Competitiveness through internationalisation

Evaluation of means and mechanisms in technology programmes

Technology Programme Report 10/2004 | Evaluation Report

TEKES

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Evaluation of the means and mechanisms for promoting internationalisation in technology programmes

Evaluation Report

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Technology Programme Report 10/2004
Helsinki 2004

Tekes – your contact for Finnish technology

Tekes, the National Technology Agency, is the main financing organisation for applied and industrial R&D in Finland. Funding is granted from the state budget.

Tekes' primary objective is to promote the competitiveness of Finnish industry and the service sector by technological means. Activities are aimed at diversifying production structures, increasing productivity and exports and creating a foundation for employment and social well-being. Tekes finances applied and industrial R&D in Finland to the extent of nearly 400 million euros annually. The Tekes network in Finland and overseas offers excellent channels for cooperation with Finnish companies, universities and research institutes.

Technology programmes – part of the innovation chain

The technology programmes are an essential part of the Finnish innovation system. These programmes have proved to be an effective form of cooperation and networking for companies and the research sector for developing innovative products and processes. Technology programmes promote development in specific sectors of technology or industry, and the results of the research work are passed on to business systematically. The programmes also serve as excellent frameworks for international R&D cooperation. Currently, 35 extensive technology programmes are under way.

ISSN 1239-1336
ISBN 952-457-157-9

Cover: Oddball Graphics Oy
Page layout: DTPage Oy
Printers: Tammer-Paino Oy, Tampere 2004

Foreword

Finnish technology policy is designed to strengthen the competitiveness of Finnish industry and the service sector by technological means. International cooperation and strategies have grown in importance when planning research and technology development actions as well as innovation activities on policy level. National and international measures and support mechanisms have been created to support developments in internationalisation of research and development.

Different types and concepts of technology programmes have become Tekes main tools to enhance competitiveness of industry and service sector. The programs have included a diverse range of support mechanism for internationalisation of activities. Tekes funding criteria's also aim at directing internationalisation. Collaborative schemes as the EU Framework Programme, EUREKA, COST, the Nordic cooperation schemes and bilateral programs have strengthened in significance for major industry actors as well as research organisations.

The main focus of this evaluation was to analyse and display structures and impacts of different types of programs and support mechanisms in enhancing internationalisation. The evaluation consisted of three main tasks:

- A literature and case study to deepen the understanding of current changes in policy strategies in enhancing internationalisation of research and development as well as impacts of these strategies.
- Impact assessment of current program strategies and structures. How has the programs affected internationalisation of research and development? Which are the mechanisms for success in enhancing internationalisation? What are the additionalities of services provided by the programs? What are the barriers and limitations of internationalisation of research, technology development and innovation?
- Assessment of strategy and suggestions for structural and functional development. To whom should different program types be directed? What kind of instruments could be used to enhance and activate companies and research organisations as well as clusters and innovation environments? How can the internal networking in programs be built? How should programs be organised?

The evaluation shows that internationalisation of research, development and innovation activities in collaborative programmes can generate extensive competitiveness and push internationalisation of participants through knowledge transfer, cooperation, building community identities and market integration. Still there are quite few indications of truly dynamic and open cooperation in technology programmes as well as international schemes. The strategies of national innovation policies and systems thinking are challenged by the rapid changes posed by globalisation.

Dynamic platforms and enabling spaces for innovation and knowledge transfer with a global focus should be further developed. Time specific coordinated structures as technology programmes can reduce uncertainties for participants, especially for small and medium size companies, and enhance the creation of community identity without lock-in effects. For small countries with only few multinational companies strategically coordinated and internationally integrated technology and innovation policy mechanisms as technology and innovation programs will constitute a key element for future competitiveness.

The evaluation was carried out by Kimmo Halme (Advansis Oy), Sami Kanninen (Advansis Oy), Tarmo Lemola (Advansis Oy), Erkko Autio (Iwory Tower Advisors Ltd.), Erik Arnold (Technopolis Group Ltd.) and Jasper Deuten (Technopolis Group Ltd.). A steering group was formed to support the evaluation, consisting of the Tekes evaluation group (Robin Gustafsson and Eija Ahola) and representatives of Tekes internationalisation and program activities (Petri Peltonen, Kari Komulainen, Juha Linden, Juha Tanskanen, Kari Tilli and Pertti Heinonen). The steering group members have with own views and expertise supported the evaluation profoundly.

