foreign-Owned Enterprises," issued by the State Council in 2001, removes these requirements for foreign companies. However, in practice, many companies are still "encouraged" or pressured to locate R&D in China (see Walsh 2003 and Long 2005).

> *China implemented a "swap market for technology" strategy, which essentially required foreign investors to "import" advanced technology in return for entering the domestic market* (Long 2005, p. 334)

[16] While there are signs of emerging labor shortages in certain regions, aggregate unemployment is still high and thus China is likely to have a large pool of cheap labor for quite some time.

As an example, China used its market as a leverage for requiring technology transfer when automobile companies competed for licenses to establish joint venture establishments in China in late 1990s (at a time when it was speculated that this would be the last license to be issued for long time) (Gassmann & Han 2004).

Furthermore, companies are establishing R&D operations in China because significant tax rebates and other financial incentives are being offered. In addition to preferential policies for FDI in general, a number of policies are targeted at attracting technology-intensive activities of foreign companies.[17] In April 2000, the Ministry of External Trade and Economic Cooperation (METEC) passed a regulation which offered preferential treatment for foreign R&D labs (von Zedtwitz 2004). Science parks and high-tech development zones advertise tax rebates and other benefits on their websites for companies willing to establish R&D activities on their premises.[18] Examples of the policies targeting foreign technology-intensive activities are exemptions from customs duties and VAT on the import of equipment and technologies for self-use. Gains from technology transfer activities can be exempt from business and enterprise income taxes. Some R&D and wage expenses can be used to offset enterprise income taxes.

Some of China's policies are argued to be in conflict with WTO rules. However, there are currently no signs that China intends to phase out preferential policies for attracting foreign R&D.[19]

Challenges of Locating R&D to China

We have identified three major driving forces explaining the recent increase foreign companies' R&D activities in China. However, companies also experience a number of challenges to establishing R&D in China. Gassmann & Han (2004) identified a number of barriers that foreign companies face when managing R&D in China. They categorized these barriers as either stemming from complexity, unpredictability, or a combination of both. Examples of barriers experienced by companies within their organization include management and communication difficulties due to language and cultural gaps, low individual initiative, lack of innovative thinking among the local R&D staff, and high employee turnover rates.

[17] Preferential FDI policies include low tax rates or tax exemptions on VAT, corporate taxes and income taxes, exemptions from import tariffs on production inputs imported by Foreign-Invested Enterprises (FIEs), favorable land use rights, administrative support, subsidized office rents, etc (see for example HKTDC 2004, and Hou 2004). Foreign companies establishing themselves in China are exempt from corporate income tax for the first two years that they make a profit. After that, they are subject to 15 percent corporate income tax on average, which is much less than the normal rate for Chinese companies of 33 percent (Prasad & Wei 2005).

[18] See for example Jiangsu Province Taixing Economic Development Zone, www.chempark.com.cn/enwhh/htm/1_guide09.htm, or Xi'an High-Tech Development Zone, www.cbw.com/business/invest/xian/policies.htm.

[19] This is exemplified by the "Opinions of Shanghai Municipality on Encouraging Overseas Investment in the Establishment of Research and Development Institutions," formulated and adopted as recently as 2003/04, see w2.tdctrade.com/report/reg/reg_040102.htm.

Outside the organization, companies identify bureaucracy and insufficient enforcement of intellectual property rights as important obstacles to operating R&D activities in China.

Political and economic stability and rule of law play an important role when companies decide whether to locate production in a given country. Arguably, expectations of a favorable political climate, and of a lasting investment-friendly environment, become even more important when considering whether to set up R&D operations in a country. This is explained by the fact that R&D operations are considered a very sensitive function and because the establishment of R&D operations can be seen as an undertaking which requires a fairly long-term planning horizon. Overall, China has been considered for quite some time to have an environment that is conducive to FDI. The recent elimination of restrictions on the establishment of foreign-owned companies and China's entry into the WTO are some factors considered to have further enhanced China's attractiveness for foreign R&D operations. However, a few factors could change this situation.

First, there could be a change in China's policy for attracting FDI in general and foreign R&D in particular. As mentioned above, criticism of the government's policy of attracting foreign R&D is growing. Critics are questioning to what extent there are positive spillovers from foreign R&D centers to domestic companies and research institutions. They claim that foreign research centers may actually be starving domestic companies of the best scientists and engineers, and criticize the government for putting too much emphasis on attracting foreign technologies, rather than promoting the growth of domestic technologies, (see for example Cao 2004 or Yuan 2006). The government's recent emphasis of the need to strengthen "independent innovation," to reduce China's dependence on foreign technology and innovation is a reflection of this emerging trend. Second, political instability may either slow down the pace of economic growth or reduce the attractiveness of China as a market or business environment. Recently, there have been signs of growing political unrest, attributed to the increasing inequalities between those who benefit from China's economic development and those who are left out. A third potential threat to China's economy is the poor condition of its banking system, and its large number of bad loans.

An issue often mentioned as an important factor deterring foreign companies from locating R&D in China, is weak protection of intellectual property rights (IPR). In our interviews, we found no clear consensus on this. While some interviewees listed fear of piracy as a clear concern, others claimed that this was not a significant obstacle. Some executives also expressed that they were optimistic that the issue of IPR would resolve itself over time, as Chinese companies become more innovative and thus acquire a stake in good IPR laws.

Summary

The following quote by an executive with a long business experience in China succinctly summarizes the development of foreign companies' R&D in China: "Initially, firms located R&D here because they had to. But once they were here, they realized how attractive it was for them to do R&D in China."

Thus, government policy of "encouraging" or effectively demanding technology transfer in return for access to the Chinese market played a key role in initially getting companies to establish R&D centers in China. This seemingly "bitter pill" was sweetened with generous tax and other incentives for foreign companies setting up R&D operations in China. Government policy still plays an important role in some industries. However in recent years, the importance of government policy has waned. It has been replaced by a combination of factors (e.g. proximity to production facilities, a large market, and human capital) that constitute a strong argument in favor of foreign companies' establishing R&D in China.

Several aspects make China a unique case. First, low production costs and the domestic market coincide to make China a highly attractive location for production. Second, and in addition to these two factors, China offers a competitively priced and abundant pool of highly skilled labor. The combination of these factors means that companies, or industries, can either locate or have access to the entire value chain of their product in one, albeit large, country. According to several interviewees, it is the combination of these factors that makes China attractive for purchasing, production, distribution *and* R&D.

10.4.7 Limited R&D Activities by Chinese Companies Abroad

Chinese companies have relatively limited international R&D activities. Maximilian von Zedtwitz (2005), examined eleven Chinese companies – all leaders in their industry in China – and found that six of them operated international R&D units. Some Chinese companies acquire international R&D centers through the purchase of foreign companies. Examples are computer manufacturer Lenovo, which "acquired" R&D centers outside China through purchase of IBM's PC business, and consumer electronics producer TCL through its merger with French counterpart Thomson. A few Chinese companies have set up their own R&D centers abroad. Thus, telecommunications companies ZTE and Huawei recently established R&D centers in the Stockholm region.

The most likely reason for Chinese companies to set up R&D in developed countries is to source foreign technology. In contrast, when Chinese companies establish R&D centers in developing countries, the main reason seems to be market-oriented R&D (von Zedtwitz 2005). Furthermore, a number of large Chinese companies are still state-owned or controlled, and therefore likely to heed the Chinese government's recent appeal to Chinese companies to "go global" with R&D.

The fact that Chinese companies' R&D activities abroad are still limited can be explained by the fact that Chinese companies still invest relatively little in R&D, particularly innovative R&D. According to a recent article in *China Daily* (2005a), while companies in developed economies allocate on average approximately 5 percent of annual revenues to R&D, in China the average rate is around 1 percent. For example, telecommunications companies Huawei and ZTE each spend 10 percent of their annual revenue on R&D. By comparison, Ericsson and Nokia spend 16 and 13 percent respectively of net sales on R&D, according to annual reports.

10.5 Conclusions

10.5.1 Main Findings

In recent years, foreign companies' R&D operations in China have increased dramatically. We estimate that currently there are at least 250 R&D centers established by foreign companies in China. Initial R&D activities by foreign companies in China consisted almost exclusively of activities aimed at developing or adapting products to the Chinese market (adaptive R&D). However, in recent years we are witnessing a strong emerging trend of foreign companies locating innovative R&D operations in China, that is, activities which are not just aimed at meeting Chinese requirements for technology transfer or adapting products to the Chinese market. We estimate that currently around 30 multinational companies have up to 60 innovative R&D centers in China, primarily in the Beijing and Shanghai areas.

The tendency to set up innovative R&D centers is heavily concentrated in selected industries, such as telecommunications, software and personal computers; in other sectors, such as life sciences, there is no similar discernible trend.

A large and rapidly growing internal market, combined with an increasingly attractive human capital base, make a powerful case for establishing R&D in China. In addition, a significant share of foreign companies' R&D activities remains driven by government incentives or "persuasion tactics." However, there are some signs that this driver of foreign R&D activities might become less important over time.

Weak IPR protection is often mentioned as deterring foreign companies from locating R&D in China. Several of the people interviewed for this study expected this issue to be addressed by the Chinese authorities in a foreseeable future. The executives did not list this as a huge problem and were cautiously optimistic that the issue would resolve itself over time, as Chinese companies become more innovative and thus acquire stake in good IPR laws. Also, improved IPR protection could contribute considerably to increasing the positive spillovers from foreign R&D activities to domestic companies. As argued by von Zedtwitz (2004), “Stronger intellectual property rights and their consistent enforcement will certainly have positive effects on the interaction of foreign R&D centers with the Chinese scientific and engineering community” (p. 449).

A few sectors, in particular telecommunications and IT, clearly dominate foreign companies’ R&D operations in China, and are likely to continue to do so for some time. In other sectors it appears less likely that companies will locate important R&D functions in China in the near future. This is partially because, in some cases, proximity to the Chinese market is not as critical; China’s human capital still lacks the necessary skills required to conduct R&D specific to that sector; or because China’s innovation system still suffers from some significant other weaknesses that are more relevant in some sectors than others. Foreign pharmaceutical and biotechnology companies provide a good example; few have set up significant R&D activities in China (see analysis of China’s biotechnology sector provided in Nilsson et al. 2006).

Developed countries are observing the increase in foreign corporate R&D with a mixture of astonishment and anxiety. China’s increasing attractiveness as a location for corporate R&D activities, in addition to remaining a top choice for multinational companies when it comes to manufacturing, purchasing and sales, poses new challenges for developed countries, such as Sweden.

There is evidence that other countries like Sweden still have a comparative advantage in performing some R&D activities, for example, in setting up and maintaining complex systems research and systems integration that require successful linkage and interaction of different R&D units. Sweden also has advantage when it comes to cooperation with academia and policymakers.

10.5.2 Looking Ahead

Proximity to market and production, an increasingly strong and competitively priced human capital base, and government policies are the principal drivers behind localization of foreign companies’ R&D centers in China. While all three factors are important, their relative weight is changing over time. Government policies – while still playing an important role – may become less of a deciding factor in attracting foreign R&D in China, at least in some sectors or industries. This could be partially because preferential policies for technology transfer may change in response to growing criticism of a bias in favor of foreign-owned companies, but more importantly because other drivers are gaining importance. In the future, companies may be less likely to establish R&D centers in China because they *have* to; instead they may do so to tap China’s abundant human capital, and to be close to the increasingly strategically important domestic Chinese market.

The attractiveness of China's domestic market is unlikely to wane (unless there is a major political, economic or other crisis), and can actually be expected to increase in importance in the near future. Weak points in China's economy today include the fact that private consumption contributes comparatively little to China's economic growth, and that China has one of the highest savings rates. The government has announced that it intends to adopt policies aimed at stimulating domestic consumption. If they succeed, China's domestic market is likely to continue to attract foreign companies to produce, sell and design products in China and for the Chinese market.

As long as China's economy continues to experience high growth rates, as long as China's supply of human capital continues to strengthen in both quantity and quality, and, as long as there are no major shifts in policy, we are likely to witness a continued increase of both adaptive and innovative R&D activities by foreign companies in China. China's human capital is likely to strengthen, as rapidly growing investments in R&D and human capital yield results, and as China's labor force gains better management and related business skills over time. The question is how quickly wages will rise, thus moderating the price argument for hiring Chinese researchers and engineers.

10.5.3 Policy Implications for Sweden

China's rise as an important global manufacturing *and* knowledge base, as well as a large domestic market, will make it an increasingly strong contender for research and development. The emergence of countries like China and India as attractive locations for corporate R&D indicates a major shift in international economic relations. R&D, knowledge and human capital are no longer the exclusive domain or privilege of developed countries. Nor is their location as path-dependent as one may have previously assumed. Rather, knowledge is becoming a mobile asset. One explanation for the growing mobility of knowledge can be found in the fact that large multinational companies account for an increasing share of R&D expenditures. Ford Motor or Siemens, for example, have larger R&D budgets than countries such as Spain, Belgium, Switzerland or Brazil (UNCTAD 2005b). These multinational companies will locate R&D where the markets are attractive and human capital is good, both in terms of price and quality.

Even if China still has a long way to go in becoming a knowledge-based economy, the country already has more knowledge resources, quantitatively speaking, than any other country in the world except for the U.S. In addition, strong international knowledge and research environments are developing within some high technology fields with strong support from the government. The combination of a large and rapidly growing domestic market and an increasing supply of internationally competitive human capital is one of the biggest challenges facing Sweden (and other countries) wishing to retain production and strategic R&D functions.

At the same time, the weaknesses in China's innovation system illustrate another important point. Knowledge and innovation capabilities cannot be created by decree, and the processes of knowledge creation, utilization, and transformation are not top-down processes. Rather, they depend on a complex set of values, learning processes, networks and interactions, which require – and must be gradually shaped by – social capital (defined as shared values, norms and trust that reduce transaction costs), communication and competition. Framework conditions enabling innovative capabilities take time to mature.

Sweden's R&D is traditionally dominated by a handful of large multinational companies. Some of these are increasingly building R&D capabilities in China, among other places. The localization of certain R&D functions to China need not come at the expense of corporate R&D activities in Sweden. Sweden has significant comparative advantages in: systems research and design; its strong tradition of science and education; and in a number of internationally renowned research clusters.

China's rapid development and growing strategic importance make it difficult for policymakers and business executives to gain an accurate impression of what China means for their policy area or line of business. In order to be able to separate the hype from actual opportunities and threats, Sweden must improve its understanding of the Chinese economy as well as China's impact on the global economy.

Proximity to production is an important determinant of localization of R&D in some industries. Thus, maintaining R&D in Sweden may in some cases require maintaining production in Sweden. Policymakers should increase their understanding of the importance of proximity to production for R&D and design and adjust policies accordingly.

