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VINNOVA´s FOCUS ON IMPACT

A Joint Approach for Logic Assessment, Monitoring, Evaluation and Impact Analysis

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About VINNOVA

VINNOVA - Swedish Governmental Agency for Innovation Systems.

Research and Innovation for Sustainable Growth.

VINNOVA´s mission is to *promote sustainable growth*
by funding *needs-driven research*
and developing *effective innovation systems*.

Through its activities in this field, VINNOVA aims to make a significant contribution to Sweden´s development into a leading centre of economic growth.

The VINNOVA Analysis series includes publications of studies, analyses, official reports and evaluations that have been produced or commissioned by VINNOVA´s Strategy Development Division.

VINNOVA´s
Focus on Impact

A Joint Approach for Impact Logic Assessment, Monitoring, Evaluation and Impact Analysis

1st February 2008

Foreword

This report describes VINNOVA's ambitions and activities aimed at understanding and increasing the impacts of VINNOVA's efforts in research, innovation and sustainable growth in Sweden. The report outlines VINNOVA's various processes for quality-assuring the direction and implementation of these efforts from an impact perspective. However, the emphasis of the report is on accounting for and drawing conclusions from the impact analyses which VINNOVA has conducted since the beginning of 2001. In significant ways, these are unique in an international perspective.

The project director with overall responsibility for the report is Peter Stern, who also heads VINNOVA's impact analyses. Several other people have been involved. Kenth Hermansson was responsible for the research status review of the connection between R&D, innovation and growth. Torbjörn Winqvist and Nina Widmark were responsible for the bulk of the extensive work of summarising the impact analyses conducted so far and their results. Joakim Appelquist, Klas Barklöf and Torbjörn Winqvist were responsible for the conclusions which can be drawn based on experiences to date in the work with impact analyses. Lennart Norgren and Jonny Ullström contributed to the overall descriptions. In addition to the above authors, Gunnel Dreborg, Lennart Elg, Rolf Nilsson, Åsa Minoz, Patrik Sandgren, Staffan Hjorth and Joakim Tiséus provided important views on the content.

An important role in the development of VINNOVA's work with impact analyses was played by Torbjörn Winqvist. The experiences gained through the studies for which he had methodological responsibility provided a very good basis for future development of VINNOVA's impact analyses. At various times, Joakim Appelquist, Lennart Norgren and Peter Stern led the work of developing VINNOVA's methods for impact logic assessment, monitoring, evaluation and impact analysis.

This report is in no way a final report on the work and should instead be considered a status report. There is much still to do. The method challenges are very great, as are the process challenges. Comprehensive work is ongoing to further develop all sections of the quality assurance of VINNOVA's ambition to generate major, measurable impacts on sustainable growth.

VINNOVA in February 2008

Göran Marklund
Head of Strategy Development Division

Abstract

Economic research shows that innovation is crucial to long-term economic development and growth. Research & Development (R&D) investment is investment in innovation and thus fundamentally important to the innovativity of companies, industries, regions and countries. Econometric studies also show a clear connection between R&D investment and economic growth. Furthermore, the research shows the general socio economic yield of R&D investment to be considerably greater than the private returns generated by investment in R&D and innovation.

The economic research into the connection between R&D, innovation and growth largely concerns the macroeconomic level and is generally based on statistical models of how the economy moves from one state to another. This research therefore provides limited knowledge on how the connection functions on the micro level and how the dynamic in these correlations appears. It thus also provides little guidance as to how R&D and innovation policy can and should be designed to generate the desired impact on sustainable growth in various countries and regions. The macroeconomic research should therefore be augmented with dynamic micro and mesoanalyses in order to achieve a good basis for policy development.

VINNOVA's task is to promote sustainable growth through funding of needs-driven research and the development of effective innovation systems. Innovation systems are an analytical perspective for understanding the dynamic connection between participants and factors influencing the volume, direction, results and impact of innovation processes. Since VINNOVA's operation aims to promote innovation and sustainable growth in Sweden, the innovation system perspective is the starting point for assessing the measures prioritised and implemented by VINNOVA.

Before commencing, VINNOVA's efforts undergo an impact logic assessment; they are monitored for their duration and are evaluated both whilst ongoing and at their conclusion. In addition, there is posterior evaluation of the efforts regarding what impact they have generated on sustainable growth in Sweden. This report shows how VINNOVA is working to develop a systematic approach and coherent processes to achieve this. An international expert panel has also been set up in that context.

Impact logic assessments are conducted before various initiatives are commenced. This means impact logic is designed and tested *ex ante*, or, in advance. Programmes and calls are subject to continuous **monitoring**. For ongoing efforts, that is to say programmes, calls and projects, the aim is to secure short-term outcomes for the efforts and provide an early indication of their impact on research, industry and the public sector. **Evaluations** are also conducted in close connection with implementation of various efforts.

Evaluations are normally carried out at the end of the programme, or *ex post*, and one or more occasions during ongoing efforts, known as *mid-term* evaluations.

Impact analyses are carried out so as to understand and learn from the long-term impacts on sustainable growth by VINNOVA's initiatives. These are often impacts resulting from more and broader efforts than those corresponding to individual programmes. Since the beginning of 2001 VINNOVA, has been working to develop methods and ways of working to carry out such impact analyses. Five have so far been conducted. These are unique in significant ways from an international perspective. The report summarises the impact analyses conducted so far and summarises the most important lessons from them in terms of content and methodology.

These are the most important lessons from the impact analyses so far conducted by VINNOVA:

- The analyses have broadened and deepened the understanding of the R&D which VINNOVA finances, how the R&D operation has proceeded and in what different ways the research has generated an impact in industry and society plus the research and innovation environments,
- R&D efforts are often a necessary, but far from adequate, condition for achieving a desired impact on sustainable growth. Additionally, other vital factors determine whether there will be innovation and whether it will be successfully utilised,
- Impacts are generated in continuous interactions between various actors. VINNOVA's impact analyses have highlighted dynamic player interactions and their development. The development logic in these interactions has proved largely specific for a number of innovation systems,
- A well-developed interaction between different actors owning different resources in an innovation system has proved extremely important in achieving important innovation impacts and major impacts on sustainable growth,
- In all likelihood, ongoing analyses will contribute to a broader general understanding of which types of impacts various R&D efforts can cause, including which mechanisms behind the successes are significant,
- The results of the analyses have proved valuable at policy level. Amongst other things, it has been possible to use them as supporting data in the work on the 2005 research proposal, in creating the VINN Excellence Center programme, and in establishing the SAFER safety centre, and
- Where it has been possible to study the complete context, VINNOVA's impact analyses show considerable impact in the form of increased competitiveness in Swedish industry and in establishing international Centres of Excellence in research and innovation.

Some of the strengths in the impact analyses are:

Problem-driven approach with clear perspectives. The problem which has been the focus of all impact analyses is how the impacts of various kinds of initiatives conducted by VINNOVA and its predecessors over a long period of time can be described and appraised.

Use of established theory and method. Another strength is that the various sub-analyses which jointly make up an impact analysis are based on accepted methods with a high level of legitimacy.

Multi-methodological approach. The three different methodological approaches, impact on research, industry and society respectively, are called for since these areas are very different in terms of their characteristics, structure and development logics. Depending on which field or system is being analysed, this has meant a number of different methodological approaches have been required in order to give a cohesive picture of the impacts.

Transparency. Naturally, the choice to mix different methods and source material in order to capture and appraise complex impacts connections can be criticised. For this reason it has been important to VINNOVA that the analyses which VINNOVA has commissioned others to conduct have been characterised by transparency concerning assumptions and procedures.

Contents

1 Introduction

VINNOVA's task is to promote sustainable growth through funding of needs-driven research and development of effective innovation systems. The activities which VINNOVA conducts in the form of programmes, projects and other operations are based on impact goals which begin with VINNOVA's task. VINNOVA should thereby make a clear contribution to Sweden's development into a leading country in terms of sustainable growth. Impact goals are operationalisations of the overall goal of promoting sustainable growth.

Research provides new knowledge, but it must be converted into innovations in order to contribute to sustainable growth. In effective innovation systems, new technology and new knowledge is generated, exchanged and used by actors in industry, academia and politics/the public sector, who interact to generate sustainable growth through innovations, i.e. successful new products, services and processes. In that context, one can say that research is the activities which convert money into knowledge and expertise, whilst innovation converts knowledge and expertise into money.

VINNOVA's operation aims to improve the interaction between research and innovation so that investment in research and development leads to more effective utilisation in the form of new goods, services and processes in industry and the public sector. Needs-driven research begins with needs in industry and the public sector. These may be customer needs, but also entirely different types of need within entirely new fields, or combinations of fields, which have growth potential. The research is conducted in collaboration between those actors carrying out the research work and those financing and seeking research results and research expertise, including scientific problem-solving methods.

The aim of VINNOVA's operation is to achieve increased impact on sustainable growth in Sweden from investment in research and innovation. Impact logic assessment, monitoring, evaluation and impact analysis are core elements of these ambitions. This report deals with VINNOVA's strategies and processes for impact logic assessment, monitoring, evaluation and impact analysis and has two main aims:

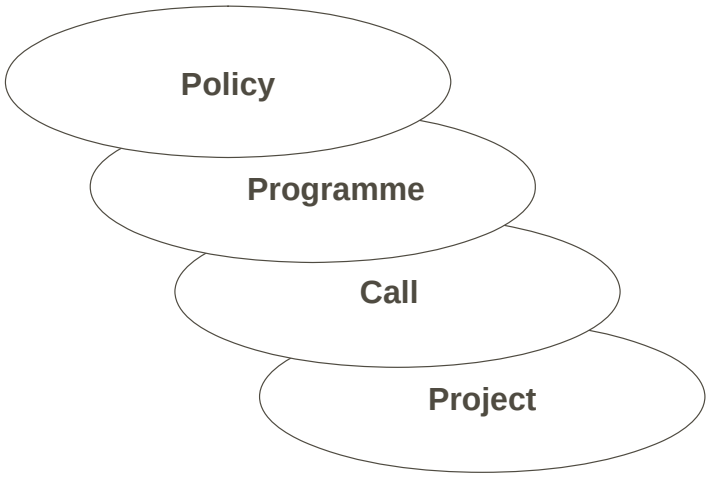
- Firstly, to describe how VINNOVA works to quality-assure strategies and processes so as to achieve impacts on sustainable growth from the R&D investment made by VINNOVA. In that context, four different types of analyses and processes are discussed which are part of such

quality assurance: impact logic assessment, monitoring, evaluation and impact analysis,

- Secondly, to provide a cohesive account of the content, output and lessons learned in VINNOVA's ongoing activity from the impact analyses VINNOVA has so far conducted. These impact analyses are unique in significant ways from an international perspective and have thus necessitated considerable methodological development, for both VINNOVA and the external experts who carried out the principal work.

Like most organisations, VINNOVA's operation can be described as a hierarchy of priorities and initiatives. VINNOVA's operation essentially comprises a four-level operational hierarchy, see Figure 1.

Figure 1. General operational hierarchy at VINNOVA.



Source: VINNOVA

Policy represents the fundamental principles of the operation, i.e. task, vision and overall goal. A **programme** is a goal-orientated plan for tangible initiatives within a field, for example specific innovation systems and fields of expertise or specific structural and player-related challenges. A programme may have more than one goal, often lasts several years and commonly generates several specific initiatives, usually in the form of calls. A **call** is a public announcement of the opportunity to obtain funds for activities which aim to contribute to various programme goals. Calls establish some or all of a programme's objectives. A call normally generates a number of projects. A **Project** is both a plan and a process for achieving certain results. A project always contains specific and tangible goals and has a clear beginning and end. VINNOVA co-finances the implementation of various actors' projects.

Since its formation in 2001, VINNOVA has greatly raised the level of ambition in relation to the activities upon which it was founded, in regard to

systematically monitoring, evaluating and analysing the impact of individual activities on R&D, innovation and sustainable growth.[1] This is in order to achieve:

- Improved opportunities for elucidating and reporting on the direction of VINNOVA's operation,
- Improved opportunities for securing socio economic impacts from VINNOVA's operation,
- Improved learning within VINNOVA through increased understanding of the operation, its impacts and impact logics, and
- Improved operational work at VINNOVA through administrators and management receiving good information on the development and impact of efforts.

To deepen the knowledge of how projects and programmes are developed, VINNOVA has intensified its efforts to clarify the impact goals which various efforts, programmes and calls are intended to achieve. This is being done with the support of Swedish and international research into the connection between research, innovation and growth. The aim of VINNOVA's raised ambitions is to develop a united outlook and cohesive processes for ways to evaluate anticipated impacts, monitor them during the programme and evaluation and eventually in a longer-term perspective (often between 10 and 20 years) measure and evaluate their impact on sustainable development.

Investment in research and development is investment in long-term development processes where the end results can not often be predicted in detail before the investment is made. In general, there is a long and variable delay between investment and impact. Implementing R&D investment aimed at effectively promoting innovation for sustainable growth thus requires a close interaction between VINNOVA and other actors and a deep and continuously updated understanding of how research and innovation processes are developed. This involves understanding how these processes affect and are influenced by the development of various research and innovation systems over time.

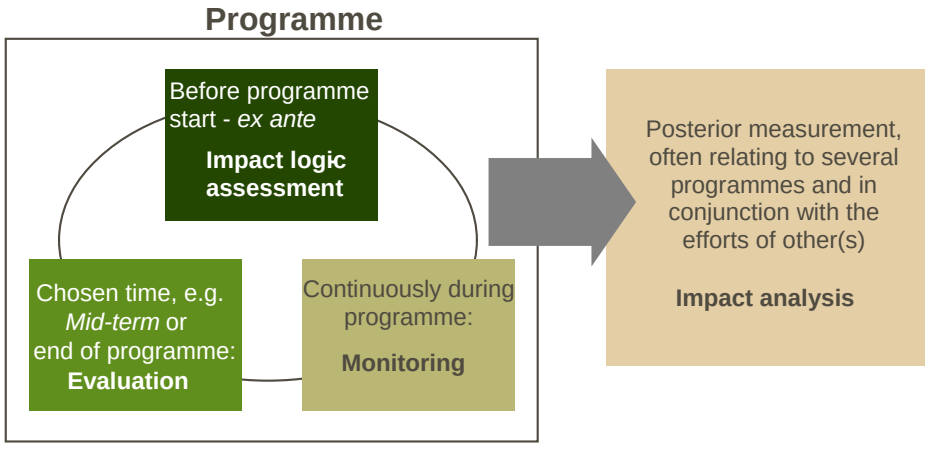
Companies and public bodies plus universities and institutes covered by VINNOVA's efforts are simultaneously affected by many other factors. These include such things as the development of business cycles, development of client companies, technical development (both in the particular field and in adjacent ones) and political decisions which may

[1] Marklund, G., Dreborg, G. & Appelquist, J., Strategi för ambitionshöjning av VINNOVAs effektanalyser [Strategy for raising ambitions in VINNOVA's impact analyses], VINNOVA, Strategy Development Division, 14/9/06.

either facilitate or hamper a desired development. What are known as attribution problems thus arise; that is, difficulty during evaluation of deciding what significance individual factors have had for observable results and impacts.

To effectively achieve impacts in innovation and sustainable growth through investment in research and development requires a cohesive strategy and organised processes with clear impact goals. That includes an understanding of the challenges in various innovation systems so that initiatives can be directed towards achieving the most important impacts. It also includes continuous monitoring of initiatives so that adaptations can be made as R&D and innovation processes are developed and different surrounding factors change. Furthermore, regular evaluations of completed initiatives are required in order to learn how different types of initiatives and working methods operate. Finally, an in-depth understanding of how R&D investment contributes to the development of innovation systems assumes that impacts and impact connections will be analysed using a time perspective, enabling the full impact to be studied and evaluated. In most cases, such analyses can only be made after a significant time has elapsed since the initiatives were implemented. VINNOVA's joint approach to impact logic assessment, monitoring, evaluation and impact analysis is illustrated in Figure 2.

Figure 2. VINNOVA's joint approach to impact logic assessment, monitoring, evaluation and impact analysis.



Source: VINNOVA

Before various initiatives are commenced, an **impact logic assessment** is carried out meaning that impact logic is designed and tested *ex ante*; i.e. an advanced description and judgement of what will be achieved and the likely route for getting there. This includes identifying desired and achievable results for programmes and calls and formulating impact goals for these; also, identifying indicators as a basis for determining whether the

programme and its projects are progressing towards their impact goals. Impact logic is thus used to design initiatives and processes leading ultimately to different results and impacts, including monitoring of whether these results and impacts are being achieved.

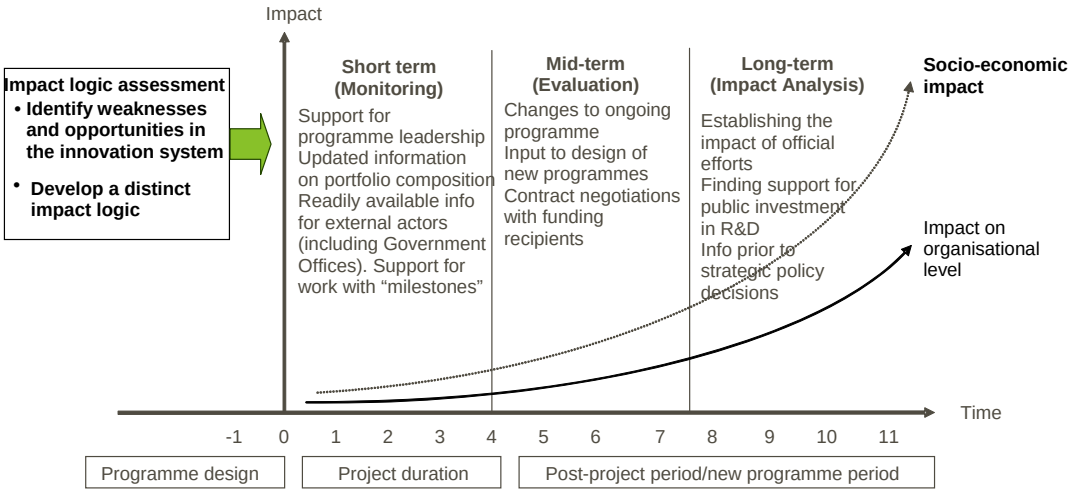
The programmes and calls which are started are then subjected to continuous **monitoring**. The aim is for ongoing programmes, calls and projects to secure short-term results in initiatives and give an early indicator of impacts on research, industry and the public sector. Thus, the monitoring is responsible for supporting the programme management and actors in VINNOVA's efforts. It also provides continuously updated information on the composition and development of VINNOVA's portfolio to VINNOVA's management, principals and other actors.

Evaluations are generally carried out in close connection with the implementation of various programmes. Evaluations are commonly carried out at the programme conclusion (*ex post)* or on one or more occasions during an ongoing programme (*mid-term*). Evaluations concentrate on clarifying whether the goals for the programme are or have been achieved, and on its functionality and effectiveness. The results of evaluations are used as basis for deciding on changes to ongoing programmes or as a starting point for the design of new programmes.

Impact analyses are conducted to study the long-term impact of sustainable growth. These are often impacts resulting from more and broader impacts than those corresponding to individual programmes. The impacts are studied on the basis of portfolios of various initiatives over a longer period, with the analysis including initiatives implemented by many different participants. They also often occur a long while after the conclusion of programme initiatives – occasionally up to 15-20 years later.

Figure 3 provides an illustration of how VINNOVA's overall initiatives to generate impacts and continuously develop and analyse the operation in this regard relate to different time perspectives in terms of investment, results and impacts.

Figure 3. Impact in different time perspectives.



Source: NIST

An international advisory board has been appointed in support of VINNOVA's ongoing work of developing the operation relating to impact logic assessment, monitoring, evaluation and impact analysis. This advisory board consists of nine leading international experts on corresponding activity in other countries.