Tekes wishes to express its deepest gratitude to the evaluators for their profound and excellent work. Their contribution has generated valuable results and conclusions on the impacts and mechanisms of technology programs on internationalisation of research, technology development and innovation that will be of great use for future strategy development. Special thanks are expressed to all parties involved in the evaluation process.

February 2003

Robin Gustafsson and Eija Ahola

Tekes, The National Technology Agency

Executive summary

The challenge of internationalisation

Internationalisation of Finnish research and development work is a challenge that has been receiving increasingly attention and is a specifically stated objective in Tekes strategy. Technology programmes are among the key instruments for Tekes to achieve these **strategic objectives**.

This report presents summarised findings of an evaluation that was carried out to determine impacts and mechanisms of national technology programmes in enhancing the internationalisation of research and development work, innovation and technology-based firms. The evaluation covers all, **altogether 64 technology programmes**, which have been, or remain to be completed within the period of 2000–2004.

Due to the exceptionally large scope of this evaluation and the complexity of the internationalisation as a phenomenon, a multimethod approach has been applied; a combination of international literature review, impact assessment of internationalisation in technology programmes by means of a survey, as well as an analysis of case programmes. This was complemented with a construction and analysis of a programme database consisting of all the available documentation on the technology programmes.

International comparison

Six case study countries were selected that appeared likely to provide relevant examples. Most are small countries since the industrial logic for internationalisation is more pressing in small than large countries: **Sweden, Germany, Switzerland, Ireland, the Netherlands** and **Estonia**.

Analysis of these countries suggests that there is a fairly high level of activities aiming to promote inward investment and inward mobility of researchers. In contrast, there is little specific activity aiming to help domestically operating research units and companies expand their activities abroad. The great weight of internationalisation activities continues to lie in the area of the established international networks and programmes, and national supports to participation in them.

Mainstream R&D and innovation funding activities continue only marginally to be touched by explicit changes directed at internationalisation through cross-border arrangements. Participation in international networks was seen as the most normal way to promote internationalisation – suggesting that the most important way internationalisation measures are being put in place is through evolution of the traditional European networks, not least the Framework Programmes.

Documented internationalisation

To address how internationalisation factually takes place at technology programmes, three stages have been distinguished in the process or a life cycle of a programme; first is the ***definition stage***, which may often take up-to one year, then comes the programme ***implementation stage*** lasting typically for 3–4 years and after the formal completion of the programme comes the ***follow-up stage*** without any distinct time frame.

In each stage of the programme, there are issues and openings for international co-operation, and as the programme progresses, the number of such openings typically increase. However, many strategic decisions, which lay the ground for the type, direction and magnitude of international co-operation at later stages, are made already at the design and definition stage.

An average programme in the evaluation sample has 55 projects and a budget of 27 million euros. More than half of the programmes had stated inter-

nationalisation objectives. The most common rationale for internationalisation was related to upgrading Finnish competence, with approximately 40% of the programmes focusing on this aspect.

The most common internationalisation activities have been the inclusion of joint research projects, participation in international seminars and invitation of international experts as consultants or seminar speakers, which were stated for approximately half of the programmes. International monitoring, feasibility or market studies were reported in 40% of the programmes.

Most programmes had international aspects even if they were not stated among programme aims. For two thirds of the programmes Europe or regions of Europe were among the geographic focus areas of internationalisation. U.S. and Canada were focus areas in half of the programmes, while 45% had some activity towards Far East.

The documentary material includes **relatively few assessments on the success of internationalisation** in the programmes. In general, the activities supporting internationalisation have not been very pronounced in programmes, resulting that the stated impact has also remained low.

Internationalisation profiles

Nine technology programmes with different objectives and approaches to internationalisation were selected from the sample for deeper analyses. These were FFUSION2, GPB, iWELL, KENNO, KESTO, NAVI, PRESTO, SPIN and TESLA.

Four partially overlapping approaches to internationalisation were identified on the basis of the rationale, objectives and activities carried out to this end. These were **big science programmes**, with internationalisation as their raison d'etre, programmes with internationalisation as a means for **up-grading and complementing national expertise**, programmes **exploiting Finnish competence** and supporting SMEs to global markets, as well as programmes responding to **regulatory changes** and opening markets.