Given the increasing global competition for knowledge, countries need to optimize the use of their available knowledge resources. One way to increase Sweden's knowledge and innovation capacity is to improve conditions for recognizing and utilizing existing knowledge resources in Sweden. Immigrant academics are just one example of underutilized knowledge resources. In addition, Sweden should seek to ensure that framework conditions are conducive to attracting knowledge resources to Sweden.

With regard to China's increasing role in the international market economy, Sweden should seek to establish mutually beneficial cooperation with Chinese researchers and companies. This requires designing national strategies for science and technology cooperation with China. Alumni networks of Chinese students who have studied at Swedish universities should also be created and then nurtured as an important foundation for future Sino-Swedish relations.

One potential response to the challenges and significant opportunities presented by China is to ensure that Sweden offers internationally leading research environments. These research environments' strength will depend not only on academic excellence but also on the successful interaction of actors from research institutions, the business sector and the public sector (the "triple helix"). Successful interaction cannot be achieved simply through creation of "bridging mechanisms" (such as technology transfer offices).

As mentioned in Schwaag Serger & Widman (2005), SMEs face particular challenges when seeking to establish themselves in China. In addition to the difficulties of financing operations in China and recruiting and retaining key personnel, SMEs face specific challenges when it comes to protection of intellectual property rights. Currently, SMEs are underrepresented in Swedish companies' R&D activities in China. At the same time, SMEs could contribute considerably to Sweden's export base and international competitiveness, especially with regard to technologies and services.

The government may consider establishing mechanisms for supporting SMEs with defense of intellectual property rights in China, and in other countries. Government policies should be designed to stimulate R&D in SMEs and to increase SMEs' role in business sector R&D and international cooperation.

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11 India's Potential as a Global R&D Power

Raja M. Mitra

11.1 Introduction

India has witnessed strong economic performance, with a rapid growth of high-tech industries demonstrating the country's development potential. Since the late 1990s, this development has been accompanied with an export-oriented expansion in domestic and foreign corporate R&D investments, particularly in the information and telecommunications technology (ICT) sector. The prospects for continued growth of foreign R&D operations, both in goods production and services, point to a significant structural change in the national and international economic order – of which the full consequences are hard to foresee.

In recent years, a common perception has been that India can emerge as a major international R&D and knowledge process outsourcing (KPO) center. This is reflected in the statements of top corporate leaders, financial institutions, consulting firms, government officials and academics in India as well as overseas. The optimism exhibited by key stakeholders has resulted in expansion of foreign and Indian companies' R&D operations directed at both the local and international markets.

This confidence in India's R&D potential is evident in the following statement made by R. A. Mashelkar, Director General of Council of Scientific and Industrial Research (CSIR) in New Delhi: "India has the potential to become the number one knowledge-producing center in the world by 2025, going by the way that things are moving" (Mashelkar 2003).

India's emergence as a major economic and R&D power is poised to have wide-ranging implications for the people of India and globally. These include effects on trade, investment, employment, the environment and trajectories for national industrial and technological developments. The impact is poised to be significant in major sectors such as: information and communication technology, industrial manufacturing; construction and other engineering; agriculture; and life sciences covering pharmaceuticals, bio-informatics, medicine and healthcare. Furthermore, continued rapid growth is expected in IT-enabled services (ITES) areas (e.g. business process outsourcing (BPO), including higher-end knowledge process industry niches such as finance, accounting, insurance, education, as well as other services). This growth is spearheaded by developments in the software industry coupled with ICT hardware and telecommunications.

U.S. companies have so far led in expanding the production of offshoring of services in India. Much of Europe and Asia have lagged behind the U.S. corporate sector in establishing R&D operations in India. There are however strong indications of a rapid expansion of R&D activities by a large number of stakeholders. This is illustrated by the way British, Canadian, Chinese, German, Swedish and other companies are expanding their operations in India.

An Economist Intelligence Unit (EIU) global survey conducted in 2004 found that multinational companies are redistributing their product innovation activities across the globe. Some 70 percent of the companies surveyed employed R&D people overseas; 52 percent reported that increasing overseas R&D spending was a priority. When asked to choose the most likely centers for overseas investment, India ranked third (behind the U.S. and China), attracting 28 percent of the respondents (EIU 2004a and 2004b).

Furthermore, the EIU survey found that 70 percent of companies employing R&D workers overseas considered India an R&D "hotspot." EIU defined a R&D hotspot as "a place where companies can tap into existing networks of scientific and technical expertise; which has good links to academic research facilities; and provides an environment where innovation is supported and easy to commercialize." India is claimed to have many of these qualities (EIU 2004a).

India still has a long way to go before it can claim to be a major world power in R&D. International trade, investment and principal R&D indicators show that India is a minor player in the global context despite its large population. Future developments critically depend on forceful action by government and corporate stakeholders to build on opportunities and strengths while simultaneously responding to risks and tackling shortcomings. Despite the challenges, the country appears poised to become a significant power in the high-tech industry, its principal asset being the size of its educated workforce.

The objective of this chapter[1] is to provide a strategic review of corporate R&D developments in India. It examines key trends, drivers and future prospects for R&D with special focus on India's emerging role as an attractive location for R&D and knowledge process services industry. The chapter also explores the numerous factors that constrain development of India's R&D capabilities, such as human resource and infrastructure developments, corporate and public sector policy and governance. Finally, the chapter discusses scenarios for India's emergence as a global R&D power and the local and global implications, including implications for Sweden in particular.

[1] This chapter is based on forthcoming publications by the author covering globalization, offshoring, R&D, and ICT industry specific developments in India and their local and global implications. One of the early outputs of this work is a more extensive version of this chapter and thereby related material published as a separate report by ITPS in 2006 (see www.itps.se).

The study draws on a wide range of published information sources and a large number of interviews with private companies, government officials and scientists in India, Sweden and the U.S. The analysis uses published information, but attempts to go beyond an understanding based on official indicators recorded by government (R&D spending, number of engineers and scientists, patents and publication indices, foreign investment, trade and other statistics) as these data are incomplete and can be misleading. Analysis of company-specific developments based on interviews is required to provide a more comprehensive picture and to ensure that the examination is relevant and up to date.

The lack of substantive analysis of corporate R&D in India point to a need for further research. This task is not easy, because of the complexity of issues involved and the lack of both quantitative and qualitative information. While the number of publications relating to R&D, high-tech industry and offshoring developments is growing, much of what is written is based on incomplete data and analysis.

In addition, much of the literature falls short in distinguishing and explaining correlations and causality of factors driving and impeding high-tech industry and science and technology (S&T) development. As pointed out by Rajesh Shukla, “Unfortunately, no systematic and comprehensive empirical assessment of S&T efforts is available in the Indian context, resulting in a relatively chaotic and contradictory picture of the national efforts in S&T” (Shukla 2005).

The varied views on Indian developments reflect the perspectives of various stakeholders. While some focus on the impact on the Indian economy at large, including the poor and rural areas, others focus specifically on the impact to well-educated, urban-middle and affluent business classes. Yet others are more concerned with the implications for foreign consumers and multinational companies. This chapter argues the need to develop a holistic understanding and a long-term perspective of opportunities and limitations of high-tech industry and R&D development.

11.2 National Science and Technology Development Context

11.2.1 Global Economic and R&D Position

Economic Position

India’s share of the world’s population is 17 percent, but it accounts for less than 2 percent of the global GDP and only 1 percent of world trade. It lags behind China and other East Asian economies in key indicators such as GDP per capita, basic education, infrastructure and volume of foreign trade and investment. While India is the star performer in Asia in exports of software and IT-enabled services, it lags behind in computer and Internet user penetration. ICT diffusion, however, has risen quickly, as demonstrated by the rise in the number of Internet users from less than one million in 2000 to over 50 million in 2006. This number is projected to reach over 80 million by 2010 (NASSCOM 2006 and Internetworldstats 2006).

A wide range of indicators point to India's potential for catching up. The country's adult literacy rate for has risen from 58 percent for men and 31 percent for women in 1985, to 68 percent for men and 45 percent for women in 2000 (World Bank 2006). Moreover, the numbers of engineering students graduated annually have risen from about 44,000 in 1992 to approximately 184,000 in 2004 (NASSCOM 2006) compared to 352,000 for China (China Statistics Yearbook 2004) and 76,000 for the U.S. (Morgan Stanley 2005). The ratio of Indian population living below the poverty line, as measured by the National Institute of Rural Development, has decreased from 55 percent in 1973–74 to 26 percent in 1999–2000.

The Indian economy is expected to grow at a rapid rate of 6–9 percent between 2006 and 2010 and beyond. By the year 2032, China will have the world's largest economy (in terms of GDP at market prices), followed by the U.S. and India, according to a much publicized scenarios presented in the BRIC report released by Goldman Sachs (Goldman Sachs 2003). In terms of purchasing power parity (PPP), India's GDP is already the third largest in the world after the U.S. and China. While much of the country is likely to remain poor and industrially backward, other parts have the potential to grow as fast as China or other East Asian economies. Some urban areas are increasingly integrated in the new global knowledge-based economy as demonstrated by the cases of Bangalore, Chennai, Delhi, Hyderabad, Kolkata, Mumbai and Pune.

To understand the prospects for India to become a major economic and technological power, a long-term perspective is required, including an assessment of the country's current global position in economic, social and technology development, a review of historical phases of change, and the evolution of government policies.

Higher Education, R&D Institutions and Access to Information Networks

The principal factors contributing to India's chances of becoming a major global R&D power are the size of its educated workforce, entrepreneurial traditions and a significant existing R&D-related institutional infrastructure. India's education and research system is diverse and ranges from internationally competitive institutions to those with inferior performance. The country's pool of young university graduates (those with seven years or less of work experience) is estimated at 14 million. This is 1.5 times the size of China's, almost twice that of the U.S., and topped up by 2.5 million new graduates every year (Farrell et al. 2005). The number of highly qualified engineering Masters- and Ph.D-level researchers is however not so large if compared to major industrial nations. India produces about 6,000 Ph.Ds annually. The IT and IT-enabled services sector had led the growth in technical human resource demand. The number of professionals employed in the IT and IT-enabled services industry has grown from 51,000 in 1990 to about 1.3 million in 2006 (NASSCOM 2006). As of 2006, India and China both had larger stocks of educated human resources, including engineers and number of new science graduates, than any other countries in the world (Mitra 2006b). India has invested much in expanding its higher education and R&D institutions since the 1950s. From the 1990s these efforts have begun to yield major payoff as illustrated by the high-tech industry developments in India and the role of the Indian Diaspora in, for example, Canada, U.K. and the U.S.

These types of observations must however be critically evaluated and put in a long-term development perspective. On a per capita basis, the number of people with higher education in India, including engineers and scientists, is still very low compared to major industrial economies and countries such as Poland, Brazil, China and Russia. This points to a major scope increase in the number of people with higher education. India indeed has a key advantage in the absolute number of persons with higher education. In addition, the number of people with relevant higher education, training and professional experience is increasing exponentially.

The number of people with higher education has increased significantly but there are major outstanding issues in the relevance and quality of education and training programs. Only between 10 to 25 percent of India's graduates are considered suitable for employment by multinational corporations (Farrell et al. 2005). In addition, there is considerable room for improvement to ensure that those with relevant higher education, talent and professional experience are employed in ways such that their abilities are effectively utilized.

The government has traditionally had the major role in education and R&D institutional capability building. It has given priority to the provision of free higher education and the establishment of a large number of research institutions within the public sector. The effectiveness of these efforts has been mixed, but improved in the 2000s. Furthermore, private institutions have begun to play a more significant role in higher education, training and research since the 1990s. This is illustrated by the rapid growth in education and training, especially in software and IT-enabled services, and business administration.

Despite substantial public spending on universities and R&D labs, India's library facilities are generally poor by international standards. However, the Internet has opened access to data, information and knowledge, and facilitated global networking among academic and corporate groups. This increased level of access has led to a major scope-shift for India (and other less developed areas), to now play a more prominent role in R&D.

R&D Spending and Funding

India's R&D expenditure is still low compared to major industrial economies, in dollar terms, on a per-capita basis and in terms of its ratio to GDP (about 0.8 percent of GDP in 2005, according to official estimates). These figures can, however be misleading. India's official data excludes much corporate and internationally funded R&D activity. Also, international comparisons at market prices are deceptive. One dollar equivalent spent on R&D in India results in an output many times larger than the same amount spent in high cost economies. Indian R&D spending levels are indeed substantial on a purchasing power parity (PPP) basis. Adjusting data on R&D expenditure to differences in purchasing power is, however, a complex affair (NSF 2006). According to UNESCO data, India's R&D expenditure has increased from 10 billion dollars in 1996 to 20 billion dollars in 2000, making it the seventh largest country in that year in gross domestic expenditure on R&D (GERD) measured at PPP. China was the fourth largest country with R&D expenditure, estimated at 49 billion dollars (UNESCO 2005).

On the other hand, a large share of government R&D outlays in India is not utilized effectively, especially compared to spending in the private sector. One example of this is the fact that a large number of, so-called, scientists in government research labs do no, or little, actual R&D.

Furthermore, it should be noted that the pattern of financing R&D operations has begun to change significantly since the late 1990s. One major development is increased access to local and international private financing for R&D, including funding from multinational companies and the emergence of more significant foreign venture capital industry activities.

Patents and Publications

Making a balanced assessment of the outputs from India's national innovation system is perhaps even more difficult than assessing its inputs. The number of filed patents and internationally acknowledged scientific publications from India is still small despite the country's large stock of graduates and academic faculty. In addition, India gets very little in worldwide royalty and license fee receipts.

India's number of patents and publications does not fully reflect R&D and innovation capabilities. In the India-specific context, several factors have hampered incentives to file for patents and to publish in foreign academic journals. Filing for patents is, in many quarters, considered complicated and expensive even when innovation capabilities are present. Academic faculty and scientists have traditionally had secure jobs with more-or-less guaranteed promotion, providing less incentive to publish than in more competitive environments. Most R&D in the corporate sector is development rather than research, and applied development work typically does not result in scientific contributions. In addition, mass-scale KPO work, while often related to science, does not generally produce scientific publications or patents.

While still lagging behind industrial economies, India has experienced a sharp increase in terms of patents and publications since the late 1990s. Gradually, the national innovation system has provided for greater incentive to do work that can result in patents and publications. Multinational companies are playing a major role but much of their activities are still not fully reflected in published statistics.

The number of patents granted by the United States Patent and Trademark Office (USPTO) to foreign-owned R&D establishments has increased rapidly since the late 1990s. An increasing trend is also discernable in the number of patents granted by the Indian Patent Office. The 2005 amendments to the Indian Patent Act, adopted to adhere to the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement, have boosted the confidence among international players to seek Indian patents for their innovations. Particularly Indian patents on drugs and electronics that have shown a sharp increase in the recent years (Bowonder et al. 2003 and Bowonder 2005).