Outline of the report

Firstly in the report, a summary (Chapter 2) is given of the research status regarding the connection between investment in R&D and economic growth, with the aim of placing VINNOVA's operation in a wider socio economic context. There is then a description of VINNOVA's overall strategy and processes for impact logic assessment, monitoring, evaluation and impact analysis (Chapter 3), followed by an account of the impact analyses VINNOVA has conducted (Chapter 4) and the conclusions and lessons deriving from them (Chapter 5).

2 Research in R&D, innovation and growth

Economic theories of R&D and growth

The macroeconomic literature on the impact of research and development is most usually based on economic growth models in which elasticity estimates [2] are made for different input factors. Having formerly viewed the technology factor as exogenously determined, modern growth analyses now examine technological change endogenously, i.e. within the model.[3]

According to what are known as endogenous growth models developed during the 1990s, human capital is viewed as an asset and growth factor in the same way as physical capital and labour. Human capital can consist of both formal knowledge and working experience.[4] An important aspect of knowledge is that it is not consumed when utilised, but rather can grow and spread to other parts of the economy, known as *spill-overs*. The basis for good growth thus lies in the investment taking place in training, research and technological development which in turn benefit the development of knowledge, expertise and innovative capacity in companies.

Another theory places more emphasis on understanding the economy's microprocesses; within the evolutionary growth theory, for example. In a major proportion of the macroeconomic research into R&D and innovation, the uncertainty which is present in all innovation processes is considered small or at any rate fully calculable,[5] whilst the evolutionary approach sees the uncertainty as great or "genuine". That means that in many cases, future output of R&D investment cannot be calculated in advance using normal economic analyses. Such strong uncertainty is particularly characteristic of pioneering or *radical*, innovations. For companies and other participants in economic systems, that means R&D investment is largely associated with a significant risk of failure from an economic point of view.

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[2] Elasticity states the estimated impact as a percentage change in growth for a 1% change in the input factor.
[3] Romer, P.M, "Increasing returns and Long-Run growth", *Journal of Political Economy*, 94, 1986, pp. 1002–1037, Romer, P.M, "Endogenous Technical Change", *Journal of Political Economy*, 98, 1990, 71–102, Romer, P.M, "The origins of Endogenous Growth", *Journal of Political Perspectives*, 8, 1994, pp. 3–22.
[4] Mankiw, N.G., Romer, D., Weil, D.N, "A Contribution to the Empirics of Economic Growth", *The Quarterly Journal of Economic Growth*, 1992, Vol. 107, no. 2, pp. 407–537
[5] Aghion, P. & Howitt, P. A "Model of Growth through Creative Destruction", *Econometrica*, 60, 1992, pp. 323–351.

Within the evolutionary theory, the existence and significance of radical innovations are emphasised and supplemented with gradual or incremental innovations. Radical innovations can appear in clusters and lead to wave-like growth progressions. The neoclassical, endogenous growth theory places more emphasis on the continuity of growth and does not assign radical innovations such a major role in the analysis.[6]

Another important aspect of evolutionary approach is that it deems the participants in an economy unable to manage the complexities of technology as rationally as neoclassical theory supposes, and instead applies rules of thumb in order to make decisions. Above all, they are guided by how other actors such as leading technology users behave, meaning that imitation plays an important role. Routines also play a central role.[7]

All in all, the evolutionary theory views economic growth as a process of renewal and choice, in which innovations give renewal and markets make choices. Elements such as Erik Dahmén's concepts of "complimentarity" and "development blocks" have been important within the theory; development blocks dealing with development and value creation relating to important innovations.[8] These development blocks can be related to structural cycles of around 40 years in length which have figured in the economy since at least the 1870s.[9]

Each cycle consists of a transformation period of 20-25 years, followed by a rationalisation period of 10-15 years. During the transformation phase, new companies are created and during the rationalisation phase, the companies become increasingly effective as competition stiffens. *General purpose technologies* (GPTs) comprise the core of the model, but this is supplemented by factors such as investment behaviour by companies and

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[6] Verspagen, B. "Innovation and Economic Growth, Fagerberg, J. Mowery, D. C. & Nelson, R. R. (ed.) *Handbook of Innovation*. Oxford, Oxford University Press: 2004

[7] Nelson, R. R. & Winter, S. G. *An Evolutionary Theory of Economic Change*, Harvard University Press: Cambridge, MA: 1982.

[8] Dahmén, E, *Svensk industriell företagsamhet. Kausalanalys av den svenska industriella utvecklingen 1919-1939 [Swedish industrial enterprise. A causal analysis of Swedish industrial development 1919-1939]*, Stockholm, the Research Institute of Industrial Economics: 1950, Dahmén, E. "Development Blocks in Industrial Economics", *The Scandinavian Economic History Review*, 36, 1988, pp. 3-14

[9] Schön, L. "Development Blocks and Transformation Pressure in a Macro Economic Perspective – a Model of Long-Cyclical Change". *Skandinaviska Enskilda Banken Quarterly Review* 1991, Schön, L. Industrial Crises in a Model of Long Cycles; Sweden in an International Perspective. From Myllyntaus, T. (ed.) *Economic Crises and Restructuring in History*. Stuttgart: 1998, Schön, L. *En modern svensk ekonomisk historia. Tillväxt och omvandling under två sekel [A modern Swedish economic history. Growth and transformation across two centuries]*, Stockholm, SNS: 2000, Schön, L., *Tankar om cykler, Perspektiv på ekonomin, historien och framtiden [Thoughts on cycles. Perspectives on economy, history and the future]*, Stockholm, SNS: 2006.

institutional changes. One difficulty with the evolutionary approach is that the impact of GPTs can seldom be tracked in aggregated growth figures or in total factor productivity (TFP), but there have been attempts to do this.[10]

Economic research into R&D and growth

A general conclusion from the research into the economic impact of R&D investment is that on average these generate an economic value clearly exceeding the investment cost. The main reason for this is that on the whole such investment generates major multiplier effects in the form of the lessons and imitation investment arising from the innovations the investment causes.[11]

Some empirical studies indicate that the average multiplier effect, through something known as spill-over, may be greater than 10.[12] It is also clear from the research that the societal yield of R&D investment is generally several times higher than the private one.[13]

Commissioned by VINNOVA, Ejermo et al,[14] researchers at CIRCLE, one of the nationally eminent centres investigating research as well as innovation and growth, conducted a literature review of the economic research into the connection between R&D and growth.

Their summary shows a positive connection between total R&D and growth. A survey of studies on a corporate level show the total societal return at the margin to be 90-100%, whilst the private return is only 7- 69%. This relatively major discrepancy between the private and societal returns justifies official support for R&D.

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[10] Craft, N. "Social Savings as a Measure of the Contribution of the New Technology to Economic Growth", *Working papers in Large-Scale Technological Change.* London, London School of Economics: 2004, Oliner, S. D. & Sichel, D. E., "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?", *Journal of Economic Perspectives,* 2000, 14**,** 4.

[11] Baumol, W. J., *The Free-Market Innovation Machine – analyzing the growth miracle of capitalism*, Princeton University Press, New Jersey: 2002.

[12] Coe and Helpman, "International R&D spillovers", *European Economic Review*, 1995, 39(5), pp. 859-887, Guellec, D. and van Pottelsberghe de la Potterie, B, *R&D and productivity growth: panel data analysis of 16 OECD-countries*, OECD, 2001, STI, Working Papers, no. 2001/3, Paris, OECD, *Links between policy and growth: cross-country evidence*, OECD Economic Outlook no 68, 2000, pp.133-154, Bassanini, A., Scarpetta, S. and Hemmings, P., *Economic growth: the role of policies and institutions. Panel data evidence from OECD countries*, OECD, Economic Department Working Papers, no. 283, 2001, Paris.

[13] Baumol, W. J., *The Free-Market Innovation Machine – analyzing the growth miracle of capitalism*, Princeton University Press, New Jersey: 2002, Wolff, E.N., *Spillovers, Linkages and Technical Change*, Economic Systems Research 9, 1997, 9-2.

[14] Ejermo, O., Enflo, K. and Kander, A., *Offentlig forskning och utveckling och tillväxt [Public research and development and growth]*, Lund: CIRCLE: 2006.

For radical innovations which are widely dispersed in society, the growth impacts can be extremely great. If government policy can contribute to the growth of radical innovations, there is a very strong argument for profitability in such activity. There is also support in the research for large-scale, radical technological shifts to then come about without official involvement.[15]

Nevertheless, the research shows that positive growth impacts assume careful design of R&D support. One cannot expect all support to automatically give a positive return. Ejermo et al thus emphasise the importance of continuously evaluating government innovation efforts at corporate level using quantitative methods.

The public sector's capacity to generate new scientific and technological results commonly exceeds the private sector's capacity and interest in using them. According to Ejermo et al, innovation-facilitating organisations such as VINNOVA should fulfil two functions above all: strongly linking official research and private industry and bridging the gap between operations which are run due to scientific interest and those run due to commercial interest. There are four requirements for successful innovation-facilitating organisations: high levels of expertise in science, technology and commerce; independence and focus; strong bonds with companies, universities and state; and reliable funding.

From a policy perspective, it is of great importance to note that as a rule, radical innovations normally come about through some form of official initiative and support. Case studies from a number of significant technological fields show that large-scale radical technological shifts seldom come about without official involvement, and that public procurement plays a major role along with publicly-funded R&D.[16]

In the growth research which has developed around R&D and innovations, a consensus has been established that innovations have a significant impact on productivity at corporate, sector and national levels. This applies regardless of whether there is investment in R&D, patenting or other new innovations in order to estimate innovativity. Estimates of the impact of R&D on

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[15] Ejermo, O., Enflo, K. and Kander, A., *Offentlig forskning och utveckling och tillväxt [Public research and development and growth]*, Lund: CIRCLE, 2006.

[16] Mowery, D. C., "National security and national innovation systems". Paper presented at the PRIME/PREST workshop on Re-evaluating the role of defence and security R&D in the innovation system, University of Manchester, September 19 – 21: 2005, Edqvist, C. & Chaminade, C., "Rationales for public policy intervention from a systems of innovation approach: the case of VINNOVA". Electronic Working Paper Series. Lund: CIRCLE: 2006, Carlsson, B. & Jacobsson, S. (ed.), *In Search of Useful Public Policies: Key Lessons and Issues for Policy Makers*, Dordrecht, Kluwer Academic Publishers: 1997.

research has shown that a 1% increase in R&D gives an average of 0.05-0.1% of the growth in total factor productivity. The societal yield from R&D has also proved significant; 20-50% and often considerably greater than the private yield.[17]

In addition to the macroeconomic studies which have been conducted, there are also studies of productivity impacts coming from R&D on a corporate level. One study of French companies shows that the ratio between investment in R&D and patent outcomes is virtually 1:1. The same study also shows that an increase of 10% in R&D gave an increase of 5% in innovations coming out on the market.[18] In a survey of results from several studies, it is clear that both the impact of investment in R&D on productivity and spill-overs is significant amongst companies investing in R&D. Nevertheless, the elasticities vary between different sectors of industry which implies that efforts will give different impacts.[19] The research thus shows that the impact of productivity from R&D investment looks different for different sectors, technological fields and stages of development.[20]

There are also other explanations for government efforts over and above the impacts coming from the results of R&D investment. Based on the assumption about market failure and underinvestment in R&D, the majority of OECD countries have implemented public efforts over a long period to stimulate R&D investment in companies. The impacts which these efforts are expected to bring about are receiving significant support both theoretically and empirically.[21]

The macroeconomic and econometric studies of efforts in R&D support the idea that the types of efforts which VINNOVA is making are important from a growth point of view. However, the macroeconomic and

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[17] Cameron, G., *Innovation and Growth: a survey of the empirical evidence*, Nuffield College, Oxford, July 1998, Ali-Yrkkö, J. *Impact of Public R&D Financing on Private R&D Does Financial Constraint Matter?* ENEPRI Working Paper No. 30/February 2005. Comment: the growth in total factor productivity gives a better picture of differences in technological levels between different countries and technological development than the growth in the labour productivity or GDP per capita (Erixon, L. *Nationalekonomins syn på tillväxtens bestämningsfaktorer [The national economy outlook on factors determining growth]*, Department of Economics, Stockholm University: 2002).

[18] Crepon, B., Duguet, E., Mairesse, J., "Research, innovation and productivity: an econometric analysis at the firm level", *Economics of Innovation and New technologies*, 1998, Vol. 7, pp. 115–158.

[19] Wieser, R., "Research and development productivity and spillovers: Empirical evidence at the firm level", *Journal of economic surveys*, Vol. 19, no. 4, pp. 587–621.

[20] Wieser, R., "Research and development productivity and spillovers: Empirical evidence at the firm level", *Journal of economic surveys*, Vol. 19, no. 4, pp. 587–621.

[21] Lööf, H, Hesmati, A., "The Impact of Public Funding on Private R&D investment. New Evidence form a Firm Level Innovation Study", Stockholm: CESIS, Working Paper no. 06.

econometric models are generally based on aggregated datasets. Essentially, the interpretation of the results in this research provides knowledge about the average changes in growth which can be expected from a given volume increase in R&D investment.

Despite considerable progress in understanding the connection between R&D and innovation and growth, the national economic research provides very little guidance on which types of R&D investment the state should make and the R&D incentives which should be present, or how these should be designed. This is true for the majority of the efforts being made, but it has also proved hard to measure the output of different efforts in the same way.

The output of efforts in technology which are at an early developmental stage can provide new technology which, if successfully commercialised, can also attract investment. If the aim of these efforts is to develop new scientific knowledge or technology which can be protected, then patents or other intellectual property rights can be studied. Innovations which can be linked to pure sales may be seen as an anticipated outcome if the purpose of the efforts is to bring forth new or improved products or processes on definite markets. [22]

The design and aim of R&D investment and R&D incentives plays an important role in what impact is generated. VINNOVA's operation must therefore pay close attention to the specific circumstances and motivators which are important to the development of various fields. Different methods and approaches are thus needed to measure and understand the impact of R&D and how this can be generated, as these look different in different parts of the economy and at different stages of technological development.

Since VINNOVA's programme always targets actors on the micro level, it is important to evaluate both the design and volume of the efforts for impact logic assessments, monitoring, evaluations and impact analyses. Important impacts may relate to the removal of various "system failures" or weaknesses in innovation systems by addressing certain actors or contributing to the development of certain interactions and thereby achieving events which would otherwise not occur.

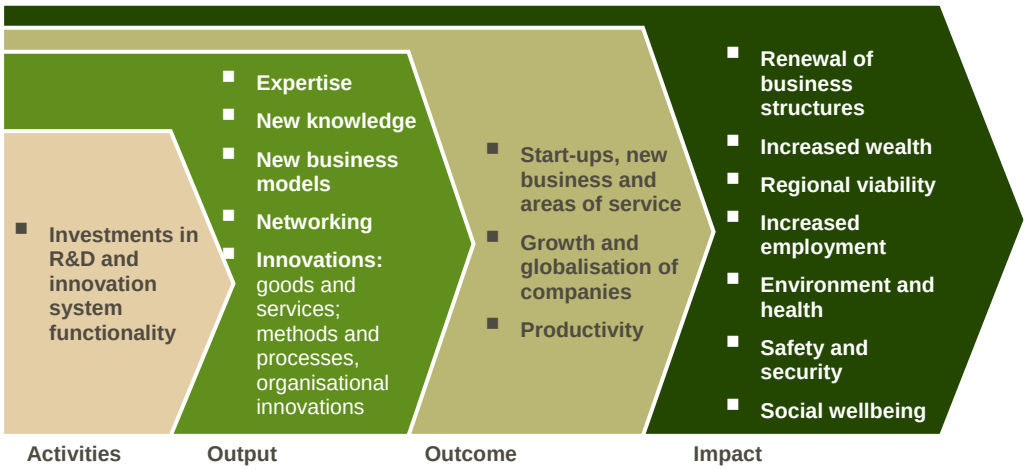
OECD studies show that several of the companies receiving state support for R&D stated that they would not have carried out their project had they not had public funds. Those projects which were started were generally also more challenging in nature. Most companies evaluated by OECD stated that

[22] Branscomb, L.M., Kodama, F. and Florida, R., *Industrializing Knowledge. University linkages in Japan and the United States*, MIT-press, Cambridge Massachusetts, 1999.

their projects would have had lower ambitions and been less technically challenging than normal R&D projects, had they not received state funding.[23]

Important impacts may also entail enabling actors in information systems to gain stronger incentives for seeing and taking innovation opportunities; often associated with great uncertainty and risk. In that context, it is important to understand and evaluate the dynamic of innovation systems, where the introduction of innovations not only changes the offering but also contributes to that dynamic and to "creative destruction", which is an essential condition for growth.

Figure 4. Principal impact logic in VINNOVA's efforts.



This figure is strongly inspired by TEKES in Finland

The figure should not be interpreted to mean that the actual processes behind the schematic connection in the figure are linear. On the contrary, innovation processes normally involve many reversals and blind alleys. Nevertheless, the figure outlines the fundamental perspective for the type of impact goals VINNOVA has for its efforts.

Additionality – different results and impacts

The evaluation literature talks about additionalities of R&D efforts. An overall definition of the concept of additionality includes the results and impacts arising as a result of public initiatives. It relates to the distinctions which a policy initiative makes. Through innovation policy efforts, the concept of additionality has gained a deeper significance associated with the dynamic and systemic nature of the innovation system. Additionalities are

[23] OECD, *Government R&D Funding and Company Behaviour*, OECD: 2006.

normally divided into three main types: output additionality, input additionality and behavioural additionality.[24]

Output additionality

Output additionality is related to outcomes in the form of results and impacts associated with public efforts. The output may be in the form of an increased number of scientific publications, more patents, more prototypes, new business plans and new goods or services. Impacts can be increased turnover, an increase in value added, more jobs, increased productivity and increased exports.