Unit-level internationalisation impact

It is difficult for the technology programmes to generate added value to international co-operation of individual projects, as far as it concerns their content. The added value of a programme is often found from encouraging and facilitating international co-operation, through closer networking between the participants, increasing the **awareness** of the field of industry or research on target areas, as well as to the improved **credibility** of the participants as selected members of a national technology programme.

Universities and research institutes appear to depict greater internationalisation readiness in technology programmes as compared to companies. They also appear more amenable to internationalisation activities and related impact generation. Universities and research institutes also have an important role as mediators of cross-border influences to domestic industrial R&D processes by providing linkages to academic expertise and leading-edge companies both domestically and abroad.

The unit-level empirical data suggests the dominance of supply-side cross-border influences in internationally-oriented technology programmes. The data also suggests the dominance of a "**home-base leveraging**" internationalisation mode, in which the bulk of R&D is carried out domestically, under domestic formative influences. While Tekes traditionally excels in linking domestic research to domestic industrial demand conditions, there appears to be a gap in linking to foreign demand conditions – an important prerequisite for internationalisation success in sectors where domestic industrial demand is not highly sophisticated. Tekes appears to remain challenged to develop approaches for fostering the "home-base extension" mode of internationalisation, in which firms connect to foreign sources of R&D and enter into cross-border R&D collaborations.

Policy implications

For the efficiency and effectiveness of international co-operation, and ultimately for the competitiveness of Finnish research and industries, the aims and approaches for internationalisation in technology programmes should be elaborated into a **clear strategy**.

Strengthening national competence would suggest at least two amendments for technology programmes. First, there should be programmes with **longer perspectives and ambitious agenda**. Second, technology programmes should focus at developing national **competencies** in the most appropriate way, even if it means **opening** the programmes for foreign participants.

Building leading edge research requires vision, commitment, many years of hard work, sufficiently resources and some good luck, too. In many cases, it is quicker, cheaper and less risky to build competencies by accessing existing expertise. To this end, Finnish competencies could be stronger and research funding used even more efficiently, if international **co-operation and outsourcing** were more actively used.

The internationalisation typology defined in section 7.2 could serve as one basis for the design of appropriate tools to better support each specific type of internationalisation in technology programmes. However, the first priority with this respect should be to increase the **amount of resources allocated to internationalisation** in each stage of the technology programmes.

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1 Introduction

1.1 Objectives and structure of the report

This report presents the findings of an evaluation that was carried out to determine impacts and mechanisms of national technology programmes in enhancing the internationalisation of research and development work, innovation and technology-based firms. This implies analysing the operation of programme concepts as well as evaluating the impact of programme-level measures. The specific objectives of this evaluation were to

- Review and analyse the latest research and international experience regarding internationalisation of research and development
- Evaluate the impact of current technology programme structures and available instruments on the internationalisation of research and development
- Assess Tekes strategy for internationalisation in technology programmes
- Provide recommendations for operational and structural development of the technology programme concept from the point of view of internationalisation.

To carry out the stipulated objectives, the evaluation work has been divided into three parts; international literature review, impact assessment of internationalisation in technology programmes, as well as to strategic analysis. During the conduction of the work, some additional tasks were also included into the evaluation. A programme database of all the available documentation on Tekes technology programmes was gathered and analysed. Furthermore, nine case studies were introduced, in order to enlighten the varying nature of internationalisation mechanisms.

The report at hand has been structured as follows:

- *Chapter 1* provides the conceptual and theoretical framework for the evaluation, as well as explains the evaluation methodology employed
- *Chapter 2* reviews the trends and issues impacting internationalisation and how they influence Tekes and its technology programmes
- *Chapter 3* reviews the literature on internationalisation of research and development, as well as provides examples of how internationalisation has been addressed in six different countries and what kind of mechanisms are at use to promote it
- *Chapter 4* describes the internationalisation process and analyses how internationalisation aims, activities and results of technology programmes have been documented
- *Chapter 5* describes and analyses the internationalisation aims, mechanisms and activities in nine case programmes
- *Chapter 6* presents the outcomes of survey results on all evaluated programmes as well as the project-level results of the selected case -programmes.
- *Chapter 7* concludes the report by presenting summarised findings of the evaluation and the policy recommendations regarding future technology programmes.

1.2 General framework for evaluation

Internationalisation of R&D poses two important questions for the assessment of the Finnish R&D system. First, how successful is Finland in international research markets? How well do Finnish operators (Tekes, