WORKSHOP ON EMPIRICAL RESEARCH ON BUSINESS R&D STRATEGIES AND THE EFFECTIVENESS OF GOVERNMENT POLICIES

RAPPORTEUR'S SUMMARY[1]

Introduction

1. Researchers in a number of OECD countries (*e.g.*, Austria, Belgium, Finland, Korea, Switzerland and the United Kingdom) are conducting research into changing patterns of business R&D and the effectiveness of government policy instruments for supporting business innovation. As part of an effort to co-ordinate this work and strengthen links to ongoing activities within the OECD's Working Party on Innovation and Technology Policy (TIP), a small workshop was held at OECD Headquarters on Friday 8 November 2002 to provide an opportunity for participating researchers to: *1)* present and discuss preliminary results of their country-level studies of changing patterns of business R&D and their implications for science and technology policy, *2)* explore opportunities for greater synchronization and harmonization of further empirical work on this topic, and *3)* discuss options for synthesizing and disseminating the results of ongoing research, such as through a unified publication. The meeting built upon the results of earlier workshops on *Changing Business Strategies for R&D and Their Implications for S&T Policy* that were organized by the OECD and the Austrian *tip* group in October 2001 and February 2002, respectively (see www.oecd.org/sti/innovation and www.tip.ac.at). Summaries of these events were presented to the TIP working party in December 2001 and June 2002

2. The ongoing research that was presented at the Workshop is motivated by a range of different policy concerns and therefore takes on a number of forms. In Belgium, the government is interested in understanding how to improve the effectiveness of various measures to support private sector R&D. A broad spectrum of quantitative and qualitative analyses are under way to evaluate subsidy mechanisms, estimate the effectiveness of fiscal incentives for R&D (Belgium does not currently have a fiscal incentives programme) and examine how different mechanisms can best be combined. Work in Korea is motivated by concerns that restructuring of large firms (chaebol) in the wake of the country's financial crisis may have altered patterns of business R&D investment, in particular that related to long-term R&D in large firms. There is further interest in determining how government policy can best stimulate leading edge innovation in large and small firms. UK work is motivated by a general recognition that a better understanding of

[1] This summary was prepared by Jerry Sheehan of the OECD's Science and Technology Policy division.

business R&D practices can lead to improvements in government policy.[2] As a result, research programmes under way in different countries to examine business R&D place different degrees of emphasis on qualitative and quantitative analyses and on work to examine changing R&D patterns in the business sector and work to analyse the effectiveness of policy mechanisms.

3. This document provides a summary of the November workshop, drawing from the presentations and subsequent discussion. It provides brief abstracts of each of the presentations, reviewing the key findings of research conducted to date and outlining plans for further research in each country. It then presents suggestions made by workshop participants for completing and disseminating in a co-ordinated way ongoing research and for planning future work that could take place in a more collaborative manner. Participants noted that the differing emphases and approaches of ongoing work will complicate integration of the results into a single report, but agreed to move in this direction. They also identified several common research themes that could serve as the basis for future, co-ordinated research.

Summary of presentations

4. The Workshop presentations all shared a common objective of enhancing the effectiveness of public policies to support business R&D and innovation. They covered a range of related topics, from 1) general assessments of trends in business R&D; to 2) results of surveys of business R&D strategies in different countries, to 3) results of econometric models that estimate the returns from public investments in private sector R&D. The summaries below are presented according to these themes rather than to the order of the agenda.

Jerry Sheehan, OECD

5. Jerry Sheehan presented the results of research conducted as part of the TIP Working Party's project on changing patterns of public and private financing of business R&D. He noted that increasing business R&D--industry-financed business R&D, in particular--had become an explicit objective of many OECD countries that wish to improve economic performance. As the structure of business R&D and patterns of government financing of business R&D have changed, policy makers are forced to find more effective ways to boost business R&D and innovation.

6. While business enterprise R&D (BERD) increased significantly across the OECD during the 1990s, trends in individual countries were vastly different. Finland, Sweden and Iceland, for example, saw BERD increase by more than a percentage point when measured as a share of GDP, while Italy, the United Kingdom, and several eastern European countries saw levels of BERD fall as a share of GDP. Countries with high levels of R&D tended to have a higher share of R&D performed in large firms, but in the US, growth in business R&D appears to have been driven disproportionately by SMEs, most likely new technology-based firms NTBF. Venture capital investments contributed to this growth and even though venture capital funding has plummeted in most OECD countries, it is still significantly above its levels of the mid-1990s. Much of the growth in business R&D came from expansion of R&D spending in high-technology manufacturing sectors and knowledge-based services.