The Indian-based R&D centers of companies such as Texas Instruments, General Electric, IBM, Hewlett-Packard, Hoechst and Intel have contributed significantly to a sharp rise in patent filings from India in the 2000s. Industry analysts expect a significant expansion of competition and collaboration between the Indian and foreign R&D entities. Also, several Indian universities are strengthening R&D programs. Overall, India's record in patents and internationally acknowledged scientific publications is likely to improve significantly in the next 5 years and beyond.

Finally, it should be noted that the number of patents and academic publications originating from the Indian's working overseas is significantly larger than that coming from India-based R&D activities (Mitra 2006b).

Foreign Investment and Trade

India has lagged behind major industrial nations, East Asian and other economies in growth of foreign direct investment (FDI) and trade over the past decades. It currently trails China in FDI and high-tech trade, although official data understates India's position (Kumar 2005 and Mitra 2006a). There are signs that India is picking up as manifested in ICT-related FDI and exports and imports. FDI inflows to India have increased from 5.3 billion dollars in financial year (FY) 2004/05 to 7.5 billion dollars in FY 2005/06 and is expected to reach 10 billion dollars in FY 2006/07 (RBI 2006 and *The Economic Times* 2006).

Also, Indian companies have emerged as significant international investors, as witnessed by their acquisition of software, pharmaceutical and automobile industry related companies in the U.S. and U.K. Some of these investments have had a noteworthy R&D component. Moreover, much of the expansion of foreign and Indian companies' operations has resulted from strategic alliances, i.e. non-equity based collaboration for which no official data is available. Rapid expansion of strategic alliances between foreign and Indian companies has been a central ingredient in development of the Indian software product and services industry.

Furthermore, foreign institutional investment (FII) play a significant role in India, reflecting India's developed financial and private enterprise system and investors' confidence in a wide range of Indian companies. FII inflows to India have risen sharply since 1999. Annual FII inflows exceed actual FDI inflows to India by a wide margin in FY 2004 and FY 2005 (RBI 2006).

India has emerged as an increasingly attractive destination for foreign investors in the 2000s. According to the Foreign Direct Investment Confidence Index 2005, compiled by A.T. Kearney, China is the most preferred FDI location followed by India, the U.S. and the U.K. Also, China and India are the most preferred countries for future R&D investments with slightly more than 40 percent of CEOs indicating they will likely make such investments over the next three years (A.T. Kearney 2004a and 2005a).

Moreover it should be noted that India is ahead of China in terms of software and knowledge process outsourcing (KPO). India's share of the world market in offshoring of software and IT-enabled services was 25 percent in 2001 (UNCTAD 2004). India has continued to be ranked as the most attractive location for KPO and IT-enabled services offshoring, well ahead of other emerging powers in this field such as China, Malaysia and the Philippines (A.T. Kearney 2004b and 2005b)

The expansion of foreign investments inflows to India (both FDI and FII) in 2004 and 2005 was prominent in all sectors, including infrastructure, automotive component and high-tech industry production and R&D. According to Mr. Dayanidhi Maran, India's Minster of Communication and Information Technology, planned investments in the ICT sector in the next 3–4 years, as announced by companies in 2005, amount to over 9 billion dollars – a dramatic increase over previous years (*Business India* 2006).

11.2.2 National Economic Reforms and S&T Development Phases

R&D focused on serving local requirements has a long tradition in India, stemming back to Nehru's policies emphasizing nation-building and self-reliance. Starting with the period of economic liberalization in the 1990s, there has been a shift in the Indian S&T landscape and corporate-led R&D operations have become increasingly important (Rajan 2001).

Since 1991, the Indian economy has significantly opened up to foreign trade and investment. Indian companies have thus been forced to be more proactive in keeping up with new technologies to maintain their competitiveness in the local market and to compete globally. There has been a major change in the strategic mindset of large Indian industrial conglomerates. Also, a new breed of smaller and medium size entrepreneurs who are inclined to think and act more internationally, are playing key roles in vitalizing the Indian economy. Perhaps the most significant examples of the latter are the dynamic expansions of India's software, telecommunication and BPO-KPO industries. The development in these sectors has served as a catalyst to connect India globally.

As noted by Rishikesha Krishnan, the impact of economic liberalization on innovation in the rest of the economy has, however, been mixed: "In the two-wheeler and pharmaceutical industries, regulatory changes, demand conditions, competitive forces and entrepreneurial initiative have resulted in the development of innovative capabilities as reflected in a number of successful products. Government support and links with government research laboratories have facilitated the process of innovation in the pharmaceutical industry. However, in many other industries, changes in the innovation profile have been limited" (Krishnan 2003).

Much of the growth in the software and knowledge-processing industry has come from external demand. In many (but not all) instances this has implied that spillovers in terms of locally oriented demand and innovation system development have been limited.

11.2.3 Government R&D and Policy

Government and state enterprises have played a central role in S&T-related development and other conditions influencing R&D. In addition, the government's role in S&T has gradually shifted. The record in public investment and speed of implementing policy reforms has however continued to be mixed in efficiency and cost effectiveness.

The central government has been the pioneer in R&D investments in the country since the 1950s. R&D is carried out by different government entities, and the prime examples are the Council of Scientific and Industrial Research (CSIR), the India Council of Applied Agricultural Research, the Indian Council of Medical Research (ICMR) as well as the universities. In addition, R&D is conducted by many laboratories of departments and ministries, such as those concerned with atomic energy, electronics, space, ocean development, defense, environment and non-conventional energy sources. The CSIR and the Department of Science and Technology (DST), part of the Ministry of Science and Technology and universities, are the premier organizations that support and carry out R&D in the country (CSIR 2005 and 2006).

The CSIR is the largest government entity that carries out research, with a network of over 38 laboratories that form the core of India's public sector industrial R&D activities. The organization been a principal played on the Indian R&D scene since the 1950s. It represents R&D infrastructure investments worth over 220 million dollars and a workforce of over 25,000, including 6,000 scientists and 2,500 Ph.Ds. Further, the CSIR has bilateral scientific collaborations with over 35 countries and spends over 110 million dollars on R&D, files about 250 patents, and publishes more than 2,000 scientific papers every year. The CSIR network of laboratories undertakes basic as well as applied research, and earns about 20 percent of its revenues by contract research. The R&D capabilities of these laboratories have been leveraged by several multinational companies, including General Electric, Boeing, DuPont, Akzo Chemicals and Novo Nordisk. The DST promotes basic research, scientific services and societal development (CSIR 2005 and 2006).

Three major S&T policy statements have been adopted since India gained its independence: the Science Policy Resolution of 1958, the Technology Policy Statement of 1983, and the Science and Technology Policy of 2003. The Indian government recognized the inevitability of the globalization and liberalization of the Indian economy. Among other things, it articulated the need for reconstruction of the academic scientific system, technology development through appropriate reward mechanisms, measures to increase active involvement of industry in basic and applied research, and management of intellectual property rights (Bowonder et al. 2003 and Bowonder 2005).

Since 2003, the Indian parliament has passed a series of laws protecting intellectual property rights (IPRs). In 2005, it passed a patent regime that is compliant with WTO standards. The legislation is aimed particularly at pharmaceutical manufacturers, but has also raised confidence that other industries will receive protection.

In addition, economic liberalization policies pursued since the 1990s have fostered competition and internationalization. Important reforms in a number of areas, such as: the tax regime, liberalization of foreign ownership and exchanges regulations, and improvements in industrial and other regulatory frameworks and the intellectual property rights regime, have contributed to accelerate growth in foreign trade and investment including R&D related activities. The Indian government has also launched a wide range of initiatives targeted at specific industries such as software, electronic hardware and telecom, biotechnology-pharmaceuticals and automotive.

This is illustrated by special incentives announced in the Union Budget for 2005–06, namely:

- A tax deduction of 150 percent on in-house R&D expenditure in the automotive sector.
- Zero custom duty on items bound under the IT agreement for the software sector.
- Increase in telecom FDI equity stake limit from 49 percent to 74 percent.
- Corporate tax for pharmaceutical companies reduced from 35 to 30 percent, and exemption for 100 percent deduction of profits of pharmaceutical companies carrying out R&D (Ministry of Finance 2005).

11.2.4 The Role of the Indian Diaspora

Internationally, the debate on "brain drain" has gradually been shifting toward a more prominent focus on "brain circulation" in which formal and informal cross-national networks of engineers and entrepreneurs can play a pivotal role in transferring technology, skills and capital to their country of origin. Such networks, coupled with the development of industry clusters, can promote high-technology development in the home country, sometimes more effectively than traditional forms of FDI (Saxenian 2002 and 2005).

While hard to measure, it can be argued that the Indian Diaspora, in the past two decades, has made a larger contribution to international corporate R&D than Indians working in India itself. The Indian Diaspora has played a pivotal role in attracting R&D activities to India, especially from the U.S., Canada, the U.K. and South-East Asia. Diaspora Indians' role in the U.S. R&D community is reflected by the large number of Indians in leading academic institutions and U.S. high-tech companies. In the U.S., Indians constitute 5 percent of medical doctors, 12 percent of scientists, 36 percent of the scientists in NASA, 34 percent of the employees in Microsoft, and 20 percent of the scientists at Intel (FICCI 2005).

Together with the Chinese Diaspora, Indians are estimated to account for close to half of the IT industry-engineering workforce in Silicon Valley. Over the last decade, Indian engineers have started hundreds of technology businesses in Silicon Valley. These new immigrant entrepreneurs generated jobs, exports, and wealth for the region, while simultaneously accelerating the integration of California into the global economy. About half the jobs outsourced by Silicon Valley companies are going to India, according to a 2005 carried out at Santa Clara University (Belotti 2005).

11.3 Corporate R&D Developments

11.3.1 Overall Growth

While still moderate compared to industrial economies, R&D in India has expanded significantly, especially in recent years. R&D expenditure has grown at an annual rate (CAGR) of 45 percent in the 2002–2004 period. Outlays have more than tripled between 1997 and 2004, reaching about 6.8 billion dollars in 2004 in current market prices. On a PPP basis, R&D expenditure are however larger by a factor ranging from three to five times depending on the coefficients used in calculating PPP (Mitra 2006b). It is indeed important to note that R&D spending in India typically yields significantly higher value (output) per dollar spent compared to high-income economies.

The public sector has traditionally been the major source for R&D spending. According to DST data, the central government accounted for 62 percent of India's total national R&D expenditure in FY 2002–03. The state governments have accounted for 8.5 percent, higher education institutions 4.2 percent, public sector industries 5 percent, and private sector industries 20.3 percent (DST 2005). This type of data should be interpreted with caution, particularly since many private-sector R&D and activities by foreign companies are not captured fully. In addition, government R&D data are partly inflated since some non-R&D outlays for higher education and research organizations are included in the total figures.

The R&D setting has gradually changed, however. Multinational companies' India-based R&D operations have expanded significantly since the late 1990s. Indian companies R&D spending has also increased, albeit from a low base. Indian public sector, state enterprises, education and research institutions have increased spending although not at the same rate as corporate R&D. The central government decided to privatize some public high-tech enterprises in the first part of the 2000s. Thus, for example the private TATA group became dominating stakeholders in the previously fully state-controlled Videsh Sanchar Nigam Ltd. (VSNL) and Computer Maintenance Corporation (CMC). In addition, government research labs have gradually become more inclined to develop partnerships with foreign and India private corporations.

Furthermore, prior to the 1990s, corporate R&D was limited both in terms of foreign and Indian companies and much of the R&D efforts focused on adopting products or technologies to local conditions. The expansion of the outsourcing business into more advanced high-technology areas and establishment of foreign company R&D centers in India are helping develop technological and innovative capabilities of Indian companies. Indian companies' and research institutions' collaboration with multinational companies have provided multiple advantages in terms of linking local industry, universities and research institutes to worldwide R&D networks. The expanded scale and scope of international corporate R&D operations, trade and interaction with financial and consulting organizations and expanded international academic collaboration and human resource mobility, have made important contributions to strengthening international awareness and inculcating a more competitive and commercial culture in the Indian research community.

Much of the foreign corporate R&D growth in India continues to be based on in-house operations, but outsourcing to Indian companies or contract-based R&D collaboration with local research institutes is also expanding. At present, the R&D requirements and strategies of multinational companies mostly originate from outside of India, but there are also examples of initiatives by Indian subsidiaries or by domestic companies in India.

11.3.2 India's Specific Drivers and Constraining Factors

India possesses a large reservoir of technically talented, hard-working and English-speaking professionals, capable of learning quickly and carrying out R&D in a variety of fields. The presence of a significant number of researchers and engineers enables R&D organizations to scale up within a short period of time.

The main expenditure in R&D is typically salaries. For example, the salary of researchers account for about 45 percent of the total R&D expenditure in the U.S. The cost of undertaking R&D in India is much less than that in developed countries. In India, the annual salary of an electronic circuit designer with a Master's degree and five years of working experience is about 18,000 dollars, compared to 84,000 dollars in the U.S.; a senior engineer in India would earn between 30,000 to 40,000 dollars, compared to 150,000 to 200,000 dollars in the U.S. (FICCI 2005, adapted from www.workforce.com). This generally translates into a savings of 30 to 40 percent, even after accounting for the hidden costs of managing offshore R&D units.

According to a study by the McKinsey Global Institute, India had the lowest labor cost for university-educated employees among the 16 countries studied. Additionally, Indian graduates work the longest hours; they work, on average, 2,350 hours a year compared to their U.S. and German counterparts, who work 1,900 and 1,700 hours, respectively. Indian graduates are also more geographically mobile than their colleagues in other countries (McKinsey 2005a and 2005b).

India also offers lower construction costs and overheads in addition to lower salaries of administrative staff, compared to the U.S. and other countries.[2] Savings realized on construction costs are estimated at 25–30 percent, and savings on salaries of supporting staff are 60–70 percent in India (FICCI 2005).

[2] Overheads account for 17 percent and the capital expenditure on the construction of laboratories accounts for 4 percent of total R&D cost in the United States (FICCI 2005).

Recent years' rapid expansion of the high-tech industry in India has driven up wages and other costs. High attrition rates and shortages of highly skilled technical staff and experienced project managers have resulted in a sharp rise in wages in years with rapid high-technology industry growth (such as the 2004–2006 period). While this trend may continue, especially in overheated market environments, total cost levels are likely to remain significantly lower than in high-income countries (Farrell et al. 2005). Also, it is important to acknowledge that many multinational companies are willing to pay advanced-economy wages to high-level staff in many areas of R&D, and top management jobs in particular, as access to competency in these cases is considered crucial.

While access to a large pool of human-resources is a key consideration in corporate investment decision-making, several other issues also come into play. The following India specific factors can be identified as driving forces for foreign companies to locate R&D in India:[3]

- Availability of a large, diverse and geographically mobile skilled workforce that enables rapid expansion in a wide range of fields.
- Wage levels and other cost advantages.
- Strong human resource competency potential to execute quality software and engineering work, including IT applications and quantitative work as well as proven ability to work in international teams.
- Existence of a diverse set of education and R&D institutions and options for collaboration with Indian companies.
- Well-established legal system and democratic institutions, including a favorable track record in intellectual property rights compliance in industrial R&D.
- Favorable trade and foreign investment policy regime, plus special provision of tax incentives for R&D.
- Large potential of the Indian market coupled with proximity to other fast-growing Asian markets.
- Time zone advantages, enabling 24 hours work cycle.
- Global and local network-related dynamics, including the formation of industrial clusters and the role of the Indian Diaspora.
- Demonstration effect of corporate success stories helping to provide arguments for decisions to expand Indian based business operations.

[3] Findings are based on interviews conducted for this report, as well as reports from A.T. Kearney, the Boston Consulting Group, Evalueserve, Forrester Research, Gartner, IDC, McKinsey & Co and PWC.

The major constraining factors include:

- Weaknesses in physical infrastructure such as transportation and communication systems, and general provision of energy and other utilities – including in major cities.
- Wage inflation and high attrition in heated market conditions.
- Capacity and quality limitations in higher education and training institutions resulting in uneven standards and shortage in supply of competent engineers, Ph.Ds and project managers.
- Remoteness from advanced industrial markets, headquarters and other R&D centers.
- Concerns of security and piracy in the consumer mass market, such as use of standard software
- Cumbersome industrial, labor, land and other legal and regulatory frameworks, coupled with weakness in compliances and time consuming settlements.
- Governance and cultural issues such as: generally mixed performance record in public and private sector productivity; accountability and transparency (and associated issues of trust and corruption); communication gaps; and impediments to innovation (e.g. reluctance to share information; strong hierarchy, timeliness and other issues related to bureaucratic inertia).

In summary, a nexus of external and India specific factors have resulted in rapid expansion of R&D operations. Access to manpower and cost factors are central but a wide range of other issues such as competency, quality, intellectual property rights, links to production and access to markets are also important considerations.

11.3.3 India-Based Operations by Foreign Companies

Foreign companies locating R&D in India have been a key driver for revitalizing the Indian R&D scene. Multinational companies began to seriously explore India's potential as an R&D destination two decades ago. In the late 1980s and early 1990s, some companies set up R&D facilities in the country. In this early stage, most companies focused on productive support or R&D for adaptation of technologies to the domestic market. Many companies had manufacturing operations in India, motivated partly by government policies and the fact that the Indian market itself was large enough to warrant local operations.

In the 2000s, multinational companies continued to expand their India-based R&D. Foreign companies began to set up innovative R&D operations to cater for the technology needs of their global markets. Texas Instruments was a pioneer of innovative R&D in the mid–1980s. General Electric and Intel have followed, as have other global high-tech companies like Cisco, Microsoft, Motorola, Oracle, Hewlett-Packard, Ericsson and many more. The trend gained strength when not just large companies but also small- and medium-sized enterprises (SMEs) expanded R&D operations in India.

More than 150 foreign companies carried out R&D in India in 2006. Over 100 of them started their operations between 2002 to 2006. Foreign companies have invested over 1.1 billion dollars in R&D between 1998 and 2003 (TIFAC 2006). There has been a further marked increase in multinational companies' interest in investing in R&D operations in India in the 2004–2006 period. The following investment plans were announced in the last quarter of 2005:

- Microsoft announced that it would invest 1.7 billion dollars over four years to expand its operations in India and increase its staff from 4,000 to 7,000. Half the proposed investment would go into making India a major hub for Microsoft research, product applications development, services and technical support covering requirements of both the local and global markets.
- Intel presented an investment plan totaling more than 1 billion dollars over five years, focusing on expanding its R&D center in Bangalore, as well as marketing, education and community programs.
- Cisco Systems announced it would invest 1.1 billion dollars over three years, and triple its staff in India to 4,200. It may also be considering setting up major hardware manufacturing facilities.

Generally, multinational companies are able to recruit and retain much of the top-level talent in India. They typically offer high salaries and advanced training, as well as international career opportunities – advantages domestic companies cannot match.

Foreign R&D operations in India are carried out in three principal ways: in-house R&D, which means that it is performed by a fully owned or principally controlled subsidiary of the multinational company in India; collaboration with other companies, for example outsourcing to Indian companies, including strategic alliances; and contracts or other forms of collaboration with private entities, public sector laboratories and universities.

In-house R&D has been a principal form for larger multinational companies, although they often outsource and pursue contract research in parallel. Thus, the strategy is often based on a combination of operational modes. In-house and other forms of equity-based operations offer more control and are preferred in instances when activities are highly complex, when there are major concerns about intellectual property rights or when the intra-company communication is of high intensity.

11.4 Sector and Company-Level Developments

11.4.1 Overview of Stakeholders and Sectors

India has developed a capacity to undertake R&D work in a wide range of areas, including ICT (software and hardware), life sciences (including biotechnology and pharmaceuticals), engineering (including manufacturing and infrastructure construction), space, aviation, nuclear technology and material sciences. Figure 11-1 provides broad estimates of R&D activity levels by stakeholder and key sector.

Figure 11-1 Estimated R&D activity levels by stakeholders and sectors in India, 2006.

	Basic Research	**Applied Research**	**Product Develop-ment**	**Process Develop-ment**
Stakeholders				
Indian government, public enter-prises and academic institutions	High	Medium	Low	Low
Indian companies	Low	Low	Medium	High
Foreign companies	Low	Medium	Medium	High
Sectors				
ICT: software services and prod-ucts, IT hardware and tele-communication	Low	Low	Medium	High
Life sciences: biotechnology, pharmaceuticals, bio-informatics	Low	Medium	High	Medium
Engineering: automobile, other manufacturing, infrastructure and construction industries	Low	Low	Medium	Medium
Space, aviation, defense, nuclear technology and material sciences	High	Medium	Medium	Medium
Financial, accounting, insurance legal, education, health and other science and knowledge process industry services	Low	Low	Medium	High

Note: Estimated levels of activity (low, medium and high) are broadly defined in an India-specific comparative context covering levels of R&D expenditures and number of employees. Level activity as used here differs from research intensity, which often is defined as R&D expenditure as a percentage of sales/revenue/expenditure at the company level, or as GDP at the national level. Estimates for stakeholders and sectors are based on preliminary generalized observations and do not reflect that there are significant variations in levels of R&D activity within each sector, industry and individual entities.

Source: Estimates derived from published information and interviews (Mitra 2006b).

R&D priorities have varied significantly by type of stakeholder. Government and public-sector R&D typically has national development goals such as need for basic competency in humanities, social sciences and national sciences, plus special national security related research such as nuclear, defense and space technology. Indian corporate R&D has traditionally focused on adopting technologies to local markets and has only recently become substantive in terms of serving international demand. Industrial research has focused on IT, pharmaceuticals, chemicals and consumer electronics. Foreign companies have emerged as a key factor in internationalization of R&D with much of the expansion focusing on needs to serve global markets, IT and automobile being prime examples.

In addition to the above-mentioned sectors, India has experienced a rapid growth in the knowledge processing industry operations, parts of which are closely related to R&D competency. The number of large and small foreign and Indian companies focusing on higher-end BPO or KPO has been growing rapidly since the late 1990s. Growth areas include data search, integration and management services, financial and insurance research, biotech and pharmaceutical research, computer-aided simulation and engineering design, medical content and services, and remote education and publishing. According to Evalueserve's estimates, the global KPO market is expected to grow from 1.2 billion dollars in 2003 to 16 billion dollars in 2010. This corresponds to a 45 percent annual growth for KPO compared to 26 percent expected for the BPO segment (Evalueserve 2004 and 2005).

Examples of major multinational companies with significant KPO operations in India are: A.T. Kearney, British Airways, Citibank, Deutsche Bank, General Electric, Goldman Sachs, Datamonitor, Fidelity, International Data Corporation (IDC), J.P. Morgan Chase, IBM Global Services, Lehman Brothers, McKinsey, Morgan Stanley, PWC, Reuters, Standard Chartered Bank, United Airlines and Union Bank of Switzerland.

11.4.2 ICT: Software, IT Hardware and Telecommunication

The Indian ICT industry has expanded rapidly in software products and services and, in recent years, also in computers and electronics hardware and telecommunication products and services. The industry is comprised of more than 100 major foreign companies and an even larger and more diverse group of Indian companies, ranging from large organizations with global operations to smaller companies focusing on exports or the domestic markets. The industry displays considerable variations in technology and organizational sophistication, cost structures, market focus and growth performance.

India accounted for 65 percent of the global market in offshore IT software and 46 percent of the global BPO market in 2004, according to a NASSCOM-McKinsey study. These offshoring industries have grown three-fold between 2000 and 2004, from 4 billion dollars to 12.8 billion dollars, accounting for 6 percent of the increase in India's GDP during this period. The offshore IT and BPO industries accounted for nearly 95 percent of the absolute growth in foreign exchange inflows associated with services industries between 2000 and 2004. While total services exports grew by 60 percent from 16 billion dollars in 2000 to 25 billion dollar in 2004, offshore IT and BPO exports tripled in the same period. These industries directly employ around 700,000 professionals and provide indirect employment to approximately 2.5 million workers (NASSCOM-McKinsey 2005).

The growing offshore software and BPO industries also face a number of challenges, including a shortage of skilled workers. Currently only about 25 percent of technical graduates and 10–15 percent of general college graduates are suitable for employment in the offshore IT and BPO industries (NASSCOM-McKinsey 2005). India needs to ramp up the number of knowledge workers fluent in languages such as French, German, Japanese and Spanish. Since salaries and other costs are rising by 10–15 percent per year, India-based IT and BPO providers must find ways to reduce total costs to continue to offer customers cost savings of around 40 percent. Thus, they must continue to innovate in service lines and operational excellence (NASSCOM-McKinsey 2005).

Another major challenge for India is to strengthen its physical infrastructure, one of the principal bottlenecks in the nation's development. India's larger cities require appropriate urban planning and major investment in infrastructure in order to sustain economic growth, including investment in the high-technology industry. In addition, major efforts are required to accelerate industrial development in second- and third-tier cities.

The software industry in India continues to focus on services. There has however also been significant development in product development especially in the 2000s. Much of this is driven by multinational companies' in-house and outsourced operations, but there are also examples of indigenous companies' own efforts to develop products for international and local markets. According to NASSCOM, revenue earning for the category IT engineering services, R&D and software products has increased from 2.9 billion dollars in 2004–05 to an estimated 4.8 billion dollars in 2005–06 (NASSCOM 2006).

India lags China. Japan, South Korea, Taiwan and other Asian economies in developing a competitive hardware industry. Several initiatives have however been taken by the government in the 2000s to development India's IT hardware and electronics industry to serve global markets as well as increasing significant local demand. The country has already attained an eminent position in semi-conductor and other hardware product design and several companies plan to establish more significant hardware manufacturing in India in the next five years.

Telecommunications has been one of the fastest growing sectors in the country. China, India and the U.S. are today the largest markets for mobile telephony. The size and growth in the Indian market, combined with the government's decision to increase the foreign investment ownership cap in the sector, has generated considerable interest among multinational companies locating production as well as R&D to India. Re-regulation, competition, and mergers and acquisitions have created new opportunities and challenges for Indian and foreign companies in the sector.

Multinational companies' R&D (as well as Indian companies) in the IT and telecom sector became more significant in the 2000s. The IT/telecom R&D market in the country is expected to show further growth in coming years. According to Frost and Sullivan estimates, the IT R&D outsourcing market in India is expected to reach 9.1 billion dollars in 2010 from 1.3 billion dollars in 2003 at a CAGR of 32 percent. The R&D offshoring market for the telecom industry is estimated to grow from 0.7 billion dollars in 2003 to 4.1 billion dollars in 2010 at a CAGR of 28.7 percent (FICCI 2005).

A large number of foreign companies have established in-house and outsourced software, IT hardware and telecommunication R&D-related operations in India (see Figure 11-2).

Figure 11-2 R&D activities by multinational companies in India: software, IT hardware and telecommunication sectors examples, as of 2006.

Major In-House R&D Operations		**Major Outsourcing of R&D to Indian Parties**
Adobe	Hewlett-Packard	Alcatel
American Express	IBM Global Services	Cisco
Baan	Intel Novell	Computer Associates
Cadence Design Systems	Microsoft	Ericsson
Cisco	Motorola	Farmer's Insurance
Citigroup	Oracle	General Electric
Computer Associates	Phillips	General Motors
Cognizant	SAP	Home Depot
Deutsche Leasing	Siemens	IBM
EDS	Sun Microsystems	Lucent
Ericsson	Synopsys	Motorola
General Electric	Texas Instruments	Nokia
General Motors	Yahoo!	Nortel Networks
Google		Xerox

Note: R&D and sector demarcations are broadly defined. List is intended to be illustrative.

Source: Compiled based on TIFAC 2006, company reports, Times of India, Business Standard, Financial Times and interviews.

Swedish-Related ICT Companies

Ericsson is a Swedish multinational company with long standing sales, production and more recently R&D operations in India. Since the beginning of the 1900s, Ericsson has contributed in almost every facet of telecommunications in India. As of 2005, Ericsson provided 45 mobile networks to 12 major operators in India (Ericsson 2005).

In the 2000s, Ericsson began developing Mobile Internet in the country. As a part of this initiative, an Ericsson Mobility World Centre has been set up in Gurgaon (in the New Delhi area). This facility enables Ericsson to collaborate with application and solution developers, as well as network operators, to develop new applications and solutions for the Indian market. Furthermore, Ericsson has set up a Systems Integration Competence Centre, also in Gurgaon, to create solutions for Indian operations. This center is expected to grow to about 100 telecom professionals. In addition, a Customization Design Center has been set up with an initial manpower of 50 experts (Ericsson 2005).

Ericsson has recently expanded its existing manufacturing facility in Kukas, Rajasthan, from AXE switching manufacturing to GSM Radio Base Stations (RBS). The GSM RBS has been adapted to Indian conditions and will help resolve challenges like higher operation and maintenance costs, severe climatic conditions, prolonged power cuts and voltage fluctuations. Local manufacturing will ensure easier handling of repair and returns, and flexible inventory management will reduce cost to operators (Ericsson 2006).