In Germany and Finland, it has been possible to establish a positive influence on companies' inclination to apply for patents when they received public funds, compared with companies who did not receive funding.[25] In Austria, the impact of state support on increased direct sales from product innovations has been measured at 2.7 percentage points, additional to the 0.7 percentage points from the indirect impact of R&D efforts. The total impact on sales by state support amounted to a 3.3 percentage point increase compared with when companies did not receive support.[26]

It has also been possible to measure direct productivity impacts. For a group of companies in an Austrian study, a 10% increase in public R&D efforts led to productivity increases of half a percentage point per employee over the succeeding two years.[27] Several Finnish studies indicate a number of different impacts on the actual productivity of Finnish public R&D efforts.[28]

Input additionality

Input additionality means that the public efforts lead to companies investing more in R&D than they otherwise would do. Various studies have shown important input additionalities from both finance policy incentives and direct initiatives to stimulate R&D efforts in the OECD countries in general.[29] One estimated impact in Germany shows increases of up to 4% in corporate innovation activity where there is public funding, compared with

[24] Georghiou, L. *Impact and Additionality of Innovation Policy*, Brussels: 2002.
[25] *European Competitiveness Report*, 2004, Czarnitzki, D., Fier, A. "Publicly Funded R&D Collaborations and Patent Outcome in Germany", ZEW Discussion Paper No. 03-24, 2003.
[26] Garcia, A., Mohnen, A., *Impact of Government funding on R&D and Innovation*, base data report for European Competitiveness Report, 2004, http://www.eco.uc3m.es/IEEF/Mohnen.pdf.
[27] Falk, M. "Productivity effects of R&D subsidies: evidence from Firm-level panel Data", TIP Working Paper, OECD, Paris 2004.
[28] http://www.tekes.fi/eng/publications/B_tekes/Results.PPT.
[29] http://www.tekes.fi/eng/publications/B_tekes/Results.PPT.

companies which did not receive public funding.[30] Other studies show estimates of the impact of one Euro invested in R&D efforts indicating an outcome in increased private efforts of between EUR 0.40 and 0.93.[31]

According to a study by Rahel Falk, Austrian companies as an example tended to increase their resources for innovation and R&D in direct connection with receiving public support.[32] In Sweden, Lööf and Hesmati showed how public funds helped increase the total R&D efforts in small Swedish companies.[33] Not only direct funds but also R&D subsidies of various kinds generally have a similar impact, provided they are well designed.[34]

We may also add the various kinds of *threshold effects* to the list of dynamic impacts. The incidence of threshold effects means that a certain level of investment is required and thus also public efforts in order to reach a critical mass in certain development processes. Where it concerns *ex ante* assessments and planning for evaluability in potential products, it is necessary to identify and estimate as far as possible the level of thresholds in order to guarantee that sufficient resources can be brought to bear. In addition, adequate tuning points must be planned *mid-term.*

Occasionally, criticism is levelled at public efforts which, it is claimed, generate crowding out. German studies show no observable crowding out, but it seemed there was a link between the impact at effort level and which

[30] Almus, M., Czarnitzki, D., *The effects of public R&D subsidies on firms' innovation activities in a transition economy: the case of Eastern Germany*, Mannheim: 2001.
[31] *European Competitiveness Report 2004,* Ali-Yrkkö et al, "Does patenting increase the probability of being acquired?: evidence from cross-border and domestic acquisitions", Helsinki: 2004, Streicher, G., Polt, W., "Trying to capture additionality in Framework Programme 5 - main findings", *Science and Public Policy*, Vol. 32, no. 5, 2005, Guillec, D., van Pottelsberghe, B., "The impact of public R&D expenditures on Business R&D", *Economics of Innovation and New Technologies*, Vol. 12, no. 3, 2003, pp.225–244, Lach, S. "Do R&D Subsidies Stimulate or Displace Private R&D? Evidence from Israel", NBER Working Paper, no.7943, 2000.
[32] Falk, R., "Measuring the Effects of Public Support Schemes on Firms' Innovation activities", WIFO working papers, no. 267, January 2006.
[33] Lööf, H., Hesmati, A. "The Impact of Public Funding on Private R&D investment. New Evidence from a firm Level Innovation Study", Stockholm: CESIS, working paper no. 06, 2005.
[34] Falk, M., "Productivity effects of R&D subsidies: evidence from Firm-level panel Data", TIP Working Paper, OECD, Paris 2004, Gonzales et al, "Barriers to innovation and subsidy effectiveness", mimeo.

technological fields were affected.[35] In the corporate sector, public efforts led to an acceleration in R&D efforts.[36] There were similar results in studies from Spain and Austria, where no significant crowding out was observable either.[37] In the Netherlands, it was found that, of 10 innovation cheques handed out, eight were used for projects which otherwise would not have taken place. In a Belgian study, R&D subsidies did not appear to create crowding out.[38] In most cases, well-designed public efforts add to private investment so that significant crowding out does not arise.[39] However, the design of the efforts is crucial to the results.

In the political decisions taken by government and parliament; in the regulation and deregulation carried out by official bodies and participants; in the procurements and standardisations to which public bodies contribute and in the efforts made by VINNOVA and other R&D funding bodies, it is always important to evaluate how decisions and activities affect incentives to invest in R&D and innovation. This must always include an avoidance of generating crowding out. Instead, the emphasis should be on finding complementarities and catalytic interactions.

This does not merely mean evaluating how to avoid crowding out. At least equally as important is evaluating how politics and policies can generate positive motivators for R&D and innovation and thereby contribute to additionalities. This also includes the fact that absence of public demand and initiatives for R&D and innovation *de facto* create negative incentives for R&D and innovation. Thus, in reality, crowding out is created by innovation investment, benefiting more short-term investment. This being the case, long-term growth is inhibited. It is therefore crucially important to the prospect of creating sustainable growth that such policy is based on understanding of the economy's long-term dynamic renewal processes.

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[35] Czarnitzki, D., Fier, A., *Do innovation subsidies crowd out private investment?: evidence from the German service sector*, Mannheim: 2002, Czarnitzki, D., Fier, A., "Publicly Funded R&D "Collaborations and Patent Outcome in Germany", ZEW Discussion Paper No. 03-24, 2003, Hussinger, K., *R&D and subsidies at the firm level: an application of parametric and semi-parametric two-step selection models*, Mannheim: 2003, http://www.tekes.fi/eng/publications/B_tekes/Results.PPT.

[36] http://www.tekes.fi/eng/publications/B_tekes/Results.PPT.

[37] Falk, M., "Productivity effects of R&D subsidies: evidence from Firm-level panel Data", TIP Working Paper, OECD, Paris 2004, Gonzales et al, "Barriers to innovation and subsidy effectiveness", mimeo, 2004.

[38] For a summary, see http://www.tekes.fi/eng/publications/B_tekes/Results.PPT.

[39] Duguet, E., "Are R&D Subsidies a Substitute or a Complement to Privately Funded R&D. Evidence from France using Propensity Score Methods for Non-experimental data", working paper, Maison des Sciences Economiques, Universite de Paris I, 2003.

Behavioural additionality

Behavioural additionality means that the public efforts lead to changes in behaviour amongst companies and other actors. In most cases, these changes involve increases in the size, risk level, time consumption and quality of a R&D project. Such changes in behaviour may mean companies start riskier projects, commence projects earlier and implement them with more speed than if they had not received external funding. It also means companies can increase the size of projects and thereby get over critical "thresholds", as well as implementing projects with greater technical ambitions for example, or on an elevated level of research.

Behavioural additionality can also be achieved in the form of influences on various capacities within companies, such as increased capacity to implement innovation processes, increased technological expertise, increased business expertise and companies getting better at making strategic choices and holding projects together and running them. It can also lead to increased and improved collaborations with other actors, enabling better utilisation of external resources in networks or partnerships. Companies may also be able to make changes which affect the organisation of projects and their results, which means forming new units in companies to manage R&D in ways that had not previously been done.

In the Netherlands, SenterNovem has demonstrated that innovation cheques have been used there to reach out to a new group of companies. As much as 40% of cheque recipients had not previously been in contact with SenterNovem and 83% had not previously taken advantage of specific innovation programmes. This indicates a high level of behaviour-related additionality. Estimates have shown that 80% of the knowledge exchange would not have occurred had there been no public effort.[40]

In Austria, it has been established that public funding programmes increased the will of those involved to enlarge their collaboration and also get involved in more risky projects.[41] In Germany, it has been observed that the length of R&D projects increased through public efforts. The efforts also led to the creation of more lasting forms of collaboration.[42] In the US, it appears that public R&D efforts impact positively on the risk level of projects, in their scope and technological level, for both projects and collaborations on commercialisation prospects.[43] Over and above the positive effect on size and scope of projects, it has also been substantiated that innovative capacity

[40] http://www.tekes.fi/eng/publications/B_tekes/Results.PPT.
[41] Falk, R., "Measuring the Effects of Public Support Schemes on Firms' Innovation activities", WIFO working papers, no. 267, January 2006.
[42] http://www.tekes.fi/eng/publications/B_tekes/Results.PPT.
[43] http://www.tekes.fi/eng/publications/B_tekes/Results.PPT.

and competence-building increased in companies.[44] Other impacts have been public R&D programmes enabling companies to be increasingly receptive to advanced technology, particularly in companies which were not using this technology when the programme started.[45] An influence on the dissemination of knowledge, collaboration and increased commercialisation are other impacts which have been observed in the US amongst other places.[46]

Conclusions

Research into the economic impacts of R&D investment have shown that on average, these generate an economic value clearly exceeding the cost of this investment on the national, sector and corporate level. The research also shows that positive growth impacts require careful design of R&D support and that the direction of R&D investment in R&D incentives plays a major role in what impacts are generated.

Studies of state R&D programmes in the OECD field have indicated positive impacts in the form of what are termed additionalities. For example, companies are investing more of their own capital in R&D than they would have done had they not received state support. It also appeared that projects were being conducted at greater speed, at greater technical risk and at a higher research level than if they had not received subsidy. No crowding out was observed either.

The design of the studied programmes has differed, meaning that this must also be included in the calculations of desired impacts. The initiatives which have been studied were direct grants for R&D as well as various subsidies and tax incentives.

From this, the following conclusions can be drawn regarding VINNOVA:

- Design of initiatives and choice of targets groups can, over and above the volume of initiatives, be of great significance to which impacts are achieved and how major they are,

[44] Falk, M., "Productivity effects of R&D subsidies: evidence from Firm-level panel Data", TIP Working Paper, OECD, Paris 2004.
[45] Arvantitis et al, "The effectiveness of Goverment Promotion of Advances. Manufacturing Technologies (ATM): An Economic Analysis Based on Swiss micro data", *Small Business Economics*, Vol. 19, 2002, pp. 321–340.
[46] Feldman, M.P., Kelley, M.R., "How States augment the capabilities of Technology - Pioneering firms", *Growth and Change*, Vol. 33, no. 2, 2002, pp. 173–195 and Feldman, M.P., Kelley, M.R., "Leveraging Research and Development: Assessing the Impact of the U.S. Advanced Technology Program", *Small Business Economics*, Vol. 20, no. 2, March 2003, pp. 153–165.

- Choice of initiatives should therefore be underpinned with existing knowledge on the impact of R&D efforts, and
- In addition to existing knowledge, VINNOVA should also build up a system of measuring results and impacts of the R&D efforts.

By using existing experiences from other areas combined with the experiences and knowledge which can be taken from its own programme activity, VINNOVA's activity can be developed in a direction which facilitates future impact measurement. This will also form a basis as to how VINNOVA can improve at achieving desired impacts.

3 Impact logic assessment, monitoring, evaluation and impact analysis

Economic and social systems are characterised by a major dynamic and a great many direct and indirect links between actors, markets, funding sources, rules of play, infrastructures, technologies and competences. A prerequisite for quality in public initiatives is thus an understanding of the dynamic in the systems they affect. Innovation represents important processes in all economic and social systems, since it relates to activities whose results renew and transform economy and society.

An innovation system is an analytical perspective for understanding the dynamic connection between the actors and factors influencing the volume, direction, results and impact of innovation processes. Since VINNOVA's activity aims to promote innovation and sustainable growth in Sweden, the innovation system is the starting point for evaluating the initiatives which VINNOVA prioritises and implements.

VINNOVA's foresight, analyses and evaluations thus proceed from questions as to how VINNOVA's initiatives can be evaluated in regard to its future, ongoing and historical impact on the innovation systems influenced by those initiatives. This sets a high bar for methods to analyse and understand developments in complex systems focusing on innovation and sustainable growth. Romanainen (Tekes) describes the problem by the following metaphor:

> *"Understanding the complexity and dynamics of innovation systems and processes and targeting them with a portfolio of policy measures is like trying to hit a continuously changing set of moving targets with an arsenal of weapons. The challenge is to hit as many targets as possible at the right time and with as few weapons and ammunition as possible. Hitting targets with the minimum ammunition requires that several weapons deliver their ammunition to the same target at the same time. It is important that the arsenal is up to date, because old weapons are in many cases ineffective towards new targets. Building big and expensive weapons and ammunition might ensure that current targets can be hit, but might lead into lock-in problems, because big expensive weapons are arduous to update and dismantle. Policies should therefore be based on a mix of*

relatively small number of well designed basic schemes, which are flexible and can be easily re-targeted in case the set or characteristics of identified systemic failures change."[47]

Innovation activity is generally characterised by greater uncertainty and thereby greater risk than other economic activities. The consequence of this is that behind every programme aiming to support innovative activity, there must be an understanding of the fact that, taken individually, a large proportion of the efforts will not result in major economic impacts. Boekholt *et al* (2001) expresses this as follows:

"Decreasing the high threshold for companies and organisations to enter into high risk innovation trajectories is, by definition, a policy domain which brings an expected level of failure. […] So innovation policy should leave some room for experimentation and calculated failures."[48]

In order to evaluate public initiatives aimed at promoting innovation, it is therefore necessary for the primary focus to be on the combined impacts of public efforts. In other words, a *portfolio approach* needs to be applied, in which all the projects and activities initiated and influenced by public initiatives are included in the analysis.[49] A one-sided focus on individual projects and events risks leading to incorrect conclusions as to the impact and effectiveness of various public initiatives.

In portfolio analyses and portfolio evaluations, the focus is on the results and impact of entire portfolios of projects and activities. The endeavour should be to contribute to a good balance in the composition of various initiatives (*the portfolio*) thus achieving a well-balanced distribution between risk and potential. A portfolio approach can be used by various actors and on various levels in innovation systems. What are the priorities like on a national level when it concerns supporting various efforts and actors? Should regional actors distribute funds between specific and general measures? Should the programme structure be changed within an authority's area of responsibility so as to better match future challenges? What is the make-up of projects in an ongoing programme?

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[47] Romanainen, J., (2004), Learning more from evaluations – the use of thematic approach and impact modelling in evaluating public support measures. Paper presented at "Research and the Knowledge-based Society: Measuring the Link", Galway, NUI, May, 2004: 2-3.
[48] Boekholt, P., Lankhuizen, M., Arnold, E., Clark, J., Kuiisto, J., de Laat, B., Simmonds, P., Cozzens, S., Kingsley, G., Johnston, R., *An international review of methods to measure relative effects of technology policy instruments*, 2001.
[49] OECD, *Policy Evaluation in Innovation and Technology*, Paris: 1998. OECD, *Small and Medium Enterprise Outlook*. Paris: 2000.

To effectively achieve impacts on innovation and sustainable growth through investment in research and development requires a cohesive strategy and organised processes focusing on impact. This includes an understanding of the challenges in various innovation systems so that initiatives can be directed towards achieving the most important impacts. It also includes continuous monitoring of all initiatives so that adjustments can be made as R&D and innovation processes are developed and different surrounding factors change. Regular evaluations of initiatives carried out are also needed in order to learn lessons about what type of initiatives and working methods are effective.

Finally, an in-depth understanding of how R&D investment contributes to developing innovation systems assumes that impacts and impact relationships will be analysed in a time perspective where the full impacts can be studied. In most cases, such analyses can only be made after a significant time has elapsed since the initiatives were implemented. The rest of this chapter describes VINNOVA's overall initiatives for impact logic assessment, monitoring, evaluation and impact analysis.

Impact logic assessment

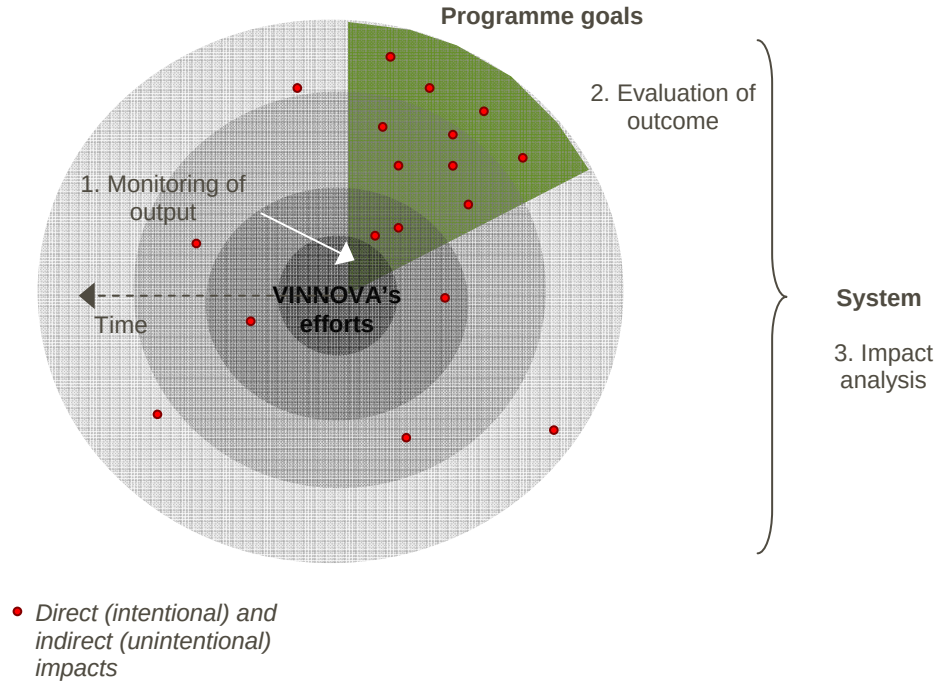
The efforts which VINNOVA conducts in the form of programmes, calls and projects can provide many different types of results and impacts. Furthermore, they can appear in more or less proximity to the time that programmes are implemented. What is to be achieved in them is framed in advance in the form of long-term impact goals. In the shorter term, the activity is expected to lead to results in the form of things like "attractive environments for academia and industry", "new networks for researchers and commercial actors", "increased mobility between industry and academia", "a more effective infrastructure" or "new incentive structures". Slightly different types of targets are "increased involvement from commercial actors", "increased investability in research" and "a more effective seed-finance market", plus goals like "increased participation in international R&D programmes", "strong international competitiveness for industrial partners" or "interaction between industry and society".

In general, the programme goals relate to a limited section of one or more innovation systems, or participant structures in one or more innovation systems. In addition, a programme effort often gives rise to a number of impacts over and above those directly intended, which in various contexts are normally called indirect, secondary or external impacts. It is therefore important in framing a programme's goals and determining its initiatives, to carefully ensure that external impacts do not negatively influence the overall development. However, it is more often the other way round, with external

impacts further strengthening the direct impact of various initiatives in a positive direction. Evaluating how the probabilities appear in this regard is an important part in every design of VINNOVA's initiatives. How direct and indirect impacts relate to each other is illustrated in Figure 5.

Time is indicated in the figure with an arrow from the centre to the periphery. An effort starts in the middle of the figure. The coloured circle segment indicates the extent of the programme goals, i.e. what is achieved by its activity. The rest of the circle represents the remaining development, which is independent of what is done in this particular programme. To illustrate the rationale, the figure compiles 18 envisaged impacts. Of these, 11 are in the coloured section. These may be regarded as intentional, i.e. a direct consequence of VINNOVA's initiatives.

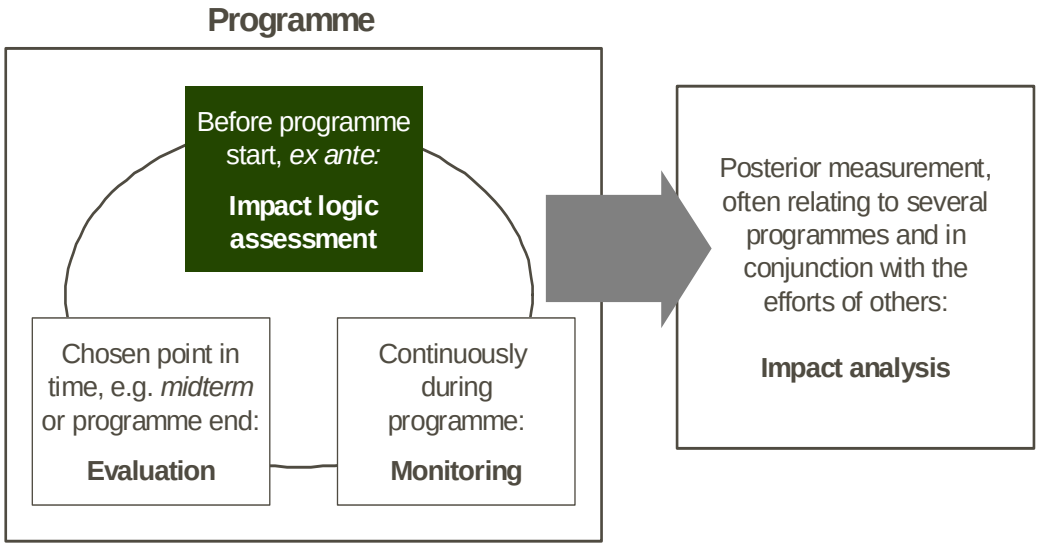
Figure 5. Direct (intentional) and indirect (unintentional) impacts resulting from VINNOVA's programme initiatives.



Source: VINNOVA

An impact logic assessment means designing and testing impact logic *ex ante*, that is to say in advance, before a VINNOVA programme starts. This is the same as describing what should be achieved and what the route there is expected to be like. Consequently, this includes identifying programme results and impacts as well as indicators to show that the programme is moving towards its impact goals. An impact logic rationale can thus be used to design initiatives and a process prospectively leading to a number of overall impacts and also comprising processes to investigate whether and how they are achieved, as in Figure 6.