7. Within firms, changes in R&D strategies have been motivated by a number of factors, including: 1) reduced time to market; 2) expanding technological opportunities, especially in the ICT, biotechnology

2. It was also noted that the European Commission is actively investigating a range of measures for enhancing business R&D investments, as well as the mix of measures that might have the best effect. Several Workshop participants are engaged in this activity.

and service sectors; 3) increased cost and risk of innovation in many sectors (*e.g.*, pharmaceuticals, aerospace), 4) globalisation of R&D, which is increasingly motivated by concerns over proximity to sources of leading edge science and technology; 5) increased mobility of workers, which diffuses knowledge; and 6) erosion of the dominant positions of many firms, especially as markets have become more global. As a result, firms have shifted from a closed model of innovation in which broad-based R&D was conducted internally and pushed into new products and services, toward an open model of innovation where internal R&D is linked to strategic business needs, and firms rely more extensively on licensing, joint research and outside sourcing of technology to serve their innovation needs. The extent of this transformation seems to vary across countries and industry sectors, being more pronounced in high-technology industries.

8. Such changes suggest that government policy should shift away from support to R&D in large firms and toward creation of an environment that is more conducive to innovation in a larger number of organisations in the public and private sectors. The increasing reliance of innovation on new scientific and technological advances and the reduction in business support for basic research suggest that government funding of fundamental research in public research institutions will be at least as important as direct support for business R&D in stimulating industrial innovation. Programmes to finance business R&D (whether direct financing or tax incentives) will need to be better adapted to the particular barriers that firms face in conducting R&D, whether they be financial barriers, technological risks, or lack of suitable markets. Ensuring proper linkages among innovators in the private and public sectors will also be more important, as will be efforts to stimulate entrepreneurship. IPR appears to be playing a more significant role in stimulating business innovation, especially in creating stronger incentives for invention, yet more work will be needed to understand how IPR affects the diffusion of knowledge among innovators.

9. Sheehan suggested that additional research would be useful in determining: 1) what factors underlie the differences in business R&D performance among countries; 2) what barriers limit investments in R&D by firms in different countries, different industry sectors and of different sizes; 3) how business R&D strategies differ across industry sectors and countries--and how such differences link to business or innovative performance. On the policy side, questions remain about the effectiveness of different forms of government intervention (direct financing of R&D, tax incentives, etc.) and their different influences on firm behaviour. Policy makers also need guidance about the policy mix that can best address the challenges firms face in innovating.

10. Workshop participants noted the environment for business R&D is changing again in the economic downturn. There was general agreement that business R&D spending was likely to decline in 2002 and perhaps beyond, as is venture capital financing, but that the major changes seen in business R&D strategies would persist. One specific concern this situation raises is whether there may soon be too many purchasers of R&D (and R&D services) and not enough sellers. If large firms are outsourcing more of their R&D, and many of the smaller firms and NTBFs that they relied on are facing economic difficulties, who will conduct R&D in the future. How will firm strategies evolve in response? What can governments do to support industrial innovation in this context?

Ki-Joon Jung, OECD (on behalf of Jung Guk Song, STEPI, Korea)

11. Ki-Joon Jung presented the results of research conducted by the Science and Technology Policy Institute (STEPI) in Korea that examined changing business R&D strategies and their implications for science and technology policy in Korea. STEPI conducted a survey of R&D-conducting firms and a series of interviews with R&D executives of large R&D-conducting firms to see how business R&D was effected by the financial crisis in 1997-98. During the crisis government funding for R&D remained steady, but business funding declined significantly before rebounding in 1999 and 2000. The question is whether the

R&D strategies of firms changed significantly after the crisis, especially as a result of policies that were put in place to reform corporate governance and that resulted in the break-up of several large chaebol.

12. The STEPI survey was sent to a sample of 829 firms, including 450 large firms, 205 small and medium-sized enterprises (SMEs) and 173 venture firms. The response rate was 24% on average, with slightly higher response rate among large firms than venture firms. Responses were received from 19 of the top 20 firms in Korea, which account for half of all Korea’s business R&D. In addition, face-to-face interviews were conducted with 7 large firms: Hyundai Heavy, Hyundai Motors Hyundai Mobis, Samsung Electronics, LG Chemical, LG Electronics, and Iljin. These interviews provided an opportunity to explore, changes in the management of R&D within large firm.