In 2005 Ericsson announced its intention to set up its own R&D center in Chennai, a global services delivery center (GSDC) in Gurgaon and upgrade its GSM radio base station manufacturing facility in Rajasthan. The company's R&D center in Chennai will conduct research in cutting-edge technologies, while the GSDC in Gurgaon is focusing on developing managed-services offerings in India. The GSDC includes the systems integration competence center, the product customization center, the regional network-operating center and the mobility world center. The company also announced plans to upgrade its RBS manufacturing facility at Kukas, Rajasthan, and commence manufacturing of mobile switching centers (MSC) and base station controllers (BSC) (*Business Standard* 2005a).

Ericsson has for several years partnered with the Indian IT company Wipro to outsource R&D as an important element of Ericsson's overall R&D strategy. Ericsson has significant R&D-related outsourcing arrangement with two other, major Indian ICT companies as well: TATA Consultancy Services (TSC) and Sasken. Outsourcing operations to these three companies combined, accounted for approximately 1,000 man-years as of 2005. Examples of other Swedish-related ICT companies with significant software R&D operations in India include TietoEnator and Telelogic.

11.4.3 Biotechnology-Pharmaceuticals

The biotechnology-pharmaceuticals sector comprises pharmaceuticals, bio-services, bio-agricultural, bio-industrial and bio-informatics. As of 2004, the biotech industry in India generated revenues amounting to 1,070 million dollars, with pharmaceuticals accounting for 811 million dollars. The biotechnology-pharmaceuticals industries could emerge as one of the country's major industries in the country, but it is still in an early stage of development. Revenues are projected to reach 5 billion dollars by 2010. As of 2004–05, the sector employed nearly 9,000 scientists and engineers and attracted an estimated 216 million dollars new investment 2005 (BioSpectrum 2005).

Recognizing the potential of biotechnology-pharmaceuticals, the government and private industry have focused on developing the sector by strengthening legal and regulatory systems, harmonizing international standards, providing financial support to early-stage development, developing bio-tech industrial parks and providing tax incentives for Indian and foreign companies.

The domestic sales and manufacturing operations of the pharmaceutical industry have expanded rapidly, and recently there has been significant growth in exports and R&D investments. Both new drug discovery research and novel drug delivery system programs can be conducted in India at a significantly lower cost than in developed countries. Products based on molecular biology, including software packages, DNA-sequencing and molecular modeling are candidates for offshoring R&D to India.

Multinational companies have been partnering with Indian companies to carry out R&D in the entire value chain, from drug discovery to clinical trails, with an emphasis on the later part of the R&D process. Their primary focus has included custom synthesis, medicinal chemistry clinical studies.

Much of the research in India have traditionally focused on re-engineering of bulk drugs. While Indian and foreign companies gradually are expanding pharmaceutical R&D in India, the country still has limited capabilities in terms of research focused on the early stages of drug discovery. Research on the early stages of drug discovery continues to be dominated by work carried out in the U.S. and Europe. Among the factors constraining research in India is the local availability to top-level scientists and experienced managers in specialized fields. In addition, while India has enacted new laws on compliance and intellectual property rights, there are concerns about the need to strengthen compliance with legal and regulatory frameworks (ICRA 2005).

The bioinformatics market in India is expected to reach 2 billion dollars by 2008, while the Indian biotechnology R&D products and services market is expected to reach 3 billion dollars by 2010 (FICCI 2005). Multinational companies have become increasingly active in offshoring IT functions across the pharmaceutical industry value chain in areas including IT systems for clinical trials, manufacturing, sales, distribution and product management (Singh, S. 2006).

Swedish-Related Pharmaceutical Companies

AstraZeneca's operations in India cover sales, manufacturing as well as R&D. It has established four major entities in Bangalore. It has a major manufacturing unit designed to meet high international standards conforming to WHO cGMP (current Good Manufacturing Practices) norms. AstraZeneca Pharma India Limited, the marketing entity of the company, is responsible for six major therapeutic areas: oncology, cardiovascular, maternal healthcare, infection, respiratory & neuroscience (AstraZeneca 2006).

Moreover, India is the site for one of the AstraZeneca's four, principal international research centers; the others are located in Sweden, the U.S. and Japan. AstraZeneca R&D in India is dedicated to advancing medicine for diseases in developing countries. The company's first research facility in Bangalore opened in 2003. It is dedicated to finding a new therapy for tuberculosis that will act in drug-resistant disease, and will reduce the complexity and/or duration of treatment. More than 70 scientists work in the center, including molecular biologists, genetic engineers and chemists. The Bangalore scientists also work closely with AstraZeneca's infection research center in Boston, U.S. and with external academic leaders in the field. A second research facility will open on the same premises in 2006 (*Business Standard* 2005b). Finally, AstraZeneca Research Foundation based in Bangalore supports education and technological innovation by organizing seminars and symposia (AstraZeneca 2006).

11.4.4 Engineering: Automotive and Other Sectors

India has been developing a substantial and diverse engineering industry since 1947. Much of the industry has traditionally been protected by import substitution policies and had little incentive to do R&D. Since the early 1990s, this situation has begun to change as Indian companies can no longer count on a protected domestic market and thus have to compete with international companies.

Examples of engineering and related industries with a large R&D growth potential include: automobiles, automobile components, machine tools, electric equipment and machinery, construction and civil engineering. In addition, there are areas such as steel, paper, textile, medical, environment, bearings, power, and infrastructure.

The engineering-manufacturing sector employs over 4 million skilled and semi-skilled workers. India's advantages in this sector are its large pool of skilled engineers and managers, competitive labor costs and availability of raw materials. Over 2,500 companies have ISO 9000 certification. The domestic market allows for economies of scale, and India has a diversified industrial base with supporting ancillary industries. Strong technological capabilities exist, particularly in certain sectors such as electrical machinery, process plant machinery and general-purpose machinery

Multinational companies from all major, industrial countries have significant and growing operations in the engineering sector. These activities tend to focus on production for local and international markets, while R&D is often limited to adaptation to the local market. There are, however, examples of companies undertaking more substantive R&D and design activities in India to serve both local and international markets.

Some of the world's leading companies with major manufacturing operations in India include: ABB, General Motors, General Electric, Ford, Caterpillar, Toyota, Sony, Honda, LG, Hyundai, Siemens, Philips, Daimler Chrysler, Fiat and Lafarge-Europe.

Swedish-related Engineering Companies

Examples of Swedish-related companies with Indian-based operations covering sales, production as well as R&D include: ABB, Atlas Copco, Electrolux, Sandvik, SKF and Volvo. ABB India had 8 manufacturing units, 26 marketing offices, 8 service centers and 3 training centers as of 2005 (Domain-b.com 2006). In addition to these, the company has a channel partner network numbering approximately 500 to facilitate market penetration for its standard products and services business. ABB constitutes an example of a company in which many persons of Indian origin have held top management and technical expert positions in India as well as Sweden and other locations. These persons have often received education in Sweden.

ABB had nine corporate centers, one each in Finland, Germany, Poland, Norway, Sweden, Switzerland, the U.S., India and China as of 2005. The company's first R&D center in Asia was established in Bangalore in 2002 and focuses on the development of software-intensive products and systems (Singh, M. 2005). In September 2005, ABB announced plans to shift high-end engineering R&D from high-cost centers, such as from Germany and Sweden, to India. These centers focus on power technologies and automation. According to the plans, ABB will nearly double the number of engineers at its R&D center in Bangalore. ABB's total number of R&D employees will reach about 500 in 2006, and is expected to increase significantly in coming years (Global Outsourcing 2005).

SKF opened its Application Development Centre (ADC) in Bangalore in 2004. Company officials have said the new facility will become a full-fledged R&D center for the company over the coming years. Initially, ADC will focus on developing competencies in application engineering, product and system design, advanced calculation and simulation, and manufacturing of prototypes, testing and validation (Domain-b.com 2004).

Volvo Trucks India has expanded into sales and production operations. In 2006, the company inaugurated its engineering and software development center in Bangalore. Volvo has plans to employ more than 200 engineers to work primarily on truck design engineering. The center will also support Volvo Group activities in the areas of IT and truck product development (Volvo Truck India 2006).

11.5 Swedish-Indian Economic and R&D Relations

11.5.1 Swedish-Indian Economic and S&T Relations

Economic and technology relations between Sweden and India have gradually strengthened, but lag other countries, like China and Japan. Trade and investment links between Sweden and India are poised to expand substantially in the long-term. This also applies to R&D activities by Swedish companies in India. In addition, Indian companies' operations in Sweden are poised to expand.

Swedish exports of goods to India amounted to 935 million dollars in 2005 (0.7 percent of Sweden's total exports) while imports stood at close to 395 billion dollars (0.4 percent of total imports) (Statistics Sweden 2006). According to data published by the Central Bank of Sweden, Swedish FDI to India amounted to 57 million dollars from 1994 to 1998, and 109 million dollars from 1999 to 2003. Swedish companies employed about 7,200 people in India in 2003, per data compiled by the Swedish Institute for Growth Policy Studies (ITPS). A broader definition including all Swedish-related companies, as well as outsourcing to Indian companies, results in a significantly larger number. While no more comprehensive data is available, it is reasonable to assume that the total number employed in Swedish-related (broadly defined) corporate activities in India has grown significantly since the 1990s and reached about 20,000 in 2006.

Swedish and Indian official data do not provide a complete picture of trade, investment and employment, R&D and other forms of S&T collaboration. Typically, data on foreign trade and investment and specific R&D developments are incomplete and underestimated (Mitra 2006a). In short, official data does not allow for accurate analysis of economic relations and R&D ties between the two countries. Therefore, an analysis of corporate R&D relations must be supplemented by company-level case studies.

The development of the ties between the two countries is reflected in a number of domains. The Swedish Trade Council has developed New Delhi operations and opened an office in Bangalore in 2006. The Sweden-India Business Council (SIBC) was established in 2003 as a result of initiatives by the Swedish government and the private sector. An agreement (MoU) was signed between the Confederation of Indian Industry (CII) and the Confederation of Swedish Enterprise. SIBC was entrusted with responsibility for development of opportunities and activities between the parties. SIBC cooperates in Sweden with the Swedish Trade Council, the Import Council and ministries amongst others (Swedish Trade Council 2006 and SIBC 2006).

The Royal Academy of Science (IVA) and Invest in Sweden Agency (ISA) have begun to give more attention to India. The Swedish International Development Cooperation Agency (SIDA) places major emphasis on S&T collaboration in the areas of environment, ICT and biotechnology, as per its India country strategy presented in 2005.

Potential areas for expanded commercial relations between Sweden and India, as identified by those interviewed for this study, include:

- Infrastructure: power generation and transmission, road and rail transport, airports, seaports, inland waterways, ship yards, water and sanitation systems
- ICT: telecommunications, IT and software services, software and hardware product development, E-commerce, Internet banking and E-security
- Life sciences: biotechnology, bio-informatics, pharmaceuticals, heath care products and services
- Social sciences: financial, insurance, education, and other BPO-KPO services
- Environment technology: hazardous waste, air pollution management and other
- Mining, steel and other metal industry
- Forestry, pulp, paper and packaging industry
- Agriculture and food industry
- Automotive parts, components and design
- Housing and other constructions
- Interior design products, sports goods, outdoor equipment
- Defense, aviation and space industry.

The interest in strengthening S&T collaboration between Sweden and India has gradually become more pronounced in several of the areas listed above. The Swedish and Indian governments signed a bilateral S&T agreement in December 2005 which is envisaged to result in high-level commitment to cooperate through joint-research, greater academic exchanges and to facilitate industrial R&D (Government of Sweden 2005).

While the number of Indian students and researchers in Sweden is small, it has grown. Indian nationals undertake higher education in Sweden, especially in IT and engineering. Some remain in Sweden after graduation but many reallocate to other European countries, North America, or back to India. Compared to the U.S., it appears that Swedish companies and research institutions find it hard to retain highly-qualified Indian graduate students and professionals. Reasons for this include: language and other cultural issues, migration barriers and tax incentives. Nevertheless, several persons of Indian origin have made significant contribution to Swedish academic institutions, held high-level positions in Swedish companies, both in Sweden and India, and have – in some instances – been central to developing economic and technology relationships between the two countries.

All major Swedish universities have India-related R&D activity. Examples include the Royal Institute of Technology (KTH) in Stockholm which has established closer collaboration with the Indian government and universities. Karolinska Institutet Medical University in Stockholm signed a MoU with Indian parties in 2006 to further develop collaboration in research and education. The Swedish South Asian Studies Network was launched in 2001 at Lund University (SASNET 2006). The aim is to encourage and promote an open and dynamic networking process in which Swedish researchers co-operate with researchers in South Asia and globally.

11.5.2 Swedish and Indian Corporate Operations

The Swedish manufacturing industry has a long tradition of exporting to and producing goods locally in India. The scale and scope of these activities have gradually expanded and now often include production as well as sales directed at both the Indian and other markets (Mitra 1986). Furthermore, since around 2003 there has been significant expansion of R&D activities by Swedish companies in India. Several multinational Swedish-related companies now have both adaptive R&D to serve local market requirements and innovative R&D that is mostly aimed at global markets.

The following companies have established and expanded significant R&D operations in India in the 2000s: ABB, AstraZeneca, Ericsson, Sandvik, SKF, Telelogic AB and Volvo. Alfa Laval and Atlas Copco are well-established players in the Indian market but do not conduct significant R&D in the country. Svenska Handelsbanken decided to open a representative office in India in 2006 and thereby become the first bank from a Nordic country to do so (Nyhetsbrev Indien 2006). Swedish banks, accounting and management consulting firms and other services providers have no or little BPO-KPO operations in India.

Large companies, such as Ericsson and ABB, dominate R&D activities in India. Major multinational companies are often well-placed in establishing R&D operations as they already have significant sales and production operations in India. The situation is different for SMEs or newcomers. Swedish SMEs typically do not have significant production or R&D activities in the country. They tend to prefer to operate in North America or neighboring European countries, including the Nordic countries and Eastern Europe. They often lack the financial recourses and country knowledge required to set up in-house R&D centers in Asian locations. In some cases, they have encountered intellectual property rights issues associated with outsourcing arrangements. There are however, signs that SMEs are looking at India more seriously.

Indian private and public sector companies have a long history of buying technology from Sweden in a wide range of areas. In first half of the 2000s there was a rapid expansion of these activities. Indian companies are increasingly active in seeking trade and offshoring business opportunities, including BPO and R&D.

Several Indian IT companies have established offices in Sweden in the last few years. They include large Indian IT companies such as Infosys, TATA Consultancy Services (TCS) and Wipro. In addition, several companies have established smaller operations, for example in ICT and KPO (Evalueserve and others). Several of Indian companies with offices in Sweden or other European locations focus on drumming up business for offshoring to India and to source technology from Swedish companies. Indian biotechnology companies (including Dr. Reddy's laboratories) have begun to offshore R&D work to Swedish companies and the Indian company Biocon Ltd. is collaborating with the Royal Institute of Technology in Stockholm and the Swedish company Innate Pharmaceuticals.

In recent years, several Swedish companies have shifted their strategic perception of business opportunities in India. In the past, companies typically viewed India's market potential as limited and had little interest in Indian-based research. However, as the scale and scope for developing Indian-related business has expanded, India is increasingly seen as part of large companies' global business operations, including opportunities for offshored industrial production and service provision. Manufacturing industry trade and investment is expected to continue to grow and dominate the economic relations between the two countries but other areas, including R&D and BPO-KPO, have also attracted significant interest.

Swedish-related corporate R&D operations in India are expected to expand in software, telecommunication, engineering, pharmaceuticals and in other areas. Large companies like Ericsson plan further expansion of R&D operations in India, both in-house and outsourced, as do engineering companies such as ABB and Volvo Trucks. The total number of people employed in R&D operations (broadly defined) by Swedish-related companies in India (both in-house and outsourcing) could potentially reach over 5,000 by 2010, compared to about 3,000 in 2006, and less than 100 in the early 1990s.

It is difficult to assess to what extent the expansion of Swedish corporate R&D operations in India (and other Asian economies) is occurring at the expense of activities in Sweden. In some cases, the expansion of R&D abroad might reflect the transfer of R&D activities from Sweden to India. In other cases, it is a new investment. The record from U.S. and British companies suggest that locating R&D abroad often is required to sustain competitiveness and can benefit all parties in the home and host countries (Mitra 2006b).

11.6 Conclusions

11.6.1 Main Findings

The review of India's social and economic development points to that the country is poised to be one of the worlds major powers both in terms of the size the domestic market and its international economic role. Also, India has potential to emerge as a major R&D power, although the timing, scale and scope of the latter is especially hard to predict. The country's principal strength includes its educated workforce, entrepreneurial talent and institutional infrastructure. Multiple considerations drive the expansion of multinational companies' R&D operations in India. These include potential for cost savings and access to technical competency and markets, along with a range of other factors.

India's development continues to be uneven. The country has traditionally scored poorly in areas such as income levels, R&D spending, education outcomes and ICT diffusion, if judged on a per capita basis, as large parts of the economy remain underdeveloped. At the same time, income levels are rising. The use of computers, telecommunications and Internet and the number of persons with higher levels of education is already large in absolute terms and continues to grow rapidly. An increasingly larger share of the population is proficient in the English language and receives higher education which makes them employable in competitive and internationally-oriented industries. India's cities are more economically developed and increasingly integrated with the global knowledge economy, as demonstrated by high-technology industry development in Bangalore, Chennai, Delhi, Hyderabad, Mumbai and Pune.

India's emergence as a major economic and R&D power will have wide-ranging local and global consequences. These include direct, as well as indirect, effects in trade, investment, employment, the environment and trajectories for technological development. The impact is poised to be significant in major sectors such as: ICT, industrial manufacturing, construction and other engineering, agriculture and life sciences. Spearheaded by developments in the software industry, coupled with those in ICT hardware and telecommunications, continued rapid growth is expected in IT-enabled services, including the higher-end, knowledge process industry niches (e.g. finance, accounting, insurance, education, health and other services). The knowledge process outsourcing industry is still in a very early stage of development but has considerable potential in a wide range of areas. It may well employ more individuals than traditional R&D operations within the next ten years.

In many respects, India is still in an early phase of development in the areas of high-tech industry and international R&D. There is a considerable scope to build on strengths and tackle weaknesses in the national innovation system and corporate investment climate. Challenges include the critical needs to improve physical infrastructure, to enhance the education system and the functioning of government. Moreover, it is essential to build private-public partnerships, expand foreign investment and enhance the role of the large Indian Diaspora and other form of international collaboration.

Following the current trends, India can emerge as one of the principal international centers for R&D and high-technology industry investment and trade within the next 10–20 years. It is however hard to predict the specific timing, scale and scope of these developments. Multinational companies and a wide range of Indian parties are developing the country's capabilities to undertake production-supportive and adaptive R&D and design work as well as innovative R&D both in terms of serving local and international market requirements. The cost of not having comprehensive strategies for developing the scope of economic and technology relations with India (and China) will prove to be significant, especially for companies with global aspirations.

The Swedish industry has a long tradition of exporting to and producing goods locally in India. These activities have gradually expanded and now often include production as well as sales directed at both the Indian and other markets. Furthermore, since around 2003 there has been significant expansion of R&D activities by Swedish companies in India. Indian private and public sector companies have a significant interest in acquiring technology from Sweden in a wide range of areas. Indian companies are increasingly active in seeking trade and offshoring business opportunities, including BPO and R&D.

Economic and technology relations between Sweden and India have gradually strengthened but lag when compared to ties with China and Japan. However, trade and investment links between the two countries are poised to expand substantially in the long-term. This applies to sales, production and R&D activities performed by Swedish companies in India as well as Indian companies' operations in Sweden.

11.6.2 Looking Ahead

Scenario for the Next Five Years and Beyond

The long-term consequences of India's (and China's) transformation from a minor to a major power in goods and services production, foreign trade and investment as well as R&D entails the emergence of a new world economic order of which the full implications are hard to foresee (Mitra 1985a, 1985b and 2006b). Few analysts anticipated the rapid, export-oriented high-tech industry developments that took place in India since the 1990's. Similarly, it is difficult to predict the future with respect to corporate R&D.

The following principal scenario for development of R&D in India is based on the interviews conducted for this study and analysis of information and forecasts by various international business intelligence providers, government entities and industry associations. The emerging baseline scenario for Indian-based R&D in the next five to ten years entails the following:[4] (Mitra 2006b).

- Total R&D spending is likely to more than double in the five-year period from 2006 to 2010. Reflecting the low starting point, R&D investment (and output) levels in India are however not likely to match that of the G5 nations or China within the next 10 years. The number of patentable innovations of Indian origin is likely to continue to grow rapidly, albeit lagging behind that of larger industrial nations in absolute terms.
- Growth in R&D spending will be led by the corporate sector. Corporate R&D spending is likely to be significantly larger than government outlays in the second half of the 2000s and beyond.
- Foreign multinational companies will continue to be the principal driving force of high-end corporate R&D investments in India. R&D in the Indian corporate sector is also likely to expand, but the research intensity of both larger and smaller Indian companies is likely to continue to be low compared to leading foreign companies.
- Corporate R&D will expand rapidly in a wide range of areas, particularly in ICT, but also in biotechnology-pharmaceuticals, engineering and social sciences. The KPO sector including finance, accounting, law, and health and education services will grow rapidly.
- Government-financed R&D will continue to focus on defense, space and nuclear power. Private-public sector partnership is likely to become increasingly significant as government institutions become more commercially oriented.
- High-tech industry centers will enter a more mature production phase, and play a more substantive role in innovation. Bangalore, for example, has potential to become an Asian version of the Silicon Valley in software and IT-related industries production as well as R&D.
- The Indian Diaspora will strengthen its importance overseas as well as in its linkages with India-based R&D activities. The Indian Diaspora's total contribution to global R&D is likely to continue to be larger than the output from India-based operations.
- Access to skilled researchers and engineers will constrain growth, resulting in higher wages and requiring more active efforts for offshoring both to and from India and greater efforts to attract skilled persons to work in India. Both govern-

[4] The principal scenario is in line with the past five years' trends in economic growth and structural change in India as well as the country's economic and technology relations with the rest of the world. A significantly lower or higher scenario for R&D development would imply major diversions in these trends (Mitra 2006b).

ment and the private sector will need to make new investment in human resource development. Human resources are likely to be a principal factor constraining prospects for continued rapid expansion of India-centric R&D.

- Both central and state governments will be exposed to increased pressure to launch and effectively implement major reforms such as improvements in the education system and research institutional infrastructure, incentives for corporate R&D, further promotion of local and international partnership initiatives and the development of networks and world-class innovation-oriented clusters.

Global and Local Implications

In the 2000s, much international attention focused on Indian exports of software and other services and the revitalization of the manufacturing sector as illustrated by the offshoring of automobile components. Exports of both goods and services are likely to continue to grow. At the same time, as the Indian domestic economy becomes larger, much of the multinational companies' efforts will focus on selling to the Indian domestic market.

Multinational companies are likely to continue expanding the scale and scope of their high-tech sourcing and India centric R&D and KPO operations in the next 5 years and beyond. U.S. and British companies are likely to continue to play a principal role in offshoring to India. Other OECD countries are likely to catch up in this process but several European countries risk lagging behind in realizing the potential benefits from India-based corporate R&D.

The Indian Diaspora is likely to continue to augment their role in R&D in major industrial countries. The U.S., Canada, U.K. and South East Asia are in a strong position to utilize the links to the Indian Diaspora. Countries without a significant Diaspora or not English-speaking will have a disadvantage in developing R&D and KPO ties with India.

Long term projections pointing to continued shortage of researchers in Europe and the U.S. coupled with the rapid expansion in higher education in developing countries such as India point to a major opportunity for India and its Diaspora to expand its role in R&D. According to the estimates of the European Commission, countries in the European Union will require an additional 700,000 researchers by 2010.

Nearly 50 percent of the present R&D workforce in the U.S. will become eligible for retirement by 2012, according to the U.S. Bureau of Labor Statistics.

The scale and scope of India's economic and technology relations are likely to have increasingly global reach both in terms of advanced industrial economies and developing countries. In addition to North America and Europe, the ties between India and China are poised to become more important, especially for India. The long-term implication of India's (and China's) transformation from a minor to a major power in production and trade of a wide range of goods and services as well as R&D activity will eventually entail the emergence of a new world economic order (Mitra 2006b).

India compared to China

As in the case of China, India's principal advantages in developing R&D capabilities are rapidly growing educated workforce, the role of the Indian Diaspora, a low-cost environment for production and R&D, and access to large markets. China is ahead of India in per capita income, size of the domestic market, growth of foreign direct investment and high-tech trade. China has also been ahead in designing and implementing policies that can attract foreign direct investment and boost exports, the establishment of a large number of well-endowed science parks, large scale and generally rapid implemented public sector investment in physical infrastructure, higher education and R&D. This has been coupled with a wide range of efforts to ensure that foreign companies have R&D operations in China and to attract qualified Chinese students and professionals overseas to return and to boost English language education in China. Developments towards greater integration in the international economy have concurred with an ideology of determined political, economic and technological nationalism (Mitra 2006b).

India on the other hand has certain advantages, such as a long standing dynamic private sector and entrepreneurial class covering a wide range of sectors, the availability of well educated persons with English language competencies coupled with a long tradition of close cultural, economic and technology ties with advanced western nations. Indian individuals have proved successful working in international teams and adjusting to foreign cultures. India also has a more favourable track record in corporate-competition law, intellectual property right legislation and systems for enforcement, maturity of financial structures, established democratic institutions and practices and a rapidly advancing ICT and KPO industry (Mitra 2006b).

From a corporate strategy perspective, the issue is not weather priority should be given to India or China – both offer major market, production and technology development opportunities in goods as well as services sectors. Both are poised to be major economic and technology powers. It is however hard to predict how the development of international corporate R&D in the two countries will unfold and which country's performance will exceed the other in the long term. The conclusion is that R&D development in China as well as India deserves close attention as both economies (and their Diasporas) are likely to be major R&D powers within the next 10–20 years (Mitra 2006b).

11.6.3 Policy Implications for Sweden

Considerable progress has been made in developing Swedish-Indian economic and technological ties. The efforts of Swedish corporate, government and academic institutions to develop links with India have, however, been modest compared to the attention given to for China and Japan. Moreover, many Swedish companies have no significant experience with India-related R&D operations, and Sweden is behind other industrial nations in terms of educational exchange and academic collaboration with Indian institutions.

It is essential to promote academic and private partnerships with Indian companies, universities and other R&D oriented institutions. Development of educational and scientific exchange programs and nurturing ties with the Indian Diaspora are all important strategies for fostering long-term R&D ties between the two countries.

India has the potential to become one of the major centers for Swedish corporate R&D and KPO operations in the next ten years. Sweden and India have areas of comparative advantage in R&D, and both countries can significantly benefit from connecting these environments. Patient, consistent and pragmatic approaches are needed to tackle the opportunities and risks involved.

Continued efforts are required to invigorate S&T links between Sweden and India. Specific measures are required from both Swedish and Indian governments, academic and corporate stakeholders to expand S&T collaboration between the two countries. The importance of India needs to be viewed in terms of its long-term potential as a large market for both capital and consumer goods and as center for a wide range of R&D-related activities.

Based on the findings in this study, a number of issues might be considered to foster economic and technological relations between Sweden and India. The efforts from the Swedish side could include the following:

1. Develop a comprehensive strategic agenda for the long-term development of economic and S&T relations between Sweden and India. Assign responsibilities to key actors, such as the Swedish Embassy, relevant ministries in Sweden, the Swedish Research Council, the Swedish Governmental Agency for Innovation Systems, ITPS, IVA, ISA, the Swedish Trade Council, SIBC, SIDA-SAREC, SASNET and others.

2. Strengthen the monitoring, dissemination and promotional activities covering economic, cultural and S&T developments in India in order to develop Swedish-Indian relations. Build up the special function at the Swedish Embassy in New Delhi to promote S&T relations.

3. Strengthen links in higher education by making it more attractive for Indian students and researchers to work in Sweden and vice versa. Improve use of various exchange programs and develop alumni networks of Indians who have studied at Swedish universities.

4. Strengthen research collaboration under the official bilateral S&T agreement and support development of public- and private-sector partnerships such joint workshops, exchange fellowships, and joint research projects. Complement bilateral efforts to strengthen R&D collaboration with development, as well as improved utilization of existing multinational programs (including EU-India R&D related cooperation initiatives, like the Seventh Framework Program).

5. Strengthen corporate-led commercial and R&D-related collaboration efforts between Swedish and Indian entities, which include large and small companies in both Sweden and India.

Finally, it is important to foster in-depth understanding of the nexus of economic and technology-related developments in Sweden and India as well as its broader global context. It is essential to move beyond fact-finding and general discussions, to move from words to deeds. It will require persistent effort with appropriate high-level endorsement and warranted funding to make significant expansion of economic and technology Swedish-Indian ties a reality.

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12 Trends, Challenges and Policy Implications for Sweden

Magnus Karlsson

In this final chapter, we (1) summarize the main findings and trends from all the studies, (2) discuss forward-looking implications for countries, with a particular focus on Sweden, and (3) suggest five issues for Swedish policymakers to consider.

12.1 Summary of Main Findings and Trends

R&D and innovation is still rooted at "home"...