Figure 6. Impact logic assessment in VINNOVA's efforts.



Source: VINNOVA

Ex ante assessments are analyses conducted prior to implementation of all public initiatives. Based on a process perspective, the most important task at this stage is to ensure that the initiative in question can be evaluated and that the evaluation generates policy-relevant information. Another purpose of *ex ante* assessments is to act as an aid in the process of going from generally framed political wishes to selecting (*selective function*) and influencing the design of the projects and programmes which are to receive public support (*formative function*).

In order to estimate the actual impact on the social economy of a given initiative, it is not enough to identify and evaluate a project's results (*output*). A more complete evaluation of the more long-term impacts of a public initiative also assumes formulation, inspection and monitoring of impact goals. Examples of impact goals may include an increased proportion of the knowledge-intensive companies' share of GDP, increased employment and growth, increased absorption capacity for new innovations and a strengthening of innovative activity amongst participating companies. Due to the shifting nature of the efforts implemented in the innovation policy arena, it is difficult to determine exactly which characteristics of results and impact goals are most suitable.

A general recommendation is to always ensure that results and impact goals meet what are known as the SMART criteria (***S**pecific, **M**easurable, **A**chievable, **R**elevant, **T**ime-bound*) presented below. Alongside each

criterion are brief comments relating to the challenges the criterion faces when a system perspective is applied.[50]

- **Specific.** In order for a goal to be usable, it must be so specific that it can be determined whether the initiative carried out has caused the anticipated impacts or not. Formulation of specific goals is hampered by a system perspective, since in most cases this means the number of variables assumed to affect the outcome is greater. However, this increased complexity does not mean that less specific goals can be accepted, but rather that more resources must be added to this stage of the policy and evaluation process.
- **Measurable**. Another important aspect is that goals are framed so as to be measured and evaluated both in terms of quantitative and qualitative variables. In cases where it is difficult to design and collect absolute measurements, methods should be developed instead to express relative changes, i.e. increases and reductions. Since this relates to measurability, application of a system perspective chiefly hampers the possibility of measuring causal connections between initiative and results.
- **Achievable.** If setting up goals is to be meaningful, it is important that these are well considered so that they are neither achieved too simply nor are obviously unrealistic. Again, what hampers the formulation of achievable goals in the system perspective is the fact that the volume of variables affecting the outcome is great, which makes an *ex ante* assessment more difficult.
- **Relevant.** This criterion indicates the significance of a clear agreement between the overall goals and the fixed operational goals.
- **Time-bound.** All initiatives must be designed so as to set out time constraints within which some type of result must be observable. The complexity and uncertainty which characterises innovation processes hampers predictions as to the time horizon for the impacts of innovation policy initiatives.

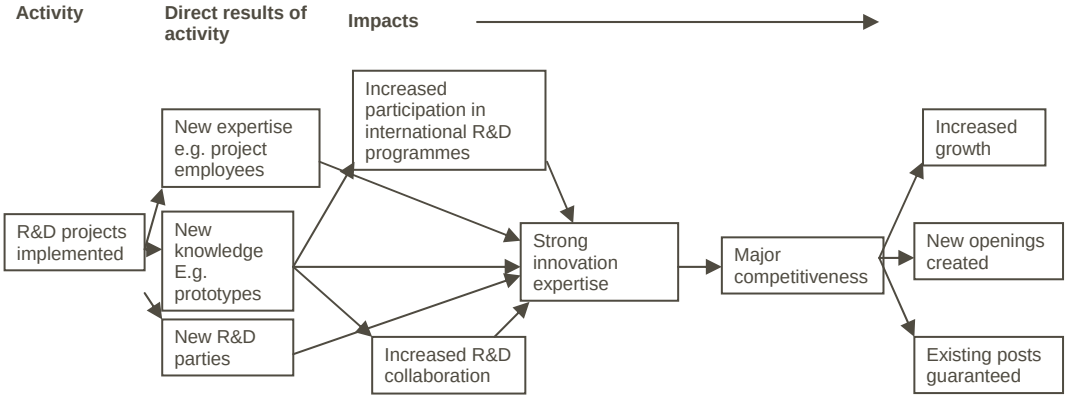
If monitoring of goal achievement is to be possible later in the policy process, requirements must be laid out for clearly framed goals. In some cases, a relevance requirement for indicators used in securing a beneficial development can be introduced. This is as an explicit criterion for selecting proposals to support. At the same time, requirements should be set for the design of routines where it concerns gathering indicators which allow goal achievement to be checked and evaluated.

[50] Use of these criteria is recommended by both the British and Swedish finance ministries. However, the Swedish SMART acronym should be read somewhat differently than the direct translation of the English concept presented above. The Swedish terms are: **S**pecifika [Specific], **M**ätbar [Measurable], **A**ccepterade [Accepted], **R**ealistiska [Realistic] and **T**idssatta [Time-bound]. Ministry Publication Series 2000:63 and HM Treasury (2003).

Important information to gather is what contact points and collaboration can be sought with other projects, which research networks will be involved, which synergies with other types of institutions are anticipated and so on. Excessive requirements for quantification and specification should not be sought; the important thing is to lay the basis for a better "map" drawn in suitable detail. The pure "archaeology" typical of many *ex post* evaluations can thus be avoided.[51] Precise planning of *ex ante* evaluability can contribute to effectively changing the situation.

The practical results of an impact logic assessment or *ex ante* evaluation may appear as in Figure 7. The example is taken from Research&Grow, a VINNOVA programme which, since 2005, has concentrated on R&D in small and medium-sized enterprises.

Figure 7. Impact logic from the VINNOVA programme, Research&Grow.



Source: VINNOVA

The example in the figure shows that activity "implemented by R&D projects" is expected to lead to a number of direct results in the form of new expertise, new knowledge and new R&D parties. It is assumed that, after a while, these results will be able to generate a number of meaningful impacts en route to the overall goal in this context of increased growth. Increased R&D collaboration between companies and research practitioners and increased participation in international R&D programmes may be expected to lead to strong innovation expertise. This leads to bolstering of companies' competitiveness which generates new jobs or leads to the safeguarding of existing ones. The example also shows that R&D alone is not enough to create sustainable growth.

[51] Since, at the implementation of most projects, there is a lack of insight into the importance of and requirement for continuous documentation and data collection, the work of the evaluators consists largely of reconstructing the development of projects and programmes through interviews and analysis of available documentation. For impact analyses, the evaluators have traditionally turned to available proxy variables.

Following from the rationale so far comes the conclusion that, in principle, it is right back at programme design where the determination is made of whether and how we will be able to comment upon its anticipated and actual impacts. The significance of the choice of goals and indicators cannot be overestimated. In a complex reality, the programme must also survey and manage several independent, more or less collaborating, and often also mutually bolstering factors of direct or indirect importance to the prospects of achieving the goal.

Based on this way of thinking about goals, impacts and evaluation, a special procedure for planning new programme initiatives has been established at VINNOVA. Before programme documents or call texts are decided upon, they are put before the internal Quality Assessment Group, or QA Group. Tests are conducted on whether sufficient monitoring and evaluation plans have been included and the impact logic assessment is inspected. The Group advises VINNOVA's management.

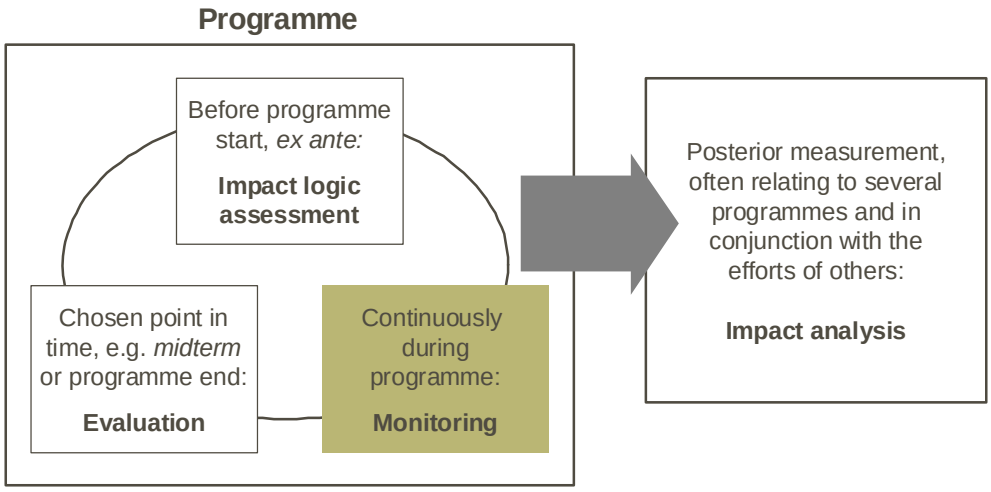
Economic growth follows from increased activity and/or productivity increases in the economy. These in turn are dependent on many factors and conditions. What should be influenced is not always directly accessible or observable but must be influenced via some other factor. The desired impacts are not always directly measurable but must be indicated or approximated by indirect indicators.

In most cases, it is no easy task to find operational definitions, or unambiguously determine which concrete, observable steps and measurements should apply to the programme. However, a clear idea from the start of what the goal is and keeping to reasonable assumptions on how the connection might look are crucial to the possibility of prescribing or studying the programme outcome.

Monitoring

Monitoring is a continuous activity aimed at securing short-term output and outcomes from all VINNOVA's ongoing initiatives, and giving early indicators of impacts on an overall societal level; socio economic impacts for example. It takes place internally at VINNOVA and involves gathering information on indicators showing whether and how an effort is moving towards its impact goals. Information is gathered both during the course of the effort and after its conclusion.

Figure 8. Monitoring VINNOVA's efforts.



Source: VINNOVA

Monitoring thus provides a basis for supporting the programme management, gives updated information on VINNOVA's projects regarding costs and output, supplies easily available information to external actors including the government in its capacity as principal and comprises support in the programme work with milestones for what should be achieved in the operation.

The opportunity to effectively carry out an impact analysis also assumes fundamental investment to have been made in systematic monitoring. Currently, VINNOVA's programme managers are responsible for following up the projects funded. This generates a wealth of information regarding ongoing activity which is an important asset to the Agency. However, a decentralised working method in this sense has certain significant drawbacks. The system is thus strongly dependent on individuals, with an obvious risk that information will be lost if people leave or go to other duties.

Under current circumstances, obtaining a summary of the impact of VINNOVA's initiatives is resource-consuming. It also means that the opportunities to compare different programme initiatives are more limited. A more comprehensive approach to monitoring may create a common platform for discussion on how to measure and understand different impacts, and might contribute to the development of the whole programme operation. Better coordination of the monitoring in keeping with this aim, including more suitable IT support, would also reduce the administrative burden on funding recipients and other organisations which must provide information to VINNOVA.

At VINNOVA during 2007, work was being conducted under the heading of Effekta, previously P.U.B. (the Programme – Call – Funding project), the output of which is anticipated to be an important step on the road to a cohesive approach to monitoring, evaluation and impact analysis. These stated goals are to achieve a simplified and more unified way of working in regard to programmes, calls and projects and to enable an overall assessment of VINNOVA's output and impacts from initiatives made. Additionally, the project should lead to increased data quality and satisfy both internal and external information requirements, as well as giving VINNOVA's operation effective and appropriate IT support.

This overall approach also includes VINNOVA's ongoing work to build up flexible and user-friendly IT support for Internet-based questionnaires, to form a tailored service for what are known as user surveys. These functions and the design include both the questionnaire platform itself and a continuously updated question and questionnaire library.

Parallel to this and operating within the framework of the VINNOVA programmes Research&Grow, VINN Excellence Center, Institute Excellence Centers, Berzelii Centers, the Key Actors Programme, VINNVÄXT, VINNMER, VINN-Verification, VINN NU and to some extent within sectorial industry R&D programmes, are pilot projects aimed at developing indicators and gathering and processing information for monitoring impacts on companies which have applied for and been granted funding. IT support and the common database structure comprise an important and integrated part of this work. Experiences from this will comprise a significant support in the ongoing development of routines for continuous monitoring and analysis of most initiatives initiated by VINNOVA. IT support will be structured so as to allow stored information to be linked with VINNOVA's administrative systems.

By working with pilots and choosing a number of programmes of varying character in terms of impact logic, actors, scope etc., there is opportunity to test the relevance and value of a range of different indicators. The pilots also offer a chance to test various ways of organising the monitoring work and develop and test different types of IT support. The work also includes a dialogue with companies and organisations supplying data to VINNOVA so that systems will not involve needless work when gathering data. Working closely with the programme managers responsible for the programmes which are used as pilots creates internal ambassadors at VINNOVA for the development of the monitoring work.

One of the chief reasons for working with existing VINNOVA programmes is the ability to show very tangibly how systems function instead of referring to visions of future systems. Finally, the work with pilots also

provides opportunities to better adapt the introduction of a new way of working to the requirements and workload of each programme.

A further important aspect of the approach described here is a pronounced focus on the actors included in projects and on the opportunities offered for classifying each participating player and linking together known and/or gathered information with recorded data provided via corporate identity numbers and official statistics. Thus, VINNOVA can generate and update a larger and more suitable body of data, of great importance to both monitoring and the impacts being sought.

These measures, focusing on systematic data capture and data processing, the pronounced player perspective and the joint working method are necessary conditions to further develop VINNOVA's focus on impact. Thus, a starting point for most of the ongoing and planned measures is the need to be able to capture and process the player perspective in VINNOVA's monitoring and administrative systems. Everything begins with those actors which implement projects and it is in consequence of their activity, collaboration and interaction that goals are achieved. Thus, it is the actors' activity which generates output and impacts.

Interactive research represents a certain type of continuous monitoring used in a number of VINNOVA's efforts. It provides an opportunity to deepen certain aspects of the knowledge requirement which may exist for activities in programmes and projects and be used for such things as identifying and analysing processes associated with method development, experience exchange and knowledge building. More specifically, based on programme goals and guidelines, it may be a case of documenting reflections from the programme or project activity, elucidating various forms of collaboration, elucidating the project activity's link to other relevant work or proposing improvements to the programme process concerned.

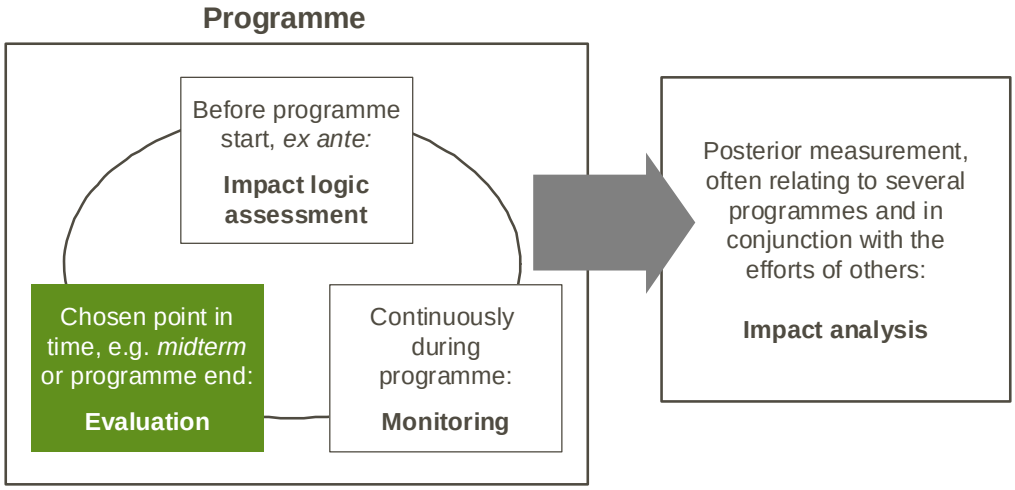
Above all however, interactive research provides development support to those actors conducting various projects and activities, as they are directly and continuously interacting with the researchers/evaluators monitoring the project and the activities. A common limitation of interactive research is that overall results and insights from interactive research can tend to remain with the researchers carrying it out. Decision-takers and policy-makers risk not gaining sufficiently deep insights from the processes; this limits the value of the supporting data to strategic policy decisions.

Evaluation

Evaluations have a long tradition at VINNOVA and its predecessors. These are conducted by external experts in close connection with programme

implementation. The main aim is generally to confirm at the conclusion of the programme whether goals have been achieved or assess the probability that they will be at any time during the programme, commonly called *mid-term evaluation*. The aim then is also to strengthen the programme or improve its activity. Naturally in that context, it is also meaningful to seek early indications of socio economic and other overall long-term impacts.

Figure 9. Evaluation of VINNOVA's efforts.



Source: VINNOVA

A challenge for *mid-term evaluations*, is developing indicators which make it possible to single out which projects should be granted further funding, i.e. those for which the goal of critical mass is within reach, and those which should be closed down because their goal is too remote. *Mid-term evaluations* generally do not profit by being like impact evaluations, since it is anticipated that impacts will appear later on. Rather, the assessments made should be aimed chiefly at measuring the output which constitutes input in subsequent processes and checking whether the development of the process towards implementation is going as planned.

What may be regarded as a good or useful evaluation can be described in several ways. However, there is a well-developed international practice for implementing and using evaluation studies. A summary which includes this has been conducted by *The Association for Technology Implementation in Europe* (TAFTIE), of which VINNOVA is a member. In the first place, the summary is intended to serve as a frame of reference in comparisons between TAFTIE members, but the criteria discussed there are highly relevant in the matter of the usability of evaluations. Accordingly, they describe the important areas as:

1 How well evaluations manage the tasks of documenting, valuing and giving recommendations.

2 How well-established the evaluation instrument is in the Agency's management and operation.
3 Influence of the evaluations on agency policy, choice of strategies and implementation.
4 How well the evaluation as such works.

VINNOVA's evaluations are designed on the basis of these criteria. Furthermore, goals for evaluations and impact analyses have been framed which can form the basis for each type of evaluation study.

One type of evaluation is aimed at strengthening the implementation of both ongoing and future programme initiatives. The questions asked are: Can ongoing initiatives be improved on the basis of the experiences gained? Are there warning signals? Does action need to be taken? In other words, this relates to a form of operationally motivated evaluation based on **operational goals**. Such evaluations comprise a quality assurance of VINNOVA's initiatives and are generally initiated and funded by the responsible programme manager/department. These are normally anticipated in the programme plan, but some form of urgent cause may also occasion a decision to evaluate. The function is chiefly to support decisions on the design and direction of ongoing initiatives; a decision on a subsequent stage for example. They can also be carried out in the final stages of a programme period as a decision-making basis on the ongoing initiatives within any contiguous areas.

Another type of evaluation relates to the possibility of providing a basis for VINNOVA's policy formulation, i.e. based on a **strategic goal**. This form of evaluation has a broader focus than an individual programme and may involve such things as a type of initiative, a particular group of actors or a field of expertise. Their implementation should contribute to strengthening VINNOVA's professionality as a national R&D financier and be initiated on divisional level or by the Agency's management.

During the period up to and including 2006, VINNOVA conducted a total of 24 evaluations. These related to such things as programmes, institutes, competent centres or consortia and special activities at institutes or activities during a particular period, within a particular field of research.

Both the positive and somewhat less positive results from the evaluations will be used in several ways. They have had direct significance for VINNOVA's own operational planning, both for determining which areas investment should be implemented and by acting as guidance in the development of applicable working methods. Forms of organisation and funding for research and innovation activity have been developed. In several cases and in a number of areas, the evaluation results have acted directly as

a decision-making basis for ongoing or renewed efforts with more or less altered or revised aims. It has been possible to clarify the benefits of the interaction between actors in innovation systems. It has furthermore been possible to observe results of direct significance to the possibility of achieving overall long-term impacts on a societal level in the longer term.

Notable amongst the overall insights from the evaluations are the relationships between small companies and research institutes which have been established, including a comprehensive mutual development work where small companies play key roles in the development of technology and knowledge. In some programme efforts, small and medium-sized companies increased their turnover to such a level that state funding *break-even* has already been achieved during programme implementation. High levels of productivity and quality are also described as characteristic of the scientific production in a number of programmes or the equivalent. PhD researchers have been employed in companies and this facilitates dialogue with university researchers and the opportunity to benefit from scientific results within the company's own R&D. Additionally, there are a number of spin-offs; new companies established by way of typical *spin-off* effects.

Some of the most important results are also those which indicate a changed attitude within universities to leadership and research organisation, combined with the fact that eyes have been opened within important Swedish industrial companies to the potential offered by collaboration with universities. New project ideas have been created and collaborations in new groupings have been established. This activity has contributed to a focusing and profiling of research at universities. The results of evaluations have been able to influence priorities within sectorial industry R&D programmes.

The evaluations also highlight a number of significant areas for improvement for VINNOVA. These include recommendations on how impact goals and tools can be changed in order to increase opportunities for actually studying, measuring and monitoring the direction, results, outcome and impacts of the efforts. A basis for developing impact indicators for evaluation has also been produced.

In the evaluation of some programme efforts, the need has been indicated to start with a more clearly thought-out long-term plan in the ongoing work. In others, the need has been described for new methods of knowledge-sharing and results dissemination so as to develop the interaction between the programme's projects and surrounding society. Still others state that special support is needed for projects to go from some form of "academic prototypes" to commercial results, plus help commercialising these, if major success is to be achieved in generating impacts which benefit industry and society.

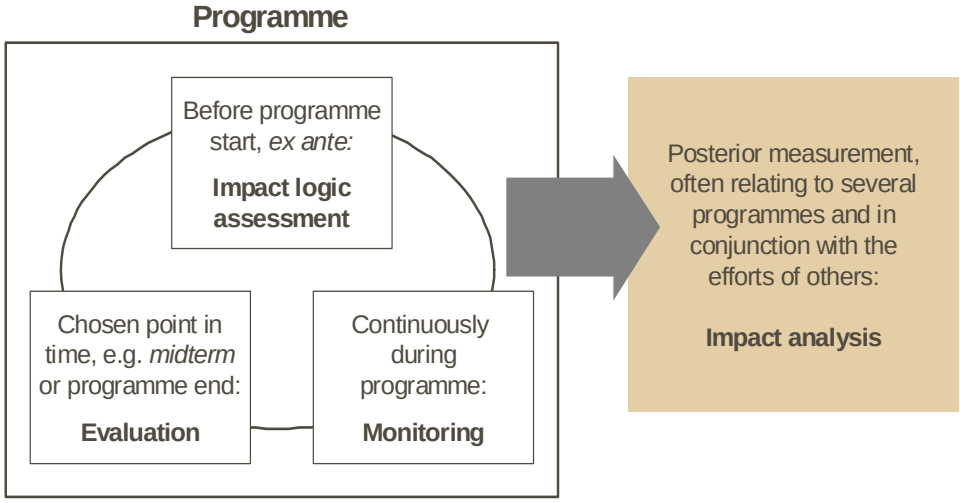
VINNOVA intends to conduct further work in the direction described and for these reasons is implementing a rolling three-year plan of evaluation activity. Divisions and departments describe in budgetary terms which evaluations are envisaged in the coming years and state which of the above types of goal are intended and thus also what type of evaluation is necessary. These have been compiled in a document which VINNOVA's management will decide upon during the Agency's operational planning. The operational planning process should also identify what are to be deemed strategic efforts, which particularly need monitoring. The purpose of this approach is to:

- highlight the need for evaluations within divisions and departments,
- create an overview of VINNOVA's planned evaluations, and
- provide a basis to initiate further evaluations.

Impact analysis

By impact analysis, VINNOVA means **studies carried out to provide an understanding of the long-term overall impacts on industry and society from the Agency and its predecessors' efforts**. The purpose of an impact analysis is to use multifaceted, independent information to elucidate impacts achieved as well as generating information about and understanding of the dynamic of research and innovation activity plus factors influencing success or failure. Impact analysis provides conclusions on the impact of official initiatives, gives support for public investment in research and development and constitutes necessary information and data for strategic policy decisions, Figure 10.

Figure 10. Impact analyses of VINNOVA's efforts.



Source: VINNOVA

Impact analysis studies are conducted by independent, external experts since they affect the output of VINNOVA's operation. They are normally conducted every 5-10 years following programme conclusion, and occasionally up to 15-20 years after the efforts have ended. The continuously collected information from monitoring and evaluation of programmes forms the basis of these impact analyses. So far, VINNOVA has carried out a total of five impact analyses. Taken in order, these have dealt with the: Impacts of VINNOVA's Predecessors' Support for Needs-driven Research 1975-2000, Impacts of the Swedish Competence Centre Programme 1995-2003, Impacts of the Neck Injuries Research at Chalmers 1985-2003, Effect of 20 Years' Research and Development in the Use of Information Technology in Working Life and Effects of Swedish Traffic Safety Research 1971-2004.[52]

The overall purpose of the analyses was to describe and understand the significance of needs-driven research to different innovation systems. It is therefore necessary to monitor, systematically and long-term, both scientific and industrial development and their interaction within the fields where research is conducted. Impacts of the kind sought in these analyses, on some form of overall societal level, often appear later rather than during actual implementation of the research project.

Impact analyses are conducted to study more and broader impacts than would relate to an individual programme. Rather, they are the result of a larger interconnection of initiatives over a longer period, which may have been conducted by many more actors than a single agency or funding body. They also involve long-term, overall impacts on a societal level occurring a longer time after the conclusion of programme initiatives; often up to 15-20 years later. Impact analyses also represent a posterior measurement as compared with monitoring and evaluation, which are conducted in direct or very close connection with actual programme implementation.

For the future, it is necessary for VINNOVA, in combination with other actors, to get different types of initiatives to interact. This is so that the operations which VINNOVA and others including its predecessors helped construct can be further developed to give tangible long-term impacts on the Swedish economy.

During 2007, a new selection principle was established aimed at complementing the previous analyses with another type of study. So far, the impact analyses have had a clear chronological nature, aimed at assessing impacts of a given programme or a particular field of research and in

[52] VINNOVA VF 2002: 1, VINNOVA VA 2004: 03, VINNOVA VA 2004: 07, VINNOVA VA 2005: 08, VINNOVA VA 2007: 02 and VINNOVA VA 2007: 08.

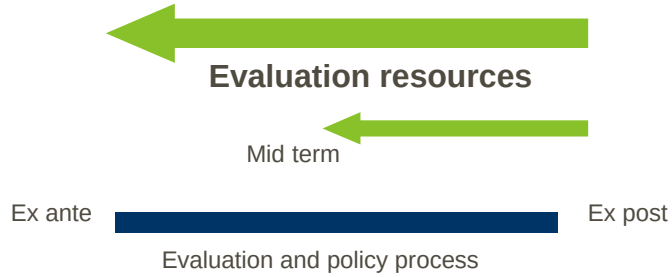
relation to the impacts on research (excellence), industry (competitiveness, employment) and society (growth and socio economic gains). The new principle involves a complementary approach with an even clearer starting point in current or future policy challenges.

A principal focus of VINNOVA's operation has been to contribute to the development of international "Centres of Excellence in research and innovation". VINNOVA uses this focus as its starting point in a plan for impact analyses 2008-2010 and assumes that it is impacts from sufficiently broad efforts over a sufficiently long period which should initially be analysed.[53] VINNOVA and its predecessors' combined initiatives in such fields will therefore be particularly analysed, regardless of the type of initiative.

Conclusions

One important conclusion VINNOVA drew in its work of raising the level of ambition surrounding monitoring, understanding and generating impacts for sustainable growth is that development resources need to be distributed across the entire life cycle of initiatives, i.e. programmes, calls and projects. This improves the possibility of achieving a high level of continuity and recurrent feedback, Figure 11.

Figure 11. Forward redistribution of evaluation work in the process.



Improved opportunities are thus provided to continuously contribute to added value in the end results. The improved planning also contributes to strengthening the evaluations carried out *ex post* since collection of relevant data reaches a significantly higher quality level by being continuously assembled and updated. At the same time, there is a greater emphasis on learning lessons for the future. Such an approach also makes it possible to change the goal if circumstances change.

[53] Stern, P, *VINNOVAs samlade strategi för uppföljning, utvärdering och effektanalys. Regeringsuppdrag [VINNOVA's overall strategy for monitoring, evaluation and impact analysis. Government assignment report]*, VINNOVA, Strategy Development Division 31/5/07 (Reg. no. 2006-04079).

To make this possible a number of measures need to be implemented. These have also been previously reported in the strategy for raising ambition which VINNOVA presented to the government and can be summarised as follows:

- Systematic and continuous data capture in all programmes, calls and projects,
- Conducting at least two impact analyses annually, communicating and discussing the results and developing learning processes around these,
- Applying international state-of-the-art methodology for impact measurement, particularly in regard to growth impacts, by using experiences from patterns such as at the *National Institute of Standards* (USA) and Molde University College (Norway),
- Working continuously with method development to maintain state of the art by such means as support from an international advisory board and benefiting from the development work carried out within the TAFTIE organisation in Europe (particularly in regard to studies on additionality),
- Rapid learning by utilising newly started programmes (such as Research&Grow) as pilots to identify anticipated impacts and develop indicators making it possible to monitor and measure impacts, and
- Examining VINNOVA's project portfolio to find indicators of the importance of projects regarding their contribution to sustainable growth. The results should be used for in-depth analyses of the connection between initiatives and impacts.

These measures are crucially important to the opportunity to realise a strategy for VINNOVA's impact evaluation activity and of analysing VINNOVA's operation. Thus impact logic assessment, monitoring, evaluation and impact analysis constitute complementary activities for considering the same unit, one and the same information and knowledge requirement, aimed at providing a basis for VINNOVA's operational development.

4 VINNOVA's completed impact analyses

It is well known that lead times are often long before the full impacts of research have developed and can be observed and evaluated. At the same time, it may be observed that the evaluations and impact analyses conducted, in Sweden and internationally, normally end in connection with programme conclusion or directly thereafter. As an example, this has been the case with the EU's framework programmes. This is thought to be due mainly to political demands for results at this point, often to underpin decisions on continued efforts. At the same time, politicians want better supporting data for their decisions.

Given this, it is positive that the Ministry of Enterprise, Energy and Communications has assigned VINNOVA to conduct more long-term analyses which "… are to include estimates of the impacts in the form of sustainable growth and renewal which R&D support from the Agency and any of its predecessors has brought about. The Agency should also analyse how initiative types and assessment criteria affect the results."[54]

The analyses carried out related to broader efforts than individual programmes and longer time perspectives.

Up to Spring 2007, VINNOVA has produced five impact analysis reports:

- *Impacts of VINNOVA's predecessors' support for needs-driven research. Four impact analyses during the period 1975-2000*, conducted by Technopolis Ltd., Friborg, G. and VINNOVA (2002),
- *Impacts of the Competence Centres: An Exploratory Study*, conducted by Eric Arnold, John Clark and Sophie Bussillet at Technopolis (2004),
- *Impact analysis of the neck injuries research at Chalmers*, conducted by Knut Sandberg Eriksen, Rune Elvik, Rolf Hagman and Arild Steen at the Norwegian Centre for Transport Research, TØI, and Arild Hervik at Møre Research Molde, MFM (2004),
- *User-driven development of IT in working life. Evaluating the effect of twenty years' research and development on the use of IT in working life*, conducted by Per Tengblad at ATK Arbetsliv and Åke Walldius at KTH. (2007), and

[54] "Budget document for the budgetary year 2007 relating to the Swedish Governmental Agency for Innovation Systems etc. within expenditure area 24, Industry (parliamentary bill. 2006/07:62)".

- *Effects of Swedish traffic safety research 1971-2004*, conducted by Marika Kolbenstvedt, Rune Elvik, Beate Elvebakk at the Norwegian Centre for Transport Research, TØI, and Arild Hervik and Lasse Braein at Møre Research Molde, MFM (2007).
    - To evaluate an area, an evaluation of completed research was first conducted: *Swedish traffic safety in the lead. Eminent researchers and research environments in state-funded research 1949-2005. An assignment for VINNOVA within the project "Impact analysis, traffic safety"*, conducted by Anders Englund (2005).

A further two impact analyses are due in February 2008:

- Significance of research for mobile telephony expansion 1980-2007, and
- The seed-finance programmes 1992-2002.

The chapter describes VINNOVA's impact analyses in summary. Impact analyses have been conducted and operationalised in various ways. The variation in operationalisation is natural not merely considering differences between the areas studied, but also since certain studies have subsidiary aims to develop and test methodology for implementing impact analyses.

It is important to note that impact analyses have a long-term perspective and include a number of different programmes.[55] The state support structures have changed in appearance several times during this period.

Impacts of VINNOVA's predecessors' support for needs-driven research

Reason for conducting pilot analyses

When VINNOVA was formed in 2001, there was an interest in better understanding what VINNOVA's initiatives are achieving and how they can be described, as well as in developing methods to estimate long-term impacts. The impacts VINNOVA was primarily interested in demonstrating were those which could be expressed in terms of sustainable economic growth, the promotion of which is part of VINNOVA's task.

Monitoring and evaluations of VINNOVA's predecessors' efforts had previously been conducted, but there had only been limited study of long-term impacts of growth and society. Nevertheless, VINNOVA considered that the development of a methodology for such long and complex studies was important, since meaningful impacts from efforts in a given area only became visible after several years. It is also important to study the entire

[55] The exception is the Competence Centres Programme which comprises one programme and which had only existed for eight years when the report was written.

system in one context, as it is "… necessary to monitor, systematically and long-term, both the scientific and industrial development and interaction between these in areas where research is being conducted" in order to achieve an understanding of long-term impact generation.[56]

This type of long-term, system-encompassing study is uncommon. Accordingly, there was little support in the research and evaluation literature so pilot studies were conducted. The intention was to create a basis for the future work with impact analyses by finding different routes to show how efforts contribute to economic growth.

Implementation

Four minor, pilot-type impact analyses were conducted during the autumn of 2001. The assignment was introduced by a search phase to identify suitable analyses. VINNOVA also found out what corresponding analyses had been conducted in Finland and Norway.

For pilot studies were selected. These were:

- The research programme *Digital communication* 1987-1993; considered the research programme aimed at mobile telephony expansion with the most direct connection to the industry's own development work,
- The gradual institute-based development 1975-1993 of tunable semiconductor lasers, intended for rapid fibre-optic telecommunication networks and how researchers commercialised the results in the Altitun company 1997-2000,
- The research group surrounding Professor Mathias Uhlén, financed by VINNOVA's predecessor for a long period and whose research generated new products and new enterprise, and
- A summary of the quality of the research which VINNOVA's predecessors funded, based on 105 peer-review-type evaluations which took place during the period 1980-2000, including a summary of the measures which the evaluations brought about.

Of the selected pilot studies, the first three were aimed at evaluating impact on economic growth, whilst the latter examined scientific impacts.

Since the intention of the work was to attempt to develop various methods for future impact analyses, the sub-studies were conducted differently. The three first (economic growth-related) studies evaluate different objects: a framework research programme, an industrial research institute and a research group. However, they used the same basic approach to gather data

[56] Technopolis Ltd., Friborg, G. and VINNOVA, *Impact of VINNOVA's predecessors' support for needs-driven research. Four impact analyses during the period 1975-2000*, VINNOVA Innovation in Focus VF 2002:1, "Foreword", p. 1.

for the studies: interviews with key people in the programmes, complemented by studies of programme-related papers and method literature. Indicators were also used for things like accumulated sales and profits.

The following supporting material and data was used:

- Academic literature studies,
- Interviews with key people participating in the studied efforts,
- Information from project catalogues, diaries from affected agencies, project descriptions and evaluations, and
- 105 peer-review evaluations of efforts by VINNOVA's predecessors (relates to the last sub-study which dealt with the scientific quality of the research).

Background and results of the pilot analyses

Digital Communication framework programme

The programme was part of the series of government funded programmes which from 1980 aimed to build up research expertise within the field of systems technology and information management. Such research had previously largely been absent from Swedish academic establishments. The funding enabled the formation of institutions with this aim, chiefly at The Royal Institute of Technology and the universities of Linköping and Lund.

The Digital Communication programme was initiated based on a direct enquiry from Ericsson and the former national Swedish Telecommunication Administration (Televerket). The programme consisted of some 20 research projects in which doctoral students were trained. It was led by an executive group of university and industry people, and lasted from 1987-1993.

Technopolis Ltd. was chosen as implementer of the analysis. The analysis took its starting point from some examples in international literature on how technology transfer can be analysed. It is narrative and does not attempt to put figures on the impacts. However, the analysts advanced an argument as to economic impacts on society using chiefly American examples. The examples maintained that the socio economic investment return in research was between 20-40% and that the return on academic research was 20% in American companies. It was also asserted that, "…where companies perform basic research it produces a pay-back three times as great as other

types of R&D".[57]

The analysis came to the following conclusions:

- The development of the Swedish ICT cluster constitutes a good example of the creation of an effective innovation system. The interaction between a) political capacity to establish stable rules of play through a standard (GSM), b) society's long-term investment in knowledge-building and knowledge dissemination (through the former national Swedish Board for Technical Development) and c) the large companies' (Ericsson and Televerket) goal-orientated global efforts in a technological field meant the creation of a major international industry in mobile telephony,
- The programme was forward-thinking in that it took place in close collaboration with researchers and industry. This involved a high level of social benefit,
- The timing of the programme was very good for the supply of expertise to industry, as the "narrow" Swedish TDMA technology was accepted as standard,
- The programme created large research groups in the field, which is a prerequisite for research of relevance and technological stature,
- The most important individual impact of the programme was that it created a pool of young talent which subsequently took high positions in industry and research. Many of those who came into contact with the programme contributed directly to the implementation of GSM,
- The programme gave Sweden a lead of up to five years in the international competition for mobile telephony expansion, and
- The programme contributed in assisting universities to prioritise important research fields in Sweden.

<u>The Optical Communication example</u>

The second sub-study, the "Optical Communication example", was carried out by people from VINNOVA. It does not contain a literature survey like the Technopolis study. The information used for the study consists of interviews and documents on support initiatives and their results.

Methodologically, an approach is used which can be called a "success story". As previously mentioned, it is very difficult to describe the impacts of a long-term effort. Instead of trying to describe all the economic impacts

[57] Technopolis Ltd., Friborg, G. and VINNOVA, *Impact of VINNOVA's predecessors' support for needs-driven research. Four impact analyses during the period 1975-2000*, VINNOVA Innovation in Focus VF 2002:1, "Digital Communication framework programme", p. 13.

which arose from support to the optical communications field through the industrial research institute IM (Institute for Microwave Technology), a highly successful case was picked out and investigated; the Altitun company. By comparing the costs of the entire effort against the revenue generated for Sweden through Altitun's establishment and sales via employment, tax revenues etc. with the cost of the efforts, the analysts produced an economic result at least equivalent to the state's initiatives. The picture was complemented with qualitative conclusions on the impacts of the total efforts.

The approach to the entire study was to see whether economic results could be observed in the effort by using a success story. The impact study was to be viewed as a lesson for future impact studies; a pilot study, and determining whether the methodology was plausible for future use.

Output:

- Long-term state support and involvement in IM was a prerequisite for Altitun's establishment,
- Functioning prototype lasers,
- The market value of Altitun's sales was almost SEK 8 billion. This constitutes approximately 23 times the initiative. Tax revenues to the state on sales comprising some SEK 1 billion,
- The economic impacts on the fibre-optic field within Ericsson were many times greater than those which can be related to Altitun, but were considered very hard to quantify, and
- A number of smaller, new companies which jointly employ more people than Altitun, plus spin-offs from Ericsson which were sold for SEK 7.2 billion.

The Biotech Research example

Since the 1970s, VINNOVA's predecessors have been financing biotech research. Up until the end of the 1990s, 12 biotech research programmes had been conducted. STU financed more than half the biotech research at Swedish academic establishments during the first half of the 1980s and was thereby important to the establishment and construction of Swedish biotech research. The strategy of VINNOVA's predecessors was to fund research which was strong from an international perspective, as well as research fields considered to have good economic potential.