13. Key findings from the survey include:

- *Globalisation and technological complexity drive changing technology strategies*. Market globalisation, rapid deployment of ICT, and firm restructuring were reported to be the most important environmental influences on firms' technology strategies. Globalisation of technology and the increasing complexity of technology were seen as the most significant technological influences on technology strategies, ahead of developments in ICT, IPR protection and growth in public and private R&D funding.

- *Technology and marketing strategies more important*. Firms reported that in 1997, production and marketing strategies were considered the most important elements of overall business strategy. By 2001, marketing and technology strategies were considered more important. The links between corporate business strategy, corporate technology strategy and business unit technology strategies have increased since 1997.

- *Lead times have shortened*. More than 60% of firms reported that innovation lead times had shortened somewhat or considerably since 1997. They further indicated that the three most important considerations for CTOs to address in developing their technology strategies are: *1)* innovation for new dominant products, *2)* integration of technology plans and business plans; and *3)* shortening lead times for innovation. Global R&D management has also become more important to CTOs, whereas technology sales (*e.g.*, licensing) and new start-up businesses are given much lower importance.

- *Outsourcing is increasing*. Firms that considered themselves leaders or average among their peers reported that the growth rate in out-sourced R&D greatly exceeded that for in-house R&D. Outsourcing declined among firms that considered themselves inferior to their competitors. Joint R&D also appears to have increased, with universities, government research institutes, other businesses, and contracting/consulting firms.

- *Government support programmes are satisfactory*. Firms reported overall satisfaction with government R&D programmes, but with higher rates of satisfaction for R&D funding and tax incentive programmes than for financial programmes (*e.g.*, loan programmes) and infrastructure programmes.

14. The interviews conducted with large Korean firms indicated some changes in R&D strategies. While most R&D labs are corporately funded, Samsung Electronics has shifted to a mixed model with funding from the corporate level and from product divisions. Most firms have globalised R&D, with research institutes in countries such as the United States, Russia, China, India, and Hungary. In contrast to the findings of the survey, the interviews uncovered some dissatisfaction with government R&D programmes, noting that they are not effective or relevant to business needs. Their main advantage is in forming networks among firms and with the public research sector.

15. Subsequent discussion revealed a few areas in which additional analysis or information-gathering would be useful. First, workshop participants suggested breaking out the results of the survey by industry sector (*e.g.*, automobiles versus ICT) and by firm size or type (*e.g.*, large firms versus SMEs versus venture firms). This would be especially interesting for the questions about outsourcing of R&D and primary interests of CTOs. Second, they suggested that additional work be done to better understand firms' evaluation of the effectiveness of government support programmes. While the survey shows a high degree of satisfaction, the interviews shows limited effectiveness of government R&D programmes. What drives this apparent contradiction? Are there differences among firms of different size? What about the structure or objectives of government R&D programmes limits their effectiveness or utility to firms? What

impediments to firms face in conducting R&D and/or in expanding R&D programmes? Finally, additional information could be gathered to help highlight the differences in R&D strategies before and after the financial crisis: What kinds of programmes were cut during the crisis and what programmes were put in place during the recovery? What was the effect of the crisis on the research community?

Luke Georghiou, PREST, University of Manchester, UK

16. Luke Georghiou reviewed research he has been conducting over the past two years that examines R&D management in leading firms. He began by identifying the factors that have been driving changes in R&D spending and the main changes in the ecology of industrial R&D. His analysis confirmed that growth in R&D spending was driven disproportionately by high technology manufacturing and service-sector industries. Venture capital appears to have driven growth in R&D spending by SMEs – especially in the United States – but has declined rapidly since 2000. Many factors may have caused the growth in R&D spending during the 1990s: *1)* wider technological opportunities (historical cycle); *2)* increased productivity of R&D (more R&D done for less input because of advances in equipment and simulation capabilities; *3)* increased competition driving innovation; *4)* greater affordability because of high profitability; and *5)* strengthening of IPR regimes, which has increased the returns to R&D (especially in US)

17. Georghiou expects that R&D spending will show a decline in 2002. The decline is not yet available in the statistics because firms attempted to preserve R&D in the first year of the economic downturn, but declining markets in the ICT sector, in particular, is already having effects on some large R&D performers. Ericsson announced that it is cutting R&D by 50%, and Japanese firms that link R&D funding to sales will see automatic reductions in R&D as markets shrink. However, cuts in R&D spending may not be evenly distributed; anecdotal evidence suggest that there cutbacks are more likely to affect near-term R&D than long-term research in core areas.

18. These changes take place against the backdrop of significant changes in the environment for R&D. Georghiou's work indicates that a new industrial ecology has emerged, with large firms accompanied by dynamic population of technology-rich SMEs. Outsourcing of R&D has also increased, with firms reporting that the share of their technology needs that are satisfied externally increasing from 5% to 15%. Globalisation also increased, especially as European firms increased their R&D spending in the United States and Japan faster than they increased it in Europe. The changing economic situation raises new questions about this new ecology: Will the collapse of venture capital markets limit growth in R&D funding in SMEs, upsetting the relationship with large firms. Will corporate labs be able to buy and sell technology as easily or will outsourcing become more difficult? Where will R&D cutbacks occur in a more global environment? They could be higher in the US because the cost of R&D is higher there and the costs of hiring and firing workers lower than in Europe. Differences in R&D productivity will also need to be considered.

19. The research project on R&D management in large firms has proceeded in two phases. The first phase examined R&D management in the central research labs of 7 large, leading-edge firms: Hewlett-Packard, IBM, 3M Corning, Nokia, Philips, and Johnson Matthey (a UK-based manufacturer of catalytic converters). The research was conducted through interviews with high-level R&D executives, although some researchers were also included in the study. Firms were sent a short, 4-page document in advance of the site visits that identified the issues for discussion. Researchers were given documents with pertinent statistics before or after the interviews, which were free-format.

20. The main results from Phase 1 of the project, which was completed in 2001, were:

- Research is core to the companies

- The nature of research has changed and time scales have been strongly compressed. Most firms are working simultaneously on breakthrough research and incremental research, but the time scales for even breakthrough research are shorter (*e.g.*, two years instead of five).

- Time scales for strategy development are also shortening. Annual strategy development is too slow for current innovation processes, so firms are finding ways to update their strategy more frequently.

- R&D is more closely aligned with business needs. Firms are shifting from corporate funding to business funded R&D. Even the remaining corporate research is better aligned with business needs.

- R&D targets are set bottom up as well as to down. Projects are not seen as an important unit for decision making; market and product-related objectives form “buckets” for top-down resource allocation. The subdivision of buckets into projects is much more decentralised. The buckets themselves are fairly similar across companies—many firms are betting on same technologies.

- Scientific values are preserved in new incentive structures. Incentive structures are more individualistic in the US than in Europe (*i.e.*, focusing on personal rankings vs. teamwork) and more formalised. Patents are increasingly used as a performance indicator, but with some scepticism.

- Best practice lies in the alignment of corporate values with laboratory and individual incentives.

21. The Phase 2 study is now underway with support from the Technology Strategy Forum (a UK-based industry group) and DTI, as well as co-operation from OECD, which is assisting with research on Korea and Japan. The objective is to expand the Phase 1 analysis to include examination of R&D management strategies in Asian countries, as well as a sample of firms in the UK and other European countries (*e.g.*, Sweden). Researchers will also re-visit the companies interviewed in Phase 1 to identify changes in R&D management in the past two years. Interviews were conducted with several Asian firms in June and October 2002. Preliminary findings suggest:

- The traditional Asian model of a very broad R&D portfolio that is exploited by a highly diversified corporation is under some pressure. Firms are beginning to focus their R&D around major product targets. For example, Hitachi merged its advanced technology lab with its corporate lab and is providing more business-unit funding of R&D.

- Corporate funding models are under pressure from both declining revenues and governance changes. For example, the break-up of some of Korea’s larger chaebol is increasing business unit funding in some firms (*e.g.*, Samsung).

- R&D models for service sector firms are different from those in manufacturing and have more complete integration with business units. This was seen at IBM, too, where there is heavy interaction with customers and an increase in the number of researchers who are working on customer premises.

22. These results lead to several hypotheses. First, that it is necessary to separate long-term trends from short term effects of the business cycle (*e.g.*, the financial crisis in Korea, the current economic downturn). Public policy needs to work counter-cyclically: there is a need to "warehouse" researchers so that firms can keep researchers during troughs in the business cycle and use them more productively during the upswing. It takes approximately five years for new researchers to become more productive and cycles of layoffs and re-hiring can be disruptive. Second, large firms recognise the need for breakthrough research to drive business growth and are looking for new models to relate it to business. Finally, there is concern that at the next level down (*i.e.*, firms just below the large leading-edge multinationals) there is an over-reliance on outsourcing and external markets for research: too many buyers and not enough seller of R&D.

23. In terms of policy implications, the research to date suggests that:

- Government agencies need to understand that they are not financing an R&D project; they are buying into a platform. Projects are not the planning unit for R&D in large firms, and government support schemes need to reflect this;

- Policy to stimulate business R&D and innovation should support the emerging industrial ecology, for example, though attempts to stimulate development of knowledge-based clusters rather than providing support for individual companies;

- Government agencies need to be aware that the pace of innovation often moves faster than government decision-making processes; hence, programmes need to be flexible enough to allow projects to be modified and updated in mid-course.

Norbert Knoll, WIFO, Austria

24. Norbert Knoll of WIFO presented results of a qualitative investigation of business R&D patterns in Austrian firms. This work complements work that was presented at the workshop in Vienna in February 2002 and focused more on the leverage effects of public support for business R&D and the additionality of the business R&D investments they encourage. Since February, the Austrian research team has looked at: *1)* trends in business R&D such as outsourcing and increasing R&D intensity; and *2)* company perceptions of government innovation policy. This work is qualitative and exploratory. In that respect, it is similar to work conducted by researchers in Korea and the UK, but it differs in that is looked primarily at small companies, not multinationals.

25. The researchers selected 9 companies for interviews in May and June 2002 and met with research managers/directors or general managers who were responsible for R&D. The firms were all technology-based, but active in different industries and with different types of customers: three manufacture electronics or electronic components; two produce machinery and equipment; one produces fibre-reinforced materials for the aircraft industry; and another provides ICT services and software. Many of the firms were highly specialised. Half of the firms had 120 employees or fewer and annual sales of less than EUR 320 million (the smallest had 20 employees and sales of EUR 3 million). The other half had between 650 and 2 700 employees and sales of between EUR 100 and EUR 320 million. Interviews with the firms revealed the following:

- *Growth*. Most of the firms had experience high levels of growth in recent years, but much of this was driven by acquisitions. Future growth prospects were good for the smaller firms, but some of the larger firms are going through a period of consolidation and anticipate slower growth in the medium-term.

- *Internationalisation*. Most of the firms are international in that they serve international markets, primarily elsewhere in Europe. Internationalisation is limited in terms of production and R&D. All firms concentrate their production in Austria, although the larger firms in particular have investments elsewhere in Europe and North America. Internationalisation has been driven by acquisitions and globalised firms are moving toward decentralised management of R&D and specialisation of foreign research centres.

- *R&D intensity*. All the companies have high levels of R&D intensity (ranging from 8% to 22%) and R&D personnel, except for the largest firm in the sample, an electronics manufacturer that reported an R&D intensity of 2% to 3%. Most firms reported that R&D expenditures had grown rapidly in recent years, but would grow only as fast as sales in future years. The two largest firms expect to boost R&D intensity.

26. Firms reported that R&D spending patterns were influenced by a number of factors, including overall industry trends, company strategy, and diversification efforts.[3] Although firms had difficulty measuring product development times, there was evidence that they had shortened, forcing firms to focus internal R&D efforts on projects with near term results and to rely on outsourcing for longer term research. Small firms, in particular, tended to outsource long-term research, but larger firms reportedly felt a greater need to do more internally. Partnerships with universities are being used to fill the need in many firms. Characteristics of products and markets had large effect on R&D strategy, as R&D is increasingly tied to the overall goals of the company—especially to their future product plans. Despite the economic downturn, firms felt that their competitive positions could only be maintained if they made significant investments in R&D, perhaps reflecting a bias toward technology-intensive companies in the survey. Nevertheless, technology roadmaps drove many R&D efforts, and large firms often had 10-12 year outlooks and strategies that they updated regularly. R&D projects tended to be divided into those that pursued 1) new platforms and product families for long term; and 2) short term improvements to existing product lines. The close link between business strategy and R&D strategy suggests that it may be hard for government policies to significantly influence the content of firms' R&D programmes.

27. The Austrian researchers also investigated firms' perspectives on the effectiveness of government policy to support private R&D. These policies include measures to 1) reduce R&D costs (*e.g.*, tax incentives, project grants & loans and personnel subsidies); 2) reduce R&D risks (*e.g.*, conditional loans and guarantees, royalty grants and stock option grants in which the firm gets a benefit only if the project fails); and 3) improvements in R&D infrastructure (*e.g.*, public research organisations, training of scientists and engineers). Firms reported a clear preference for measures that reduce R&D costs, and within this category they preferred project grants. Among risk-sharing measures, firms reported a preference for conditional loans,[4] which allow them to test the limits of technical capabilities and allow small firms to conduct larger research projects. Ownership structure was seen as a factor that could potentially limit the use of some risk-reduction schemes, such as stock option guarantees; only 2 of the interviewed firms are listed on the stock exchange. Research infrastructure is also highly valued in the home country--both human capital and public research, although firms differed in the level of scientific and technical skills they need in their workforce. While firms were not asked to compare the importance of public research to government financing of business R&D, the interviews do suggest that infrastructure itself is not as important as collaboration among domestic partners in the public and private sectors.

---

3. As an example of the latter, one firm (Fronius) initiated a solar energy project in 1992 as part of a diversification effort. Early success led to the creation of a new unit devoted to this sector in 1997. The company now has a division that focuses on solar electronics and is much more R&D intensive that the parts of the company that focus on welding technology. ,

4. One participant noted that conditional loans are the risk-reducing measure that is most similar to a direct subsidy or grant. They tend to be used more often for product development than for research.

28. The Austrian research will continue its work on the leverage effects of public R&D subsidies on privately funded R&D in Austria through advanced econometric analysis. They plan to use data from the Austrian Industrial Research Promotion Fund (FFF)—Austria's most important source of finance for research and development projects carried out by industry—to examine the impact of R&D subsidies on the subsequent R&D spending of firms (*i.e.*, additionality issues) and to focus on the relationship between government subsidies and company performance. The data analysis will start with extensive descriptive statistics on the firm level, information on successful as well as unsuccessful projects and the different developments in industries, firm size, type of funded projects, etc. Analysis on the firm level will be used to gain more quantitative understanding of the factors influencing business R&D patterns. In combination with the qualitative case studies conducted to date, the research should provide additional insight into the impact of government policies on business R&D strategies, which provides insight into the likely effects of different policy interventions. The project is expected to conclude by the middle of 2003.

Tanya Tanayama, Tekes and VTT, Finland

29. Tanya Tanayama described ongoing work within Tekes (Finland's National Technology Agency) to quantitatively analyse the selection mechanism underlying allocation of public R&D subsidies, in particular grants and loans for R&D conducted in the business sector. She views the selection mechanism as consisting of two inter-linked decisions:

- Firm's decision to apply for a subsidy (or not) for a particular project

- Public agency's decision to provide subsidies based on their budget constraints, policy guidelines and the population of applications received.

30. The study will model both the firm's and the public agency's decision processes, as well as the feedback from the second to the first. It will use a general game theoretic model to summarise the decision rules of the firm and the agency, as well as their inter-linkages. Dependent variables include the firm's decision to apply for a grant and the amount for which it applies. The public agency's behaviour equation will be included in firm's decision equation. The resulting econometric model will be used to assess how changes in the government's funding policy influence firms' decisions to apply for subsidies.

31. The project will examine Tekes' awards to firms, including both grants and subsidised loans. It will not include funding for feasibility studies, which Tekes also provides to firms. Of the Tekes awards made to industry, about half finance product development, one quarter finance research, and one quarter finance feasibility studies. Tekes grants and loans account for most of the Finnish subsidies for business R&D, which can fund both research and product development. Data is available on applications made in 2001, which included 1358 applications and 1039 firms. This data will be compared against firm level data available from a private database with information of financial performance and the database of a research institute with responses to a business survey.