When discussing the internationalization of corporate research and development (R&D), it is important to keep in mind that R&D remains the least internationalized activity of multinational companies. Our studies show that companies continue to keep a proportionally larger part of R&D activities close to their home base, when compared to production and other business activities. For example, U.S. pharmaceutical companies spend a major share of their R&D money in the U.S. (Nilsson)[1] and Swedish-controlled multinational companies have a higher R&D intensity at home than at subsidiaries abroad (Löf).

The reasons for keeping R&D at "home" include the complex and strategic nature of innovation, as well as the embeddedness of R&D activities in the domestic environment. Large multinational companies play a dominant role in the innovation systems of their home countries. They have invested in that environment and often their technological advantages reflect those of the innovation systems in the home country (Johansson & Lööf). This explains the low mobility and high geographic inertia of R&D activities by multinational companies.

The embeddedness argument is highly relevant for Sweden. Several large technology-intensive multinational companies have contributed to – and benefited from – strong national innovation systems in the past. Sweden remains one of the most R&D-intensive countries in the world, with corporate R&D expenditure almost 3 percent of GDP in 2003. Companies are dominating the national R&D enterprise, with corporate R&D spending at about 78 percent of total R&D expenditures in Sweden 2003 (Karlsson, Löf).

[1] Citations in this section refer to authors of previous chapters in this report.

...but international R&D is increasing.

The domestic character of R&D has changed over the past two decades as the process of innovation has gradually become more globalized. A growing share of corporate R&D is undertaken abroad. As an example, R&D investments by companies in Sweden have increased both in Sweden and abroad, but the share of investments outside Sweden is increasing (Löf). The pattern of internationalization can be seen in many industrial sectors, including pharmaceuticals, information and communications, and automotive sectors (Marklund, Nilsson). European companies, especially from smaller countries, are more international in terms of R&D than U.S. and Japanese companies.

The internationalization of corporate R&D is a two-way phenomenon for the specific country. It comprises both the extent of R&D performed abroad by companies operating in the country, and the extent of foreign-controlled R&D performed in the country.

In the case of Sweden, 20 major enterprise groups performed approximately 40 percent of their R&D outside of Sweden in 2003, up from 20 percent in 1995. The communications manufacturing industry has been the main driver behind R&D investments abroad. During the same period, the share of foreign-controlled R&D in all industry sectors in Sweden increased from 10 to 45 percent (Löf). Sweden is one of the most internationalized countries in the world when it comes to corporate R&D.

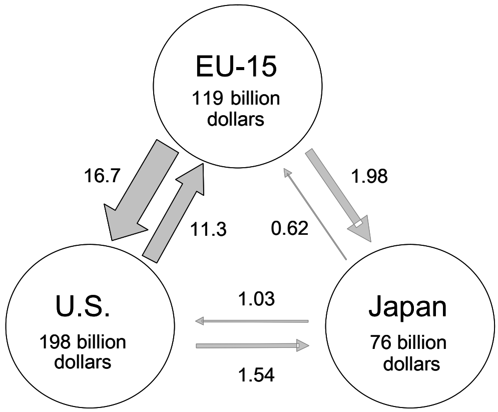
Most R&D is located within the Triad...

The greater part of the internationalization of R&D takes place within the Triad (the U.S., Europe and Japan). The U.S. is the major location for foreign R&D. Japanese companies are least internationalized, and Japan is the least favored location within the Triad. Japanese companies are planning to expand their international innovation networks, but so far they lag behind because of industry structure and corporate culture (Nakazato & Hausman).

The flows of R&D expenditure between the U.S., the EU-15 and Japan are illustrated in Figure 12-1. U.S. multinational companies invested 11.3 billion dollars in the European Union in 2001. The automobile industry accounted for 37 percent of this investment and the pharmaceutical sector 28 percent. In the opposite direction, EU-15 R&D investment in the U.S. (total 16.7 billion dollars) was concentrated mainly in the pharmaceutical sector, accounting for 30 percent of that investment (OECD 2005).

As is also the case of Sweden, the largest share of R&D abroad is within the OECD. Most of that R&D was carried out within affiliated companies (subsidiaries of the multinational company) (Karlsson, Löf).

Figure 12-1 R&D flows in 2001 between the U.S., the EU-15 and Japan, and total business sector expenditures (inside the circles) in each country/region (in billion dollars PPP).



Source: OECD 2005.

...but the share of developing countries is increasing.

More recently, developing countries are attracting corporate R&D. The increase in developing Asia (most notably China and India) is the most dramatic. Moreover, multinational companies are planning to increase R&D investments in the region, while not increasing, or even decreasing, at home in the near future. Despite recent increases, the levels of corporate R&D activities in developing countries are still low.

If not interrupted by national events, political or otherwise, it is likely that foreign companies will continue to increase R&D activities in China (Schwaag Serger). Also in India, the potential for increased foreign R&D investments is high; it is possible for India to emerge as one of the international centers of R&D and high-technology trade and investments within the next 10–20 years (Mitra).

In the case of Sweden, corporate R&D activities in India and China have been growing rapidly during the last five years, but are still in an early phase of development. In general, R&D investments in non-OECD countries increased faster than in OECD countries. For example, several Swedish companies in software, communications, engineering and pharmaceuticals have increased R&D, or are planning to do so, in India (Löf, Mitra).

Foreign R&D is driven by acquisitions and political requirements,...

Mergers and acquisitions are important drivers for the internationalization of corporate R&D. Foreign-controlled R&D is often the result of acquisitions. However, the motives behind mergers and takeovers might not be only to acquire strategic R&D capabilities. More often, the objective is broader, targeting larger market shares, economies of scale in production, or expanding brand portfolios (Johansson & Lööf).

It is important to point out that the extent of R&D internationalization is not only, or not even mainly, the result of strategic and rational decision-making by companies seeking to optimize external innovation networks. History and organic growth are important factors explaining the development and configuration of corporate R&D networks (Nilsson).

Other non-strategic drivers for foreign R&D are various forms of government requirements, for example as a condition for market access in a particular country. However, in China there are some signs that this driver might become less important over time. In the future, companies are less likely to establish R&D centers in China as a result of government requirements, but because they want to have access to skilled researchers and engineers, and be close to the strategically important Chinese market (Schwaag Serger).

...as well as corporate strategies to be close to production, markets and knowledge,...

Foreign R&D is becoming increasingly integrated into the overall R&D strategies of multinational companies. In a more rational approach, companies are strategically establishing or re-locating R&D activities to be close to production facilities, leading markets and centers of front-line research and innovation, with access to skilled personnel, on a global scale. Localization decisions are based on cost-benefit analyses, which take into consideration the cost and coordination difficulties, as well as other possible constraints for a particular R&D activity (Nilsson).

As production becomes more and more international, companies in some sectors decide to move or establish certain R&D activities close to manufacturing facilities. This might be a driver for foreign R&D in the communications and automotive sector, but less so for pharmaceuticals. In China, for example, proximity to production is an important driver for foreign R&D (Nilsson, Schwaag Serger).

For multinational companies it is also important to have certain types of R&D in countries with specific regulatory conditions (i.e. pharmaceuticals), to adapt products to local market conditions (i.e. software), to participate in standardization processes (i.e. communications equipment) or to launch new products and services on leading markets with advanced users (i.e. information technology services).

With increasing competitive pressure, cost and complexity of technological developments, companies are also searching globally for new technologies, leading-edge knowledge, and skilled researchers and engineers. For example, increased complexity in the science of medical innovations drives pharmaceutical companies to locate research facilities close to centers of excellence around the world that offer a supply of qualified researchers. Clusters combining front-line research with clinical expertise are the most attractive (Nilsson). In Japan, for example, the aging population – and the resulting lack of skilled researchers and engineers – drives Japanese multinational companies to seek foreign locations for R&D (Nakazato & Hausman).

As noted in our study, existing innovation systems often have systematic and self-reinforcing lock-in characteristics. This means that the technology specialization in the system changes only gradually. As a result, national innovation systems evolve more slowly than the technology needs of multinational companies (Johansson & Lööf).

...and is facilitated by technology, people and new actors.

An important enabler for any type of geographically distributed collaboration, including R&D, has been the development of global information and communications networks. Researchers and engineers at different locations can work around the clock as one integrated and global "virtual" team. In addition, innovation processes have become more modularized, allowing for different tasks to be performed at different locations (Karlsson).

Another factor stimulating the internationalization of corporate R&D is the presence of large groups of highly-skilled and motivated immigrants in certain technology-intensive regions in the world. People are attracted to these regions because of the access they provide to high-quality education, research and business opportunities. Immigrants from India and China, for example, are important players in the internationalization of the Silicon Valley region (Jonsson-Franchi, Mitra).

New intermediary players, most of them U.S.-based, are emerging on the global R&D market. Their business idea is to help companies solve specific problems and find technologies by employing their networks with global reach. As an example, a company can reduce cost and time by posting a specific research problem in an open marketplace for problem-solving, and then have researchers and engineers worldwide compete to provide the solution. These markets will never replace significant components of the innovation process, but do offer companies a cost-effective alternative to in-house R&D, as well as the option to source globally for technologies and talent for specific tasks (Ohlin).

International R&D is becoming more advanced...

International activities of multinational companies are moving up the value chain. It may begin with basic support for manufacturing and move up to development, technology design and even research, (e.g. telecommunication manufacturing companies in China). Or it may start with the offshoring (re-location) of low-end services and move to more advanced development and design services, (e.g. software companies and knowledge process outsourcing in India) (Karlsson, Mitra).

It is important to note that most R&D abroad is either production-supportive or for the adaptation of technologies to local markets (adaptive R&D). Adaptive R&D is thus often located close to production facilities and key markets. Even if adaptive R&D still dominates, the share of international innovative R&D is increasing. Innovative R&D is typically located close to centers of excellence or clusters of companies and universities with global technology leadership (Johansson & Lööf).

For example, initial R&D activities by foreign companies in China were almost exclusively adaptive. However, in recent years we are witnessing a growing number of innovative and strategic R&D activities in China. While innovative R&D activities may continue to increase, they might expand more rapidly in specific sectors such as communications equipment, electronics and information technology (Schwaag Serger). India is developing its capacity to undertake adaptive as well as innovative R&D to serve both local and international market requirements (Mitra).

...and is beginning to involve also smaller companies.

International R&D is still dominated by large multinational companies. However, even smaller high-tech companies have now started to locate R&D abroad to some extent. In the Silicon Valley region, this is a significant change from the past and mainly driven by requirements from venture capital companies. The rationale is that access to foreign talent and large emerging markets will reduce cost and time to market for new technologies (Jonsson-Franchi). This trend is not yet significant in other markets.

The implications for national economies are not yet fully known...

The findings in this report show that it is still too early to fully evaluate the impact of R&D internationalization on specific national economies. The internationalization of corporate R&D is only one factor behind economic restructuring and labor market changes, and appears to be relatively less important compared to other factors, such as technological change and domestic outsourcing.

Increased international investment, trade and exchange related to R&D will most certainly have both positive and negative effects. However, outcomes are uncertain and might not be observable without a considerable time lag given the expected inertia of the international R&D system (Karlsson).

...and we need better research and forward-looking analysis.

In general, findings regarding trends, scope and strategies behind the internationalization of corporate R&D are heterogeneous and still limited. In addition, available data is often incomplete, difficult to compare between countries, difficult to interpret, and only available after considerable time lag. Policy-relevant analysis must not only be current but also forward-looking as well as identify trends, challenges and possible implications in a long-term perspective (Johansson & Lööf, Karlsson).

12.2 The Dynamics of Internationalization and Future Challenges

As mentioned in the introduction to this report, the reason for analyzing the internationalization of corporate R&D is to investigate how these processes will influence national economic performance, both in the short- and long-term. The globalization of R&D and innovation is making the relationship between the R&D activities of companies and national competitiveness and economic growth more complex. Its analysis and understanding is also becoming more important for policymakers. What are the possible future developments for Sweden in the next five to ten years?

Sweden will benefit from the internationalization of R&D...

It is important to point out that Sweden has, so far, largely benefited from the internationalization of corporate R&D. For example, an increasing knowledge flow into companies based in Sweden can be an important explanation for the recent productivity growth (Lööf 2005). Based on a number of indicators, Sweden seems to be in better shape than many comparable countries when it comes to R&D internationalization. It is also possible that things will stay that way in the near future (see for example ITPS 2004 and NIFU 2005).

On the one hand, increased competition and the emergence of a global R&D market will force companies and countries to try even harder to capture a reasonable part of the created value. On the other hand, global markets are expanding dramatically (adding, for example, consumers and workers in India and China) which means increased opportunities for multinational companies. Since everything is growing, there might be a place for everyone; this is not a zero-sum game. Even if emerging economies capture more of the R&D value chain, it does not mean that Sweden must lose. An expanding world economy will present possibilities for Sweden to strengthen its national innovation systems and provide for industrial renewal and economic growth (see Kenney & Dossani 2005).

...but needs to proactively consider challenges.

However, with increasing global value flows, small countries especially may be quickly “hollowed out” when flows shift to more favorable destinations (see for example Norgren 1995).

For policymaking to be forward-looking, we suggest considering a set of future challenges for the internationalization of corporate R&D. The six identified challenges are based on the analysis of trends and driving forces in this report. Each challenge, taken separately or in combination with the others, might contribute to both positive or negative scenarios and future consequences for Swedish innovations systems and the larger economy.

1. As companies take advantage of R&D opportunities abroad, can the level of R&D activities in Sweden be sustained?

To improve their competitiveness, Swedish and other multinational companies will surely take further advantage of large emerging markets and new talent pools, particularly in developing Asia and Eastern Europe. The rise of countries such as China and India as locations of corporate R&D may indicate a major shift in international economic relations. The combination of a large and rapidly growing domestic market and an increasing supply of internationally competitive human capital attract production as well as adaptive and innovative R&D. Sweden must find ways to leverage its relatively small market and talent pool and to increase its attractiveness as a location for production.

2. With increased globalization and specialization, can Sweden maintain and develop leading research and innovation environments?

Increased international competition is driving R&D specialization and "division of labor" on a global scale. Some regions may emerge as hosts for innovation clusters and centers of excellence serving a global market; these regions may be highly specialized in specific disciplines or technologies. In the ongoing restructuring process, some countries will lose their leadership positions and their attractiveness in certain sectors or areas relative to other world locations. It is not self-evident where knowledge-intensive and high value added operations will grow strong and become successful in the future. Sweden must evaluate the level of public investment in research in certain areas compared to competing locations globally. Also it must address the fact that the share of public R&D is small compared to corporate R&D, and that the industrial research institute sector needs to be developed further.