The starting point for the analysis in this case was that research is a) a continuous process which builds on earlier research and b) generally carried out by research groups and not individual researchers. This means that economic impacts of research group activities should be seen as an outcome of a number of successive research projects. The economic impacts which

may appear in this perspective are generally a result of research over a longer time in the group.

A research group at KTH was chosen as a study subject. It had received funding from VINNOVA's predecessors over many years and from a long succession of research programmes. The group was also known to have commercialised its research, meaning that the research had had economic impacts. However it was not known what significance, if any, the funding from VINNOVA's predecessors had had in these impacts.

This study too was conducted by personnel at VINNOVA's Strategy Development Division. Work commenced with a compilation of the amount of funding to the research group by VINNOVA's predecessors. Through interviews with the group, knowledge transfer (licenses) to companies was identified as well as companies which had been spin-offs from the research group, generated by research funding from VINNOVA's predecessors. Information about economic impacts from licences was then gathered from companies and the volume of financing from VINNOVA's predecessors compared with the economic outcome.

The analysis resulted in the following conclusions:

- The funding generated research, which in turn generated knowledge which was patented and licensed to companies or formed the basis for newly established enterprises. The funding was a necessary condition (there were no alternate funding sources) for implementing the research and thus for the economic impacts,
- However, the research funding was not a sufficient basis to establish the economic impacts identified. Developing patents/licences for products required major corporate investment. For newly established enterprises, major resources are required in the form of venture capital,
- It is possible to measure economic impacts from research funding provided that research groups and companies are willing to give out information. Economic impacts on companies which could be linked to licenses and measured were development costs, accumulated sales revenues and profits plus the volume of venture capital which new companies attracted, as well as their increased employment, and
- The support was estimated to have led to impacts on economic turnover equivalent to at least 10 times the state subsidies, which is a very cautious estimate.

<u>Monitoring of STU/NUTEK's "international evaluations" (peer-review evaluations) 1981-2000 of the scientific quality of the research</u>

During 1981-2000, VINNOVA's predecessors conducted quality-orientated evaluations of the R&D programmes aimed at basic knowledge development. The methodology used was peer reviews according to the

Swedish Natural Science Research Council's model.[58] It was the principal duty of an industrial/scientific council to monitor these evaluations for the purposes of quality assurance.

VINNOVA had the impression that these evaluations had not come to the attention of anyone outside the programmes and researchers involved in them. At the same time, VINNOVA deemed it of interest to gain an overall impression of the evaluations and what they led to as VINNOVA was to devise its ongoing evaluation operation.

The study was conducted by Göran Friborg, who initiated the methodology when the evaluations were begun in the 1980s. The report summarised the opinions framed by international, well-qualified researchers on researchers, research groups and research programmes in all 105 evaluations. Furthermore, they compiled the measures which these opinions had brought about in VINNOVA's predecessors' ongoing funding. Accordingly, the study made no claim to account for societal or economic impacts. On the other hand, it did focus on the scientific impacts.

The report summarises the opinions expressed in the individual evaluation reports, the measures adopted as a result of deficiencies highlighted on a subject level. This implies a certain generalisation, since the individual evaluations had varying emphases; on individual researchers, on research groups and occasionally on larger groupings. A detailed analysis would have required a significantly larger initiative. However, VINNOVA considers the essential results to have been captured in this report.

The monitoring resulted in the following conclusions:

- The evaluation process had resulted in a robust scientific quality assurance of VINNOVA's predecessors' programmes aimed at basic research. The comprehensive detailed information in the various evaluations showed how active and enduring this process of quality assurance had been during the entire period,
- The opinions in the evaluations strongly confirmed that VINNOVA's predecessors had invested in sustainable scientific methodology and that the leadership had worked well in conducting the research,
- Possible application output had been found in all R&D programmes aimed at basic knowledge development. The programmes were clearly

[58] The model builds on the research community's own methodology. It is therefore a powerful instrument which gives manifestations, interpretable to a wider circle, and expedites the assessment which is always ongoing amongst international, refereed scientific journals. The appraisal of the scientific issues is chiefly captured as opinions on scientific methodology, scientific leadership, research group structure, doctoral student recruitment, external collaboration, internal publication and equipment.

aimed at the opportunities for industrial utilisation. On the other hand, in a good number of these cases there were comments that the exploitation process should have been further developed and bolstered, and

- In the number of cases, comments had been made that the methodology applied had not led to the programme goals which had been framed. This occurred primarily in cases where the methodology had been weakly developed, but a couple of prominent research groups with internationally recognised methodology also pointed out that the methodology needed to be changed in order to achieve programme goals.

The Competence Centre programme 1995-2003

Origins of the Competence Centre Programme

The Competence Centre Programme originated with the working method which VINNOVA and its predecessors developed in successive stages. Prior to 1980, a bottom-up approach had usually been adopted, meaning that, funds permitting, the best project proposals within priority fields were supported. This is reminiscent of how research councils and the EU's framework programme generally work today.

Around 1979/80, STU introduced what are known as framework programmes for knowledge development. The *programme* was thereby established as a way of working, with expressed programme goals. In the implementation of programmes, the relevance of projects to programme goals was given a high priority, alongside quality requirements. By way of example, we can mention *Information processing 1980-1985*, whose goal was to supply Sweden with highly trained individuals in computer technology, a field which at that time had not yet been prioritised within Swedish academia.

Another major step in the development of the working method was taken in 1987 when the *Consortia on Materials Engineering [Materialtekniska konsortier]* programme was initiated. It was now that efforts in what are known as "Centres of Excellence" were introduced in Sweden, based on American and English patterns. It was a programme aimed at 11 strong research environments concentrating on basic research within the field of materials. The researchers were chosen using a two-stage procedure with particularly strong expert groups appointed to assess the applicants.

The establishment of the Competence Centre Programme should be seen as a natural step forward in the ambition of establishing Centres of Excellence at universities in which competent companies contribute on equal terms. The principal pattern was the *Engineering Research Centres* programme at

the National Science Foundation, which is the rough equivalent in the US to the Swedish Research Council. There were also other international patterns.

Implementation of the Competence Centre Programme

The competence centre was an innovative way to organise and implement concentrated, long-term and integrated research collaborations between universities and companies with the goal of mutual benefit for the parties. The aim was to strengthen the link between university research and corporate R&D and thereby develop the Swedish research and innovation systems. A fundamental requirement was for companies to actively participate in both research and the management of each centre and its research programme.

Amongst other things, the programme was framed as a response to a debate regarding a perceived low level during the early 1990s of highly trained workforce in Swedish industry. A number of research financiers addressed the problem during the period, but VINNOVA's predecessor NUTEK was alone at this point in firmly linking its initiative to the needs and participation of industry. Amongst other things, this was demonstrated by an important selection criterion being that companies supported and took part in the centre's planned activities.

Since the start of 1995, the programme has been gradually expanded and broadened. Twenty-three centres are being funded at eight universities. In addition, following the division of NUTEK and the Swedish Energy Agency in 1988, five centres were financed by the Swedish Energy Agency. The Competence Programme was jointly funded by companies, academic establishments and VINNOVA, with the parties contributing around one third each. The programme ran in the period 1995-2005.

The programme was conducted in four stages (two years, three years, three years, two years). Prior to each stage, an agreement was set up between academic establishment, corporate group and VINNOVA in which central issues were regulated such as rights to the results achieved. Individual centres were evaluated towards the end of each stage, prior to negotiation for implementation of the succeeding stage. A group of international centre specialists evaluated how well the centres were functioning as such, whilst the scientific quality was evaluated in the traditional way through international peer review.

Reasons for carrying out the impact analysis

The Competence Centres Programme had been in existence for eight years when VINNOVA chose to carry out an impact analysis of the programme in parallel with the evaluation being conducted of the programme's third stage. Eight years is a short timespan for an impact analysis. In addition, one

individual programme was analysed instead of a group of efforts. It can therefore be said that this did not constitute a proper impact analysis. On the other hand, it is fully possible to trace certain impacts even after a shorter period. A strong reason for carrying out the impact analysis after only eight years, two years before the programme was to end, was the need for a basis to underpin decisions regarding implementation of the next generation of Competence Centre Programme.

Implementation and method for the impact analysis

As described above, the Competence Centre Programme was evaluated three times during implementation of the programme (after years 2, 5 and 8). This means that valuable supporting data was available for an impact analysis. The Competence Centre Programme was also included in the European MAP collaboration (Multi Actors and Multi Measures Programme), which enabled comparisons with similar programmes in other countries.

Technopolis Ltd. was chosen as analyst, with an international team of considerable past experience evaluating similar programmes, including contributing to evaluations of other programmes within the MAP collaboration. As a first step, VINNOVA chose to have Technopolis conduct a method study to clarify what the overall impacts of the Competence Centre Programme were and how they could be appraised.[59] The method study was based on an analysis of two separate competence centres at different academic establishments each with different subject aims.

Based on the method study, a main study could then be framed. The goal was to describe the impacts of the programme as a whole, not of the component centres. The two main foci of the analysis were to describe the impacts on affected academic establishments and contributing companies. VINNOVA monitored the analysis work through discussion seminars.

The analysis was based on an assessment of previous evaluations and on empirical evidence. This included a survey of the competence centres' network. Networks of people rather than organisations were studied since a fundamental idea in the approach was that knowledge is transferred through human contact and mobility. One difficulty was the lack of systematised information about the network.

To show how work at a centre yielded important impacts for society and economy, interesting case studies were identified in companies, departments

[59] Arnold, E., *Impacts of the Competence Centres: An Exploratory Study*, Technopolis, 2003.

and five centres. The empirical evidence also included 12 “success stories”, plus validation. A questionnaire survey was also carried out, designed to capture quantifiable information aimed at 950 relevant people in the centres’ network.

The approach also contained a discussion on attempted economic evaluations of the centres’ impacts.

Other supporting material and data included:

- Interviews with people working in/with/around the competence centres (management, researchers, company and institute employees, representatives of research financiers etc.),
- Interviews with people who participated/controlled the programme to find necessary quantitative information and comprehension,
- A literature study of international literature on similar programmes abroad and on the competence centre in academic theory,
- Literature/writing regarding the competence centre, the programme, the academic establishments and involved companies, and
- A meta-evaluation of the peer review evaluations of the centres carried out during 2003.

Results of the impact analysis

The analysis was able to indicate a number of clear impacts:

- The most important impact was considered to be that industry was able to employ 350 research trained people who were particularly well prepared for work in industry,
- The programme expanded universities’ openness to collaborate with industry, making the Competence Centre Programme an early initiative within a larger systemic shift,
- Scientifically, the programme was successful through a high level of intrascientific quality and relevance and a significant output of doctoral and scientific publications,
- Through a number of case studies, commercial revenues were identified for participating companies. Even at the time of the analysis, these were equivalent to the total cost of the programme, and
- One final impact was that some multinational companies chose to keep their research in Sweden, close to Swedish competence centres, since they valued the company being close to an attractive research environment.

Regarding attempts to calculate the impact of the activities in the Competence Centre Programme, there are four types of value to mention. The first three of them are usually regarded possible to measure in monetary terms:

- Value of new business arising as a result of interaction in the centres within participating companies,
- Value of the PhDs produced by the centres,
- Value of spin-off activities, and
- Value of business, activities, research and development kept in Sweden as a result of companies' interaction with the centres.[60]

The report estimates that value of approx. EUR 270 million has been created, of which EUR 200 is from new business, EUR 45 million from PhDs and EUR 25 million from spin-offs. The estimate for this covers the total cost of the programme including corporate subsidy and comprises more than three times the investment supplied by NUTEK, the Swedish Energy Agency and VINNOVA.

The report does not take a position on the extent to which competence centres pay for themselves better than other types of effort. The report also emphasises that the figures are the result of highly uncertain calculations. At the same time, it is pointed out that it may still be meaningful to work with figures as an intellectual exercise and to elucidate policy issues in future.

The analysis gave VINNOVA its clearest picture to date of what competence centres really are and how they work. Not least of all, the analysis clarified the breadth in the range of impacts generated by the Competence Centre Programme.

The neck injuries research at Chalmers University of Technology 1985-2003

Origins of the research

The knowledge fields of crash biomechanics and crash safety are cornerstones within the injury prevention field. The former is more fundamental in nature. The latter is more applied, but shares many issues with and requires an understanding of crash biomechanics.

As early as the 1980s, there was the realisation that crash biomechanics had a central role in such things as whiplash injuries, but an effort in such research was considered risky. There was no guarantee of success in finding solutions which would prospectively reduce the problem of neck injuries, which had long posed a growing problem. The risk level notwithstanding, there was great need for a solution.

[60] I.e. the value of business, activities, research and development being kept in Sweden. Participation in a competence centre should strengthen the argument against emigration. This point is considered impossible to estimate.

The Swedish automotive industry was aware early on of the health problems posed by traffic accidents and saw it as socially responsible to seek to manufacture safer vehicles. Volvo was chief amongst those saying so. It was also Volvo which made a donation to establish the first professorship in the subject (Bertil Aldman at Chalmers, 1972).

It was understood early on that neck injuries (whiplash) arise when there is a rear-end collision and that many people are affected by these injuries. The scale may be deemed epidemic; such injuries currently account for 2,000 of the 3,000 annually leading to lasting disability. However, these injuries were difficult to diagnose. Also, considering the low speeds generally involved, it was unclear why these accidents led to such severe consequences in relation to other types of collision.

During the mid-1980s, a proposal was presented for a research focus aimed at reducing the effects of whiplash injuries. The core of the research idea was to conduct further in-depth study to and try to understand the mechanisms which cause injury or functional changes leading to whiplash injuries. VINNOVA's predecessor, the Transport Research Delegation (TFD) found the idea interesting, given its potential to reduce a worrying trend in injuries. TFD chose to assign Per Lövsund to conduct basic research into his idea.

In 1994, the Vehicle Research Programme (ffp), was formed as a part of the Programme Board for Automotive Research (PFF). PFF is an independent organisation, financed equally by the automotive industry and the state. Approximately one third of the research funded by ffp relates to traffic safety. According to their rules, funding from ffp goes to companies, but these in turn may finance research at a university. Through funding from ffp, the Chalmers researchers were able to collaborate with development managers within the automotive industry.

Implementation of the research

When an accident occurs, personal injury can be prevented or alleviated by measures affecting each and every one of the components in the traffic system. Where it concerns *road users*, this can take place in the form of personal equipment such as a cycle helmet or special clothing. Where it concerns the *traffic environment* there are opportunities to avoid or mitigate injuries with such things as suitable crash barrier design, deformable posts and suitably designed side areas. Regarding the *vehicle*, there is work with exterior and interior design as well as equipment; some examples are crumple zones, seat belts, air bags, side-impact protection, head restraints and child seats. Common to the measures is a dependence on knowledge of the origins of various injuries; how injuries occur and what types and at what levels of load and force, injuries of varying degrees of severity arise.

As early as 1972, Chalmers was able to start its operation in the field with a donation from Volvo which enabled establishment of a professorship and formation of the Department of Traffic Safety. Key factors were Bertil Aldman and the recruitment of Per Lövsund since these researchers understood the value of teamwork in order to achieve success. In addition, the significance of the Swedish "traffic safety culture" should not be underestimated. The traffic safety field has long had high priority political backing, which has also provided the conditions to conduct broad, advanced research.

The generic nature of the knowledge means that through its independent research funding bodies, the state gained a decisive role when it came to knowledge-building in the field. R&D grants also provided opportunities to bring leading expertise to Sweden from other countries, as guest professors for example.

Chalmers' research into passive safety in vehicles has led to an interdisciplinary expertise which is essentially world-leading. Because the research group has long had an intensive exchange of knowledge and personnel with the automotive industry (not least of all Volvo), the environment has also created a platform for the early exchange of ideas.

Reasons for carrying out the impact analysis

There was an intuitive understanding within VINNOVA that whiplash research was important to the improvements which could be introduced by the car industry. However, the Agency also wanted confirmation of whether, and in what ways, VINNOVA's predecessors' financing of the field had been successful.

Another reason for analysing the neck injuries research was to gain an idea of the significance of the various types of funding models and project organisations used during the time of VINNOVA's predecessors; this was because, "… the research programme had entered a new phase in regard to content and organisation."[61]

Implementation of the impact analysis

The analysis was restricted to basic research at Chalmers during the period 1985-2003 combined with the vehicle research programme's traffic safety-orientated research, 1994-2003. The analysis therefore comprised an 18-year perspective.

[61] Sandberg Eriksen, K., Elvik, R., Hagman, R. Steen, A. and Hervik, A., *Impact analysis of the neck injuries research at Chalmers*. VINNOVA Analys VA 2004:07, p. 1.

During the course of the analysis, it was widened to include Autoliv's development of side-impact protection, known as crash curtains. This was because the concept of crash curtains had been developed within the framework of the doctoral programme at Chalmers which the then head of research at Autoliv, Yngve Håland had taken.

The question of who should conduct the analysis was not simple. VINNOVA chose to combine a Norwegian technical institute, the Norwegian Centre of the Transport Research, TØI, with evaluation expertise in the form of Arild Hervik, a well-known professor of economics in the Norwegian system at Molde University.

The analysis was conducted in three successive, relatively evenly-sized stages, whereby the focus could be specified as time progressed. The analysis can be described as a journey which gradually took shape in a dialogue between TØI, Møre Research Molde and VINNOVA. A methodological standpoint consisted of aiming the analysis at describing impacts achieved in three dimensions: impacts on research, industry and the national economy; as well as the importance of VINNOVA's initiatives to the impacts which have arisen. The aim was to express the societal impacts (i.e. on consumers and industry) in some form of economic terms.

The methodologically most interesting approach is the one used to describe the societal impacts, i.e. benefit to the consumer and industry. Where it concerns consumer benefit, the analysis began with a variant of the type of cost/benefit calculations normally used in investments in transport infrastructure. The benefit to industry was also calculated using assumed average costs and revenues, in this case per car. The analysis here is based only on exports. Production costs are used as an approximation of increased market value.

The sensitive points in the calculations of social welfare value are clearly outlined and it should be emphasised that the figures presented constitute only one way of fixing the rationale on value creation rather than comprising the truth in the form of exact figures. The transparency increases as certain sensitivity calculations are carried out.

The following supporting material and data was used:

- Written self-evaluation from Chalmers' research environment,
- Panel discussions and interviews with representatives of the research environment and other actors in the system (representatives of research institutes, companies and financiers),
- Document study of both traffic safety field and impact analysis methodology (previous reports, programme evaluations, international findings etc.),

- Statistical bases for societal impact calculations,[62] and
- Cost estimates for efforts in neck injuries research (from both VINNOVA's predecessor and industry).

Results and impacts of the impact analysis

The neck injuries research analysis was able to describe clear impacts:

- A breakthrough in terms of safety, through possible reduction in the risk of injury in whiplash accidents by 45-50% from 1998 car models onwards due to the possibility of introducing a new type of seat (13 years after the research was commenced),
- The research at the Chalmers group was considered world-class and the researchers are in demand for international collaborations,
- There have been major corporate revenues. It is very clear that Volvo and SAAB were able to sell more cars due to increased safety against whiplash injuries. However, it has not been possible to distinguish the impacts of this improvement from other improvements. Autoliv sold crash curtains worth approx. SEK 10 million, and there were revenues from sales of whiplash protection,
- Major socio economic gains have been demonstrated as a result of fewer injured individuals. At the time of analysis, the current value of accidents not leading to injuries is estimated to be SEK 5.5 billion,[63] and
- A natural and necessary part of the research work led to a further development of mechanical, mathematical and biological models including a previously developed the so-named Hybrid III dummy. This work has had major overall significance for the development of the entire field. It also resulted in a subsequent development of a "female" dummy.