32. To date the research team has conducted interviews with managers who are responsible for the selection process within Tekes. They have also gathered information about the grant programmes and the selection process for R&D grants. Information gathered to date indicates that firm that apply for Tekes grants tend to be more globally oriented and have greater expectations of growth than the population of non-applicant firms in Finland. Many of them are in the electronics and data processing industries, and many of them are young firms. Applicants also tend to be more R&D-intensive and have more often experienced considerable R&D intensity growth over the last three years. A large majority of applicants have introduced a product or process innovation during the previous three years, which is not the case for non-applicants. Ownership structures among applications are more diverse, with greater foreign ownership

(although it is still low) and higher levels of change in recent years. Applicants are more likely than non-applicants to have received public funding from sources other than Tekes in previous years. Nevertheless, the overall funding structures of applicants and non-applicants are similar.

33. The research project will run through early 2004. Theoretical modelling starts in early December 2003, after which the econometric analysis will be conducted. The research team will run simulations of the funding process and model firm decision making processes. Variables to be included are: risk, technical challenge, markets to achieve, and strategic effects. These factors are considered in the evaluation process. Workshop participants suggested including information about the length of the application process and analysing firm decision-making processes as a follow-up to the current study. How do firms decide which projects to finance and how much funding to give them?

Sigrid Suetens, Belgium (Flanders)

34. Sigrid Suetens of the University of Antwerp presented preliminary results of an econometric analysis that examines: 1) whether Flemish R&D subsidies enhance the hiring of R&D personnel in the business sector (instead of substituting for private R&D investments) and 2) the degree to which the knowledge stock is an important production factor. The analysis takes a systems approach, estimating two equations: a production function and an R&D subsidies equation. The R&D equation controls for possible simultaneity between private and public R&D decisions and between private R&D and private output. The output equation is a Cobb-Douglas production function where knowledge stock enters as a production factor. R&D stock is measured in terms of personnel, which is more robust for time series (no need to depreciate), are easier to interpolate for missing years, and avoid problems of double-counting of capital stock. The data used in the analysis come from a set of cross-sectional and time-series data of innovative Flemish firms from 1992-99. Data on R&D and subsidies come from the IWT; other data on Belgian firms (*e.g.*, for value added and capital expenditures) come from national accounts. The final data set includes more than 1000 observations covering 262 firms. No young or start-up firms are included in the database; rather the focus is on larger firms that are already known to IWT.

35. The analysis showed that R&D stock is a significant factor in the production, a result consistent with that found in previous work. Additional evidence was found for substitution effects between privately and publicly financed R&D personnel. The results indicate that when fixed firm effects are ignored, about 60% of the publicly financed R&D substitutes for private R&D. When firm effects are taken into account, public financing almost completely substitutes for private R&D. Of course, these results apply only to large firms with a history of involvement in subsidy programmes and may not extrapolate to the larger population of firms (including SMEs and venture firms). In addition, such analysis does not capture other possible benefits of the public subsidy compared to private funding that is crowded out. As one participant noted, public R&D may substitute for private R&D, but it may not fund the same R&D. For example, public funding may be better able to promote co-operation among firms or between firms and public sector research organisations. There may also be some reduction in the overlap among firms' R&D spending that could enhance the effectiveness of overall private sector R&D spending. Future analysis may need to incorporate other output effects of R&D, such as new product or service introductions and patents to better capture some of these effects.

Next steps

36. Workshop participants considered next steps for advancing work in a co-operative fashion. There was general agreement that a summary of the workshop should be presented to the TIP working party at its

December meeting and that the workshop materials should be made available on the OECD Web site. As for future activities, participants discussed two ways to follow-up on the workshop.

- *Publication of results*. The first would be to pursue publication of the various country analyses in a single document. The challenge is that there is considerable variation in the work under way: some work focuses more on evaluation of the effectiveness of government policy interventions; some examines patterns in business R&D strategies. The *STI Review* series was seen as the most appropriate channel for this sort of work, but given that the series has been discontinued, another type of publication will need to be considered.

- *Joint research project*. Participants also discussed the possibility of a future research project that could be designed co-operatively from the start. One idea would be to better understand firm-level decision processes regarding R&D investments as a step in improving the ability of public policy to influence those decisions. This theme is already present in many of the ongoing studies, but would benefit from a more focused effort. An initial stage of the project could consist of surveys to map key considerations in firm R&D decisions. The next stage could examine portfolio management approaches to R&D strategies. The focus could be on small firms as opposed to large firms, which have been more extensively studied already by researchers.

37. OECD staff agreed to evaluate various options for publishing the results of the ongoing research activities. The Belgian participants agreed to develop a preliminary outline of a future joint research project and sketch out ideas for a theoretical model that would guide formulation of a survey.