3. Will foreign-controlled companies maintain their level of R&D activities in Sweden even under economic pressure?

The presence of foreign-controlled R&D in a country is often the result of mergers and acquisitions by R&D-intensive multinational companies. The R&D networks of these companies have grown organically and might include overlapping, under-performing or non-core R&D capabilities. Competitive pressures and market down-turns within an industry sector might demand down-sizing and consolidation in order to optimize the R&D network. This was done by Ericsson (Swedish-controlled) in 2001, giving priority to home country R&D investments (see Chapter 4). Sweden has a strong presence of foreign-controlled R&D that might increase even further (see for example NIFU 2005). A future consolidation pressure in, for example, the pharmaceutical or automotive sector (foreign ownership is dominating) might follow a similar pattern. This could result in priority being given to home country R&D and thus the reduction of R&D activities in Sweden.

4. Will Swedish public investments in education and research and in R&D performed in Sweden benefit the domestic economy?

When different parts of the production process are being located abroad by both domestic and foreign-controlled companies, the economic value and employment opportunities generated by these activities might benefit other countries rather than the country where R&D is located. For example, some foreign-controlled companies acquire or establish R&D in Sweden to take advantage of the strong science base, educated researchers and engineers at moderate cost. But the output of that R&D might be integrated into innovative products and commercialized in other countries. Conditions favorable to entrepreneurship and sufficient venture capital markets (particularly in early stages) are examples of important factors to ensure that Swedish R&D investments will benefit the domestic economy.

5. Will there be fewer employment opportunities for researchers and engineers in certain areas in Sweden?

The R&D sector is, in itself, not a major source of employment for a country, but the quantity, quality and composition of this specialized workforce is of high importance for sustaining and developing higher education, research and business activities throughout the entire national innovation system. However, it may not be sufficient for a country to use this strategy alone to move up the value chain, since advanced research and engineering work is also becoming increasingly, internationally mobile, and competition to attract these functions is intensifying. One of the critical questions for countries seeking to attract and retain knowledge resources is how much and what type of R&D can be located abroad? Certain types or sectors of R&D are more likely to be exposed to offshoring than others. As a result, specific areas or disciplines might lose employment opportunities, experience downward pressure on wages, attract fewer students and foreign researches and engineers, and create negative consequences for the innovation system as a whole (see for example Kenney & Dossani 2005).

6. How will the long-term performance and renewal capabilities of Swedish national innovation systems be affected?

National innovation systems have many interconnected and interdependent components that require a critical mass of R&D activities, collaboration between different actors, and coordination through a common, strategic perspective shared among policymakers and other actors in the system. How well can these systems adapt and develop when other countries are preferred for certain types of R&D investment? When R&D is becoming more competitive and specialized on a global scale? When the share of R&D under domestic control is decreasing and foreign-controlled R&D is being down-sized? When the value of R&D results is exploited elsewhere and when certain R&D professions are being “hollowed out”?

As a result of these challenges, all being dynamic processes, the internationalization of corporate R&D might have a number of positive or negative systemic effects for Swedish national innovation systems and for the long-term renewal capabilities of Swedish industry. With a systems perspective, a number of challenges can be identified:

- How vulnerable are Swedish innovation systems to the geographical distribution of activities?
- Is a certain co-located critical mass necessary to avoid weakening or disintegration?
- Are Swedish systems slow to adapt (high inertia), incorporating anomalies that might not be detected until it is too late?

Sweden is a small country, dependent on a few large export-oriented and R&D-intensive multinational companies, with corporate R&D concentrated to basically three industry sectors; communications equipment, pharmaceuticals and automotive. Only within the communications sector is most of the R&D still under domestic ownership and control. These challenges are highly relevant since Sweden is one of the most R&D-internationalized countries in the world.

…but the outcome is still uncertain

It is important to point out that the outcome for Sweden and for other countries is still uncertain. The above proposed challenges can be used to build more comprehensive scenarios and to stimulate a dialogue among relevant stakeholders. In order to inform policymakers, the purpose should be to identify the main dimensions of uncertainty and the most likely – as well as the most critical – scenarios for the future of international corporate R&D in Sweden.

12.3 Policy Objectives and Measures for Sweden

Proactive Policy Measures are Necessary

There are reasons why it is necessary to design a policy response even if, thus far, no major negative implications have been identified in Sweden as a result of the internationalization of R&D.

First, the dynamics and structure of corporate R&D is changing. As we have shown in this report, an increasing number of multinational companies are opening up their innovation processes to include external partners and activities at different locations worldwide. Following the internationalization of other business activities such as sales and production, corporate R&D is now increasingly organized in the form of strategic global networks. As a result, global R&D markets for capital, talent and knowledge are emerging.

Increasingly, Sweden has to compete with other countries to keep and attract value creating activities when a larger share of corporate R&D and other knowledge-intensive activities are becoming internationally mobile.

Second, the impact on the national economy is delayed. Continuous innovation and industrial renewal is of fundamental importance to national competitiveness and economic growth. However, building national R&D capabilities is a long-term effort that is characterized by path-dependency. The challenge for countries is to maintain a national innovation system that can meet the future needs of domestic and multinational companies.

Potentially negative consequences for the Swedish economy as a result of the internationalization of R&D might appear when it is too late to implement effective policy measures.

In short, the changing structure of corporate R&D and the path-dependency of national R&D efforts require proactive policies.

An Integrated Swedish Policy Response

A Swedish policy response should be based on a vision embracing internationalization. Policy objectives should include: establishing Sweden, in selected industry sectors, as a center of globally distributed R&D activities; establishing Sweden as the most attractive location for R&D; and establishing Swedish-based companies, institutes and universities as preferred partners for international science and technology collaboration.

The government has a key role in formulating the vision, designing policy measures and coordinating the activities of the relevant actors involved. In the policy measures introduced, the role of the government is to create favorable conditions to realize the full potentials of the internationalization of corporate R&D. The Swedish policy response should:

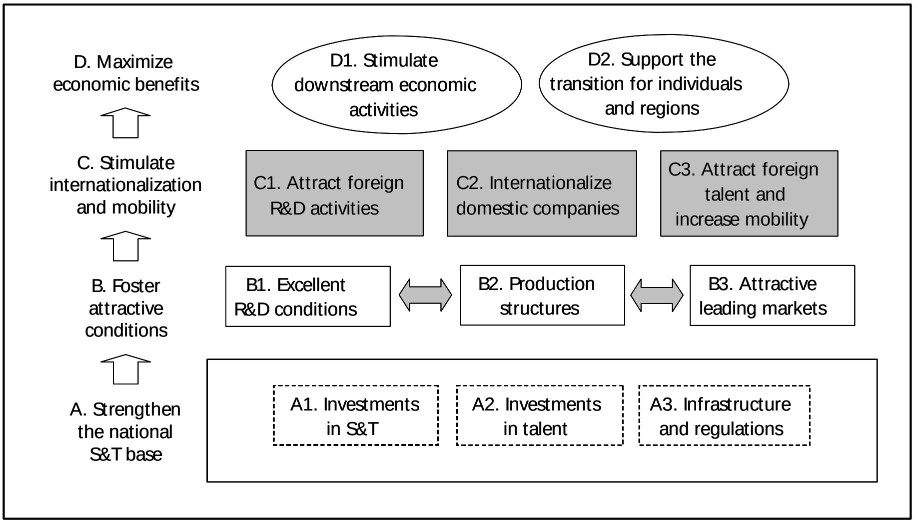
- *Build on the strengths of Swedish innovation systems*. Sweden has a good starting position compared to many other countries, with a strong science and technology base that benefits from world-leading centers of excellence, a highly skilled workforce (including world-class researchers and engineers), a modern infrastructure and legal system, (including favorable conditions for businesses and innovative activities), and an advanced consumer and end-user market, (including early adopters of new products and services).

- *Maintain a forward-looking and long-term perspective*. Many of the internationalization processes described in this report might develop over a relatively long period of time. A time frame of at least 10 to 20 years is necessary, as the structure of international corporate R&D and the configuration of national innovation systems are changing fairly slowly. However, for reasons described above, it is worth taking the early signs we see seriously.
- *Integrate policy measures in a mutually reinforcing way*. A systematic approach should include policy measures at all the levels and policy domains described in Chapter 1, and should build on current Swedish policy initiatives (for example Regeringskansliet 2004, 2005a, 2005b, 2005c, and ongoing studies and inquiries, such as KAKI 2004, SOU 2005:95 and Regeringskansliet 2006). The policy response should include a collaborative approach involving all relevant actors in the Swedish innovation system.

Strategies and Policy Measures to Consider

What are the most relevant policy objectives and appropriate policy measures that can (or must) be implemented in Sweden, in order to respond to current and potential challenges of the internationalization of corporate R&D? One can argue that we must focus on all policy domains outlined in Chapter 1 of this report (see Figure 12-2).

Figure 12-2 Illustrative structure of policy measures in four different levels or domains, in response to the internationalization of corporate R&D.



Source: ITPS.

It is possible to make a long list of known policy measures designed to: strengthen the national science and technology base; foster attractive conditions for knowledge-intensive activities, production and leading markets; stimulate internationalization and the mobility of talent; and maximize economic benefits from corporate R&D activities. How can we select the vital few that must be given specific attention in the Swedish setting?

Swedish-controlled multinational companies responded in a survey (ITPS 2005) that tax reduction measures (especially for foreign experts) and various forms of financial support were the most important policy instruments to attract and maintain R&D investments in Sweden. Support for higher education and collaboration between universities, institutes and industry were also high on their list of recommendations. For foreign-controlled multinational companies in Sweden, the most important policy measures were: increased government funding for research at universities and institutes (including applied research) and incentives to attract foreign experts and students. See also, for example, Karlsson 2004, Teknisk Framsyn 2004, NIFU 2005 and Andersson & Friberg 2005 for policy issues to consider.

Based on the studies in this report and the current Swedish policy context, we would like to point out five specific areas that need particular attention and additional resources in order to address the challenges raised by the internationalization of corporate R&D:

1. Ensure the Quality of the Swedish Education and Research System

A strong science and technology base is the foundation for attracting foreign R&D activities and for competitiveness. A priority for the government should continue to be making available R&D resources in order to ensure the quality of the education and research system. In addition, stronger industrial research institutes could serve as a bridge between domestic and foreign corporate R&D environments and encourage the exchange of researchers and engineers in certain sectors. Internationally competitive research institute alliances could be established, for example, between the Nordic countries.

2. Create Conditions for Excellent R&D and Innovation Environments

Focus more resources on, and create better conditions for, excellent R&D and innovation environments in disciplines and industry sectors where Sweden has an internationally competitive advantage. Identify R&D clusters where the co-location of niche production is an advantage, or where specialized leading markets are served. This requires further embracing specialization and the global division of knowledge-intensive work. Identify areas and types of R&D activities that are desirable to keep at home and those that can be sourced worldwide.

3. Develop Proactive Strategies for R&D Internationalization for Key Countries

Develop focused and action-oriented international R&D and innovation strategies for selected key countries and regions, such as the U.S., Japan, Europe, including Eastern and Central Europe, and other Asian countries, such as China, India and Korea. The objective should be to strengthen Swedish innovation capabilities in selected industry sectors. The government should initiate and develop integrated strategies together with other actors and build on the bilateral science and technology agreements implemented with some countries. Support large and small companies to identify R&D opportunities abroad.

4. Develop Stronger National Attraction Policies

Establish coordinated national attraction policies with the objective of promoting Sweden as a location for sales, production, R&D and living, and target both domestic and foreign companies and talent. Strengthen and unite the current fragmented efforts to create a more forceful and systematic approach to trade and investment promotion in other countries. Sweden should be effectively marketed as an innovation-friendly and knowledge-intensive country.

5. Support the Inflow of Foreign Talent and International Skills of Swedish Students

Implement measures to increase the inflow of foreign talent, including immigrant academics, and measures that will help retain foreign students in Sweden after they have completed their education. Further reform of higher education is required to attract foreign students, as is reform of the labor market, so that it comes to more wholly appreciate and utilize knowledge workers with foreign origins. Universities should be encouraged to establish alumni networks of, for example, Chinese and Indian students who have studied in Sweden. Create more opportunities for Swedish students to spend time abroad and to learn critical languages.

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In order to support the strategies and policy measures discussed above, it is necessary to further develop Swedish capabilities for monitoring and analysis. We need to increase our understanding of the processes of internationalization in general and in relation to specific economies, such as China and India, as well as those in Eastern and Central Europe. Embassies can be used more purposefully and the network of Science and Technology Offices can be extended and better utilized. With improved data collection, international collaboration and adequate resources for analysis, we will be better equipped to provide foresight and early warning of trends and implications.

The purpose of this report is to provide policymakers with a description and analysis of trends, driving forces and challenges facing countries – Sweden in particular – as a result of the internationalization of corporate R&D. It is our hope that the studies in this report will stimulate a broad and informed dialogue on the processes of internationalization and the appropriate policy measures to take.

With this report as the starting point, the next step should be to more systematically evaluate the results and effects of the different policy measures discussed. Evaluations will further inform policy making by providing benchmarks and insights from policies implemented earlier, at home or in other countries.

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Abbreviations, Terminology & Exchange Rates

BPO	Business Process Outsourcing
E.U.	European Union
EC	European Commission
EPO	European Patent Office
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
Greenfield FDI	Establishment set up from scratch
ICT	Information and communication technologies
IPR	Intellectual property right
ITES	Information Technology (IT) Enabled Services
KPO	Knowledge Process Outsourcing
M&A	Mergers and acquisitions
MNE	Multinational Enterprises
OECD	Organization for Economic Cooperation and Development
Offshoring	A company moves an activity abroad regardless of organizational form
Outsourcing	A company moves an activity to an external supplier
R&D	Research and development
SME	Small- and medium-sized enterprise
STP	Strategic Technology Partnering
UNCTAD	United Nations Conference on Trade and Development
USPTO	United States Patent and Trademark Office

Exchange rates used for conversion to U.S. dollars

1 Swedish Crown (SEK) = 0.125 dollars

1 Euro (€) = 1.24 dollars

1 Japanese Yen (JPY) = 0.01 dollars

1 Indian Rupee (RS) = 0.023 dollars

The Swedish Institute for Growth Policy Studies (ITPS) is a Government Agency responsible for providing policy intelligence to strengthen growth policy in Sweden. ITPS primarily provides the Government Offices, Members of the Swedish Parliament, other state authorities and agencies with briefings based on statistical material, policy papers and key analyses. Business policy and regional development policy are areas given high priority.

Changes in policy should be based on:

- Statistic data and analyses of the structure and dynamics of industry – to obtain an up-to-date view of future challenges and opportunities.
- Evaluation of results and effects of policy measures and programmes – to provide benchmarks and learn from measures implemented earlier.
- Policy intelligence in order to look outwards and ahead – what issues are likely to come on the growth policy agenda in the future?

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