The report states that it was "...of crucial importance to the implementation of 'the programme' of neck injuries research to be able to obtain funding from the former Swedish Transport and Communications Research Boards (TFB and subsequently KFB) and VINNOVA."[64] The research mentioned refers here to basic research and the analysis shows it would not have taken

[62] Amongst the most important are SIKA's (Swedish Institute for Transport and Communications Analysis) calculations of the cost of death and injury in traffic accidents; number of neck injuries per year in Sweden; reduction of such accidents when safety measures based on neck injury research have been taken adopted; the number of cars in Sweden with and without protection and their average useful life and reason for discontinuation.

[63] It should be noted here that it is worthwhile estimating the socio economic gains within the traffic safety field, since values have been produced for the costs of killed and severely injured or slightly injured people.

[64] Sandberg Eriksen, K., Elvik, R., Hagman, R. Steen, A. and Hervik, A., *Impact analysis of the neck injuries research at Chalmers*. VINNOVA Analys VA 2004:07, p. 46.
TFB and KFB were predecessors to VINNOVA in the field.

place without VINNOVA, as the commercial risk was considered too great for companies and the academic risk too great for Chalmers.[65]

Different forms of financing have been highly significant. The analysis showed a success factor to be the combination of types of initiatives, research support to Chalmers' neck injuries research and development support to the industry via ffp. The research and industrial development work was enriched by a mutual interplay, something which has been underlined in no small measure by the research group. Apart from long-term and sustainable contributions to knowledge development, the collaboration programme between state and industry has also been of crucial importance.

The interviews showed that the co-financing via ffp resulted in increased research in both large and small companies as well as stimulating a wealth of ideas amongst companies and research institutes. Large companies collaborated chiefly horizontally with other large companies (for example, the production of the BioRID dummy), but vertically (often regarding improvements of components) with smaller supplier companies.

The analysis also showed research to have been developed in a number of successive stages and that researchers sought collaboration with different partners depending on the research questions posed at the various stages. A significant factor behind the success was the Centres of Excellence in research and innovation which had been developed since the 1950s between the automotive industry and Chalmers University of Technology. The representatives of industry and research knew and had confidence in one another. In particular, the car safety company Autoliv said that the biomechanical research at Chalmers had been a prerequisite for the establishment of the company's own research division.

User-driven development of IT in working life 1982-1997

Origins of the research

Hardly any other technology has attracted and involved such a large amount of economic, political and scientific interest as IT. Ever since the breakthrough in the 1970s, major public and private research funds have been invested in further development of IT and IT applications. Still, at an early stage there was widespread unease that the rapidly progressing computer technology would constitute a threat to employment, working

[65] Purely from an academic point of view, the research environments at Chalmers at the time were considered insufficiently qualified and the studies were not considered to be in the nature of basic research.

environment and integrity. Amongst other things, this led to research being commenced into the impacts of computer technology.

Fairly soon, the techno-critical attitude was replaced by an equally clear techno-constructive approach. It was a case of using interdisciplinary and practically-based research to utilise the opportunities of the new technology rather than questioning its existence. The need for increased knowledge on the problems and opportunities of the new technology was then obvious. In the light of this, VINNOVA's predecessors financed a range of R&D programmes concentrating on the use and users of information technology in working life; here referred to as ITA research.

Implementation of the research

The sweeping and often indefinable consequences of information technology for work in society are reflected by the variation in direction, approach and participating actors which characterised the ITA programme.

Following a period during the latter half of the 1970s, characterised by techno-critical research focusing on consequences and with influence reforms in working life and active union organisations in the background, the first more cohesive ITA programmes were initiated in the middle of the 1980s. As a rule, the programmes were conducted with a framework of a broad collaboration between stakeholders. After long negotiations, a development agreement was struck with the private sector. A considerable amount of research on the consequences of technological development was waiting to be applied and the Working Environment Fund (Arbetsmiljöfonden) thus commenced "The development programme for new technology and working organisation (UP) 1982-87".

UP was quickly followed by two major efforts (MDA and DUP) which placed more emphasis on the balance between research and development and set standards for interdisciplinary research collaborations based at universities, yet still within the constraints of the stakeholder collaboration on various levels. Alongside these programmes, there was also rapid establishment of a number of interdisciplinary research groups at several universities which, in addition to funding from programmes, also attracted considerable resources within their respective academic establishments. The programme efforts were thus able to influence the direction and resource allocation at universities and ITA research was gradually accepted as an independent research field with its own doctoral students and its own researcher training courses. As a result, several ITA-orientated basic training courses were established somewhat later.

During the latter half of the 1990s, the ITA research increasingly specialised on various subsidiary areas; partly concentrating on various fields of

application and user categories (industrial production systems, care applications, advanced decision-making support, CSCW etc.), and partly in the form of stronger subject links at universities. The broad R&D programmes were replaced with more specialised and profiled efforts and the financiers increased in number as Wage Earner Fund foundations were established.

At the same time, the financiers' requirement for increased returns in the form of commercialisable research results was strengthened, a requirement which the ITA research, with some spectacular exceptions, had so far had difficulty satisfying.

Insofar as ITA research can be said to exist as a limited research field today, it is now being operated with considerably clearer goals in terms of future products and business development opportunities. The most important knowledge legacy to today's R&D funding bodies, including VINNOVA, is that businesses, technology, organisations and people must be encompassed by an overall vision; that is to say, viewed as part of an integrated innovation system.

Reasons for carrying out the impact analysis

Since both Working Life Development and Information and Communication Technology (ICT) are two of VINNOVA's fields of activity, it is important to study more closely how and with what impacts VINNOVA's predecessors worked with various types and forms of initiatives in this interface. VINNOVA runs a number of service-orientated IT efforts in which the user and organisation perspective is central, as well as several working life orientated programmes in which knowledge and technological development play a central role in the work science analysis. In both cases, the analysis of the previous ITA programme's impacts is worth observing.

Implementation of the impact analysis

The impact analysis was conducted in two stages. In the first, a relatively broad survey was made of the programmes, projects and research environments involved. A range of interviews with key people including financiers, researchers, suppliers and representatives of various user categories was conducted. The material was compiled in a preliminary study report which was used as the basis for design of the main study.

From the preliminary study, it was clear amongst other things that the research field was highly heterogeneous and that the documentation was variable in quality. One conclusion was that the main study must be limited to a certain number of programmes and that several methodological approaches should be used. In brief, this meant the analysis finally included

seven out of around 20 programme efforts during the period 1983-2002 and that the study was conducted in the form of sub-projects with differing organisation and methodology:

- An *in-depth survey study*, in which all projects in the selected programmes were analysed and classified in regard to three impact areas: impacts in working life, impacts in technological developments and impacts in the research system,
- A *programme study*, in which the results and long-term impacts (in all three dimensions) from two of the programmes (DUP and MDA) were studied on the basis of programme-specific aims and goals,
- An *institution-orientated study*, concentrating on how the research field had developed within implementing research departments and institutes in Göteborg and Linköping,
- An *application study*, investigating the research link to systems/programmes which had been awarded the "Users Award",
- An *actor-related study*, in which a number of interviews and a questionnaire to customers, developers and usability experts elucidated their contact with and use of the research, and
- A *workplace study*, with five reports on return visits to workplaces which had previously contributed to various development projects.

Both preliminary study and main studies were run together by the consultancy company ATK Arbetsliv in Stockholm. The evaluation team included people with different expertise backgrounds. In addition to ATK's own consultants all of whom had long practical experience in the field, there were contributions from researchers at the School of Computer Science and Communication at KTH and cognitive scientists from Linköping University. An experienced science journalist within the field carried out and compiled the workplace studies. VINNOVA and the evaluation team were also supported during both pilot and main studies by an external reference and expert group consisting of key Swedish researchers within the field and representatives of different receiver interests.

The analysis was based on a specially developed impact evaluation model. The basis of the model is a target, *the use value*, operationalised from the original impact goals since these were considered poor starting points for analyses. The use value then formed the basis for a valuation approach which seeks impact chains and accumulation and dissemination of knowledge/products.

The following supporting material and data was used:

- Interviews with about 100 people: programme managers, researchers, party representatives, clients, developers, consultants, usage experts etc., and opinions which emerged at seminars and conferences,

- Information from project catalogues, records from involved authorities, project descriptions and evaluations,
- Nominations for the Users Award,
- A literature study,
- Quantitative project data (number of projects, budgets figures etc.),
- Patents, citations, qualification index, theses etc, and
- A questionnaire survey for the Swedish Interdisciplinary Interest Group for Human-Computer Interaction (STIMDI).

Results of the impact analysis and demonstrated impacts

Divided into the three primary impact areas (working life, technological development and the research system), the strengths/successes and weaknesses/setbacks of the ITA research can be summarised as below.

Impacts in working life

Perhaps the most visible success was a broad national development of expertise above all on the client's side and amongst representatives of various user categories. The research also contributed to changing the profile of operators/users from passive/reacting to active and creative which in turn strengthened the Swedish tradition of accepting technology-driven rationalisation. In this way, the view of professional knowledge and expertise was changed which led to increased professionalisation of previously "simple" jobs.

On the other hand, despite the strong penetration on the policy level, the dissemination of local examples and experimental IT solutions was limited. There were only weak signs that programmes and projects have had positive impacts on working environment. Some projects often had far too weak a corporate financial basis or were too situation-specific to spread. Internationalisation and standardisation within the framework of a few dominant technological platforms contributed to the dissemination problem. The actors demonstrated the "difficulty of getting usability issues onto the agenda in development and procurement when timeframes and financial conditions were dwindling".[66]

Impacts on the technological development

The clearest positive impact on technological development was a number of new and internationally acclaimed methods and guidelines for user involvement in systems development (known as participatory design). This

[66] Tengblad, P., and Walldius, Å.,' *User-driven development of IT in working life. Impact evaluation of 20 years research and development into use of IT in working life*, VINNOVA Analys VA 2007:02, p. 69.

also contributed to increased professionalisation of “usability research” taking such forms as a rapidly growing number of newly trained ITA experts who soon found work within the expanding Swedish IT industry.

At the same time, the capacity to link commercial IT suppliers to individual projects and research prototyped was limited. Thus the number of systems and software programmes further developed commercially based of this research was rather small.

Later, with outsourcing and increased standardisation came a number of application obstacles, including method development. In practice, this meant major limitations on the scope of local user influence. The ITA research had difficulty linking up to these new development and supply structures. In individual research projects however, development-orientated researchers succeeded in achieving results in the form of both successful industrial collaborations and spin-off establishment of IT companies.

Impacts in the research system

The research efforts contributed to the growth of more interdisciplinary research groups/centres, many of which are still strong and active, and also to the establishment of training courses in these subjects at the majority of universities. Swedish research within the field also found major international recognition, not least of all for its strategy of involving end users in the research process and of conducting action research relating to implementation of the new technology out in the workplace.

If any difficulties and setbacks regarding the research and innovation system should be mentioned at all, once again it is the difficulties of creating effective links between research and further commercial development. At the same time, it can be said that this difficulty is true of many other research fields. The interactive nature of the ITA research is also seen as a problem, since academic requirements of scientific reporting come into conflict with industrial requirements for direct reporting and development.

In summary therefore, the study demonstrated that the research being studied was probably most significant as a driving force behind a range of expertise-building surrounding the opportunities and problems of IT development. At the same time, the report showed that the greatest problem for research in Sweden had been turning its research-based knowledge into new products and services. A number of reasons for this can be mentioned, including the fact that companies’/public administrators’ internal IT expertise and own development operation had largely been pared away during the 1990s. Systems are being developed elsewhere, often in other countries, which means that pure Swedish standards and models for development and usage are no longer realistic.

Lessons about methods

The impact study also highlights a number of important yet thorny method problems, some of which may be considered general and some more specific (or at any rate clearly demarcated) within the ITA field. Three examples may be brought out:

1 Difficulties generalising situation and time-dependent impacts from a low analysis level to a higher one, from the short time perspective to the longer. For example, it proved difficult to assess what long-term significance a locally successful technological solution in any individual project (of which there were several examples) subsequently had at sector level. The specific solution seldom spread, whilst knowledge about the problem and the principles of the solution were taken further, often along paths which were difficult to trace and via undocumented channels.
2 Difficulties assessing long-term economic impacts (in terms of both business economics and socio economics) of primarily behavioural and policy-influencing research. In the analysis, it was demonstrated that of around 700 million IT-associated working hours per year, around 5% were lost due to various kinds of usability deficiencies. Including only the labour costs, this is equivalent to around SEK 10 million. Would this economic loss have been any greater if the ITA research had never been conducted and would new, more effective efforts in the field yield corresponding outcomes?
3 General difficulty in judging impacts (other than economic) of social and behavioural science research whose results do not indicate or cannot be evinced and dated as new rules, laws, institutions, agreements etc. The analysis gives several instances of a clear change of attitude having taken place amongst a number of contributing actors in programmes and projects, but also shows how difficult it was to monitor whether these (often individual) strands of thought were taken further, accumulated and converted into practical action.

The traffic safety research 1971 – 2004

Origins of the research

The road transport system is responsible for some of the greatest health problems in modern society. The need for action has long been a politically important issue and even as early as the 1950s, it was clear that this growing problem demanded new research-based knowledge.

The Swedish Traffic Safety Council (Statens trafiksäkerhetsråd) was created for this purpose and was able to initiate a build-up of expertise within the field. Since that time, traffic safety has been a priority research field and the Swedish Transport Research Delegation (TFD, 1971-1984), Swedish Transport Research Board (TFB, 1984-1993), Communications Research

Board (KFB, 1993-2000) and VINNOVA (2001-) have continued to grant research funds to research environments started up as far back as when the Swedish Traffic Safety Council was in operation. This involved psychological research at Uppsala University and researchers at the then Department of Traffic Safety at Chalmers University of Technology and Department of Traffic Technology at Lund University, established during the time of TDF.

The Swedish state has also long prioritised research within the traffic safety field and support has been concentrated on a small number of key research environments.

Implementation of the research

The R&D efforts have been characterised by a broad approach (human, machine, environment) and an advanced scientific level. Breadth has been considered important in order to build a research platform for knowledge development for the many elements involved in the traffic system: traffic technology; road users' behaviour; traffic medicine; vehicle safety and injury prevention.

A key starting point, perhaps chiefly for KFB and its predecessors, was to support long-term knowledge-building research to serve the need for a common knowledge base for the field of traffic safety. This meant ensuring access to well-functioning research environments and competent researchers within fields of significant societal interest but with no natural responsible authority. Part of the financed research was theme-orientated to give freer scope in the research process, manage unexpected results and develop new ideas.

The research has also been characterised by a major exchange between the leading environments. This exchange has probably been simplified by the fact that they were not directly competing but concentrating on different parts of the traffic system. The research leaders have persevered and worked within their respective environments over a long period.

There has been an exchange both between environments and between environments and their most important customers. The technical aspect of traffic safety has already been described in the neck injuries study. The Traffic and Road section of the Faculty of Engineering at Lund University has worked closely with municipalities to be able to implement various demonstration trials. Naturally, all environments have also been key in regard to influencing the political sphere in terms of policy development, due amongst other things to their key roles in investigations, questioning and other political contexts.

Reasons for carrying out the impact analysis

Sweden has a unique and internationally leading position within the field of traffic safety and Swedish expertise is internationally sought after. Swedish visions and ideas surrounding traffic safety thinking have influenced international policy development and traffic safety has had major importance for the positioning and competitiveness of the automotive industry. Many different explanations for these successes have been put forward; one is that the research has been a key part of the success. However, its significance has never received more detailed analysis.

The analysis was also justified by the fact that for some years, some key areas of expertise within traffic safety research had been greatly underfunded and thereby threatened. This applied to such areas as behavioural research generally and the traffic technology research at Lund University. At the same time, there was an awareness that such expertise was a pre-requisite for the automotive industry's increasing emphasis on the development of what is known as active safety.

The analysis was also justified by VINNOVA's need to get a firmer hold on traffic safety research generally.

Implementation of the impact analysis and method

From the start, it was unclear what the analysis should be aimed at. Preparatory work was commenced when VINNOVA carried out exploratory interviews with the key individuals available within the research field and automotive industry. Independent experts were also interviewed, which strengthened the overview of the research field.

A senior advisory group with a background in research and the automotive industry was formed to support the framing and implementation of the analysis. This group assisted the impact analysis by participating in seminars relating to observations and challenges from the entire analysis.

A crucial step was the decision to focus on the researchers (the people) instead of things like projects or money. The analysis was therefore introduced with a survey of the important research environments. This would cover the period 1949-2005. At this point, it was uncertain whether it was possible to conduct the analysis at all. It was conducted by Anders Englund, who had worked in the traffic safety field over a long professional career.

The survey concluded that the analysis should concentrate on the period 1971-2004, i.e. a 33-year time perspective. Initially, the analysis was to relate to support from VINNOVA, its predecessors and the vehicle research programme, but also taking into consideration other financing essentially

from the Swedish Road Administration (Vägverket) and Swedish National Road and Transport Research Institute (Väg- och trafikinstitutet, VTI).

The strongest available expertise was sought in order to implement it and once again, the choice fell on the Institute of Transport Economics in combination with Professor Arild Hervik at Molde University, Norway. Linked with the TØI team was Rune Elvik, principal author of their internationally renowned survey, *The Traffic Safety Handbook*, of known traffic safety measures and their effectiveness including the extent to which individual measures have been based on research. The survey is based on more than 1,600 Norwegian and international research reports.

The methodological approach was to weigh analyses on three levels.

The first level was a survey of the total traffic safety research in Sweden. The intention was, based on a database of all projects supported during the period, to choose key research environments for further study. A problem arose here in that neither the Swedish Road Administration nor VTI could supply supporting data as to which research had been conducted further back in time, despite their best intentions and efforts.[67] The selection took place by "following the money", i.e. examining what scale of support various environments had received. The analysis showed that four dominant research environments had developed during the period, which had jointly received 59% of projects and 60% of funds granted. The database studies were supplemented by checks with experts in the field.

The environments were:

- The Department of Applied Mechanics at Chalmers University of Technology – concentrating on the needs of the automotive industry,
- The Department of Technology and Society at the Faculty of Engineering at Lund University – concentrating on traffic safety in local traffic environments,
- The Department of Psychology at Uppsala University and the Swedish National Road and Transport Research Institute – concentrating on human behaviour in traffic situations, and
- The Swedish National Road and Transport Research Institute – several foci; approx. 40% of VTI's research relates to traffic safety.

The second level was an analysis of the research conducted within the four dominant research environments.

[67] Thus, the database only included support from VINNOVA's predecessors and not the total support the field received during the period.

The third level comprised case studies relating to a selection of traffic safety measures: speed-reducing measures in population centres including roundabouts (LTH, Lund university); development of rear-facing child seats (VTI and Chalmers); development of better protection against neck injuries and side collisions (Chalmers); more effective police monitoring (Uppsala University and VTI) and the development and use of VTI's driving simulator (VTI). The scope of the analysis meant that other important Swedish research fields had to be excluded.

The actual impact analysis was conducted in two stages with gradual clarification of the direction of the analysis. The advisory group provided valuable contributions in discussions on existing empirical evidence and tentative conclusions.

The studies of research environments resulted in attempts to demonstrate what impact the investments had had in different dimensions: in the form of academic results; socio economic impacts (economic impacts on industry and society); and impacts on knowledge development in society plus internationally (including changes in society's way of thinking).

The methodology for producing impact is based on the approaches produced in the neck injuries study. This means value measurements by using cost/benefit analyses of the type used for investing in infrastructure and explanatory descriptions of more indirect impacts such as knowledge dissemination and altered thinking.[68]

Thus the analysis worked on both the macro level; the cost/benefit model and the micro level in the form of case studies on research environments and fields for example.

The following supporting material and data was used:

- Written self-evaluations from selected Swedish research/occupational environments,
- Interviews with representatives of selected Swedish research/ occupational environments,
- A document study (including previous reports and a "non-traditional *peer-review*" of the research, parliamentary bills, EU documents on traffic safety, international findings etc.),
- A database of project information for all traffic safety related projects in road traffic funded by VINNOVA, VINNOVA's predecessors and within pff between 1974 and 2004, and

[68] For a more detailed description of the cost/benefit discussion, see the neck injuries study.

- Statistical bases for calculating societal impacts.[69]

Results of the impact analysis and demonstrated impacts

The analysis was able to indicate a number of clear impacts:

- VINNOVA's funding had resulted in a system of four central research environments which complemented each other well – what the analysts called "a good research circle". VINNOVA's other funding had complemented the stated environments or attempted alternative research approaches which had not gone any further,
- The research had made a major contribution in that 96 people per year avoided being killed, also some contribution to a further 385 people avoiding being killed. In addition to this, for every person killed, on average 10 people are severely injured and 100 slightly injured,
- Significant socio economic returns had been achieved – a summary of only those measures appearing in the five case studies showed a socio economic return of approximately SEK 20 billion (current estimates of adopted safety measures),
- There had been significant corporate returns within the automotive industry, chiefly as impacts of the Chalmers research. As mentioned in connection with the neck injuries analysis, traffic research has proved important to the Swedish car manufacturers' position within their American-owned groups,
- Good intrascientific internationally accepted research, and
- The research had had impacts on society's thinking on traffic safety, expressed amongst other things in Vision Zero (governments goal of eventually no deaths in traffic). This new thinking has also spread internationally.

The analysis also observed that the division of responsibility for traffic safety research which took place in 2001 has had unfortunate impacts on two of the observed environments.

[69] Amongst the most important were SIKA's (Swedish Institute for Transport and Communications Analysis) standardised costs for deaths and serious and slight traffic injuries; Swedish accident statistics and analyses of various factors' contribution to traffic safety, vehicle statistics and discount rate.

5 Conclusions on impact analyses

A major part of this report has dealt with the impact analyses which VINNOVA has conducted since 2003. This is because, on the one hand, important general lessons can be drawn from the development of the specific fields of expertise, research fields and instruments which were analysed; and on the other, VINNOVA's unique approach can provide methodological inspiration to clients and implementers of evaluations and impact analyses in other fields.

The requirement by VINNOVA's management and subsequent assignments from the Ministry of Enterprise, Energy and Communications for VINNOVA to conduct two impact analyses a year mean that, not only are assignments placed with external consultants but an entirely new way of working has had to be developed; one in which impact logic assessment, monitoring, evaluation and impact analysis are regarded as integral parts of a cohesive impact evaluation process. Prior to the requirement to conduct impact analyses, the major proportion of the analysis activity aimed at internal processes was primarily evaluation and somewhat monitoring. In addition, these were mostly regarded as two distinct activities.

In most cases, the task of the evaluations conducted was to check goal fulfilment (i.e. monitor output goals) and check that programme activity including leadership was working well or whether there was opportunity for measures. The monitoring in turn was decentralised to programme management level and often had a project focus not primarily aimed at post-project impacts. With the requirement to conduct impact analyses, it became clear that an approach like the one presented in this report was necessary.

It is important to note that a collected approach to impact logic assessment, monitoring, evaluation and impact analysis as discussed in this account also presupposes a common starting point and a common attitude in terms of the activities conducted to monitor, evaluate and study the long-term impacts of VINNOVA's initiatives. A well-implemented impact logic assessment also leads to conclusions on which information needs to be gathered during the course of a programme as well as what the main evaluation issues will be in various evaluations.

What have we learned? Policy lessons from implemented impact analyses

This section gives an account of what may be considered the major lessons learned from the impact analyses which have been conducted, initially on an

overall level and subsequently in regard to those sections represented by each of the analyses. The first major lesson is that, taken together, the analyses have been able to illustrate how state financed R&D initiatives can lead to significant impacts on research and the research system, on industry's innovative capacity and innovations and in the wider society. Another lesson is that the impact analyses relating to activities in a longer time perspective and generally in programmes broader than individual ones can be successfully implemented.

The analyses have broadened and deepened understanding of the research which VINNOVA funds, how R&D activity has taken place and in what essential ways the research has benefited industry and society as well as the research and innovation environments. The analyses thus complement the approach within the research which investigates overall impacts on growth of R&D. It would be valuable if both these approaches could draw closer together.

Where it has been possible to study the complete context, VINNOVA's impact analyses have been able to demonstrate the socio economic benefit of accomplished efforts, as well as the fact that the various actors' ways of thinking and relating within the field itself have changed. The efforts have contributed to the creation of value in Swedish industry in the form of increased competitiveness, as well as the creation of Centres of Excellence in research and innovation.

A further lesson learned is that efforts in research are a necessary but far from adequate condition for achieving desired impacts on sustainable growth. Over and above this, goal-orientated initiatives need to be implemented in order to generate innovations. This takes place in a continuous interplay between the actors. VINNOVA has further deepened its knowledge on the interaction between actors which have different resources and roles, or which independently own and control their part of the conditions for facilitating positive development.

In the analysis of competence centres, a number of unexpected impacts emerged in a broader range than had been thus far anticipated. The significance of research-based expertise was highlighted. The fact that industry, as a result of the programme activity, could employ trained researchers who were particularly well prepared for working in industry was valued the highest by companies. This conclusion contains another dimension than the current pattern, which says that research ends in discoveries or other results which are then commercialised.

According to the analysis, VINNOVA's competence centres have been characterised by a high level of scientific quality. They had a significant

influence on the Swedish research system by contributing to the development of openness on the part of involved academic establishments to collaboration with industry; this may be considered an essential policy level initiative early on in a major process of change. For VINNOVA's part, a significantly clearer picture simultaneously emerged of what a competence centre is; an understanding which came to important use in such things as the design of VINN Excellence Center.

In the neck injuries analysis, it was possible to exemplify how research motivated by industrial and social need could be initiated, how research work runs through a number of stages in collaboration with various competences and how accrued basic knowledge is further developed in an interplay with development expertise in industry. The overall picture is one which agrees well with established theory of innovation systems. Research in itself does not lead to productification. Rather, it provides a contribution which is occasionally decisive in complex innovation processes.

The significance of the research for knowledge-building within industry is also clearly illustrated in this analysis. Autoliv would presumably not have had a research department, if the Chalmers group had not existed. The car industry employs trained researchers from that department. The position of Saab and Volvo as group specialists within the safety field has been strengthened as a result of the analysis.

The analysis also illustrates the time perspective in a successful innovation process, characterised by good conditions including an established cluster around the automotive industry. The major safety and commercial breakthrough only came 30 years after the research was commenced. Ongoing needs-driven basic research has contributed to: further industrial and societal benefit in the form of new and successively improved products; the employing of PhDs within the automotive industry; and the fact that improved neck injury protection is now being introduced by other car manufacturers. Together, these factors have improved safety for motorists all over the world.

In the traffic safety analysis, it has been possible to describe how a cohesive research system - a good research circle - has been built up within an entire research field. This build-up is described in the 30-year perspective. An important part of the explanation of this is thought to be that the responsibility for research funding was joint. It was therefore possible to act on the basis of an overall picture.

The analysis describes how a research environment (Chalmers) contributed to product development and increased safety within the automotive industry. It also describes how research at the Faculty of Engineering at Lund

University led to considerable increased safety as a result of various measures introduced in the municipal traffic environment; innovations which were utilised by actors other than those in the manufacturing industry. It also covers how behavioural research within a third research environment at Uppsala University has yielded major impacts on traffic safety by influencing opinion, as exemplified by things like Vision Zero, police monitoring strategy or the design of road crossings. Several of these thus comprise examples of fields in which innovations have been utilised by actors other than those in the manufacturing industry.

The results of the analyses have proved valuable at policy level; amongst other things, it has been possible to use them in the work for the 2005 research proposal, in the establishment of the VINN Excellence Center programme, establishment of the SAFER safety centre and so on.

How did we do? Method lessons from implemented impact analyses

From the rundown in Chapter 4 of the impact analyses accomplished by VINNOVA, it is apparent that the work of selecting and carrying out impact analyses has had and does have the nature of an ongoing learning process. The following section constitutes an attempt to summarise and reflect on some of the general lessons VINNOVA has learned so far.

Conditions for a successful impact analysis

Expertise. Requirements for disciplinary and evaluation expertise seem greater in the impact analyses compared with ordinary evaluations. A vital condition is therefore access to sufficiently capable and competent evaluators with both subject or disciplinary expertise and evaluation expertise. However, it is rare for both subject and methodological expertise to coincide in individual people or even individual organisations. VINNOVA's method of solving this with such things as the neck injury and traffic safety analysis, was to assemble a team consisting of people with different expertise.

Access to source material. Written documentation linked to the activity to be analysed, for example proposals, programme descriptions, decisions, completed evaluations and other documentation produced during the course of the programme is naturally of major importance. If this information is also gathered in a structured fashion in archives or databases, the prospects are improved and resource consumption reduces considerably. For example, in the traffic safety research impact analysis, a complication arose when actors (due to inadequate archiving routines) had considerable difficulty describing their initiatives. At least equally as important as access to written

material is the availability for interview of individuals with experience from the relevant operation. Occasionally, these needs conflict with the requirement for sufficient time to have passed before the full impacts of the operation are felt.

Acceptance by participating actors. For the three impact analyses which studied a field of technology or research,[70] VINNOVA chose to appoint a reference group consisting of representatives from academia, industry and organisations. In the main, these reference groups consisted of people who were themselves more or less participants in the events being studied in the analysis. Naturally, the chief reason for this was that an opportunity could thus be created for the people involved to "remember together".

In addition it is of vital importance to have proper processes for goal setting, data acquisition and monitoring, an ability to present impact results in a theoretical framework as well as in plain words, and a dedicated participation from VINNOVA management and administration.

Experiences from the implementation stage

With the exception of the first of VINNOVA's impact analysis reports, the impact analyses conducted were conducted by external implementers.[71] There are therefore two clear fields to manage with method lessons: one relating to VINNOVA's work initialising the analyses (choice of evaluators, control of the work etc.) and one consisting of the investigators' work of conducting the actual study.

Initiation of impact analyses

Despite the differences between the studies, there are certain general implementation points which apply to VINNOVA's staging of impact analyses:

These studies are always conducted by external evaluators. This is intended to safeguard a certain amount of independence and objectivity. Using people outside VINNOVA also contributes to a greater degree of free thinking in regard to methodology and anticipated results. One problem in that context is that the complexity which characterises the impact analyses means the organisation, or more usually the people, who conducted an impact analysis possess valuable knowledge which VINNOVA needs to employ on various occasions. However, overly frequent use of the same

[70] Applies to *User-driven development of IT and working life 1982-1997*, the traffic safety research and neck injuries study.
[71] In the first impact analysis, *Impacts of VINNOVA's predecessors' support for needs-driven research*, VINNOVA personnel conducted two out of four sub-studies.

organisation as implementer can raise doubts as to independence. This underlines the importance of widening the circle of potential implementers.

To date it has taken between 18 and 24 months to conduct an impact analysis. An ambitious impact analysis takes a long time to implement; approximately two years based on VINNOVA's experience so far. This time consumption is partly due to the extent of the field of investigation for the analysis but also because the analyses so far conducted have had elements of method development. In addition to demonstrating impacts, VINNOVA and the investigators have also been interested in how the investigation methods are working, which has probably lengthened the implementation time. It is hoped that the method development which took place and the fact that there are now a number of templates in the form of completed analyses will mean that project times can be reduced in future.

Impact analyses have been divided into pilot studies and sub-projects. Experience shows that implementation of an impact analysis is both more effective and the end results better if the work is divided up into several stages and introduced by a pilot study. Pilot studies have been used to sound out the field, set up hypotheses, provide ideas on a suitable method, create contacts with necessary key people etc. However, the most important function is for potential implementers to be given an opportunity to familiarise themselves with the field and with available source material and thus form an understanding of how a main study might conceivably be planned. There have even been cases where pilot studies concluded that it was impossible to conduct an impact analysis for the field concerned, or that it was associated with too many method or resource problems, whereupon VINNOVA has decided not to proceed. To facilitate a focus and deeper understanding in the main studies, these have occasionally been divided up into several sub-studies.

The approach of the analyses in regard to the investigation subject has had major significance to the content of the study. In the impact analyses, the investigators have attempted to monitor either people, organisations or cashflow. Which perspective is chosen depends partly on which of these have been practically possible to study.

Operationalising of impact analysis

As has been clear, the approaches to conducting impact analyses have varied greatly. However, three principal approaches for identifying and appraising impacts can be distinguished:

Descriptions of the field in the form of embedded accounts aimed at deeper understanding. One advantage of this approach is that they can often be correlated with overall programme aims and political goals.

Furthermore, they indicate the complexity within a studied field and make it easier to focus on what the actors consider important impacts, rather than verifiable impacts.[72] A disadvantage is that the economic growth dimension disappears since the approach seldom or never results in figures or economic values. The fact that it is based on interviews with "those who were there" may carry a risk of distortion.

Reporting of individual successful examples (case studies/success stories). This clearly limited approach means that economic estimates are possible. "The profits" are often compared with the expenses of the programme and indicate whether the effort has been successful. By indicating impacts in one or more specific cases, a "minimum impact" is given. In this context, the case study approach is interesting. Apart from it attempting to deal with questions on the contribution to economic growth (which is after all fundamental to VINNOVA) it is also straightforward in that it does not aim to show the whole picture. Instead of identifying total growth impacts, economic outcomes from a few successful examples are related to the total costs of an effort. It becomes clear that the revenue side comprises only a subset of a number of positive impacts. A kind of minimum impact value is thus achieved.

The positive thing about this approach is that it is a relatively easy model for readers to take in and, due to its relatively modest claims, the argumentation is clear. It is also a manageable approach in terms of time. the negative side is that it only provides a limited picture (as distinct from a specific picture) and only a few successful cases are included. Furthermore, the approach does not provide opportunities to capture system impacts, nor does it give a cohesive picture of the field being studied. The approach has proved suitable for preliminary studies and as a complement to more ambitious analyses.

Socio economic calculations. One advantage of the approach is that it shows socio economic system impacts. It also has a high level of scientific integrity, since it is based on acceptance methodology in the form of cost/benefit analyses within the national economy. One problem is that it only works when basic data is available, i.e. the field has had some form of well-developed system of data capture. In addition, the analyses are based on a battery of assumptions and the conclusions are only valid if there is sufficient material to support them.

[72] There is always a risk that an investigation will concentrate on the type of impacts which are easy to find; where data is available and investigators see a navigable path. However, it is not certain that these demonstrable impacts are the most important. A narrative study is not as sensitive to this type of distortion since it does not concentrate on numbers.

It is interesting that it is precisely the socio economic calculations which have received by far the most attention from VINNOVA's impact analyses, both for results and the methodology. As an approach, they form a contrast to the descriptions. The calculations work with averages, assumptions etc. in order to arrive at aggregated volumes. They can never entirely reflect a specific case but nevertheless provide an overall picture and give easily communicated results and conclusions. The descriptions often give both specific information and provide in-depth understanding.

Use of the "upstream approach". In some cases, the choice to study the impacts in a given field have been based on a perception that there have been successful examples in that particular field. Subsequently, analysts have sought to find links between successful examples and the efforts which VINNOVA or its predecessors made. Thus, the starting point is the successful examples not the efforts; hence the name for the approach. Naturally, this course of action can be criticised, but it has proved a good way of obtaining an analysis of a number of positive development processes from which general conclusions can be drawn. With the same approach, it is not impossible to imagine starting in a field where the sense is that the development has not been as positive.

Strengths in VINNOVA's impact analysis approach

From previous discussion, it has emerged that it is very difficult, if not impossible, to capture the total impact of the activity which VINNOVA and its predecessors conducted. The problems are both practical in the form of lack of data, unclear recollection of events which may be up to 30 years old, delimitation of the field which is to be studied and so on; they are also theoretical in terms of what may be said to constitute an impact, the appearance of causality chains etc. Despite these problems, which are well known in the evaluation literature VINNOVA, in partnership with knowledgeable analysts, has succeeded in developing types of analyses which are well received and considered as reliable in the Swedish innovation policy discussion. Some of the strengths in the impact analyses are brought out below.

Problem-driven approach with clear perspectives. The problem which has been the focus of all impact analyses is how the impacts of various kinds of initiatives conducted by VINNOVA and its predecessors over a long period of time can be described and appraised. To make this high ambition manageable the analysts, ever since the neck injuries analysis of 2004, have concentrated on three different impacts fields: impacts on research, impact on industry and impact on society (Triple Helix). Apart from these dimensions being a good reflection of VINNOVA's assignment, it has involved a clear focus and structuring of the analysis, whilst the

subdivision has been an efficient educational framework for presenting results. The division of the impact field into three has also made it clear that it is whole systems which are analysed, and that the impacts cannot just be ascribed to the initiatives made by VINNOVA and its predecessors.

Use of established theory and method. Another strength is that the various sub-analyses which jointly make up an impact analysis are based on accepted methods with a high level of legitimacy. For example, in both the neck injuries study and traffic safety study, cost/revenue analyses were used to calculate the socio economic gains of reduced numbers injured and killed in traffic resulting from initiatives based on research funded by VINNOVA and its predecessors. One important reason for the reliability of these conclusions is the type of calculations used to make infrastructural investment decisions. Similar methods are also planned for use in calculating socio economic gains from improved health in the coming impact analysis of the life science field. Another example of an established method being used is bibliometric analyses as a basis for conclusions on scientific excellence.

Multi-methodological approach. The three different methodological approaches, impact on research, industry and society respectively, are called for since these areas are very different in terms of their characteristics, structure and development logics. Depending on which field or system is being analysed, this has meant a number of different methodological approaches have been required in order to give a cohesive picture of the impacts. By way of an example it can be mentioned that the traffic safety study, apart from cost/revenue analyses and bibliometric methods, also contains text analyses of policy documents in Sweden and at EU level in order to capture impacts of how concepts developed within traffic safety research have influenced legislation. Another example is naturally the analysis of User-driven Development of IT in Working Life 1982-1997 which required great creativity regarding composition of methodological approaches in order to comment on the impacts of the programmes studied.

Transparency. Naturally, the choice to mix different methods and source material in order to capture and appraise complex impacts connections can be criticised. For this reason it has been important to VINNOVA that the analyses which VINNOVA has commissioned others to conduct have been characterised by transparency concerning assumptions and procedures. The aim has been that even those without special knowledge of the methods being used will be able to understand how the conclusions being presented were reached. Although it is possible to criticise individual conclusions, the various sub-analyses taken together should constitute a sufficiently strong whole so that the “story” which the impact analysis is telling stands out as reliable.

Challenges to future work with impact analyses

As well as the work of integrating VINNOVA's work with impact logic assessment, monitoring, evaluation and impact analyses, there are a number of future challenges directly linked to implementation of the impact analyses.

The impact analysis approach and research in R&D, innovation and growth

So far, innovation researchers in general and Swedish ones in particular have not been directly involved in any of the impact analyses which have been published by VINNOVA. However there has been a certain indirect influence due to their presence in the literature lists in the analyses produced. This is also in the process of being changed since during 2007 the Swedish Institute for Studies in Education and Research (SISTER) conducted a study of the impacts of seed financing activity by VINNOVA and its predecessors.

Innovation researchers at *R&D, Innovations and Dynamics of Economies* (RIDE), Chalmers University of Technology will probably constitute one group of implementers of the study of the impacts of selected efforts in the life science field being conducted in 2008. Despite these positive signals, VINNOVA should work actively to interest innovation researchers in carrying out all or parts of future impact analyses. This applies in no small measure to researchers at the four Centers of Excellence which VINNOVA funds under the "Innovation Systems Research on R&D and Growth" programme. Apart from widening the circle of potential implementers, it is important to bring the impact analysis work and the research closer together so as to gain new theoretical and methodological ideas from independent researchers, enabling the acquisition and didactic introduction of more complex impacts.

Ongoing methodological development

As emphasised above, expertise on the part of external analysts is crucial for impact analyses to achieve high-quality. However, it is important to emphasise that the incidence of strong teams (as in the case of the neck injuries study and traffic safety research) is probably the exception which proves the rule. The result is that the future work of finding competent teams of analysts will involve major challenges.

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VINNOVA´s mission is to promote sustainable growth
by funding needs-driven research
and developing effective innovation systems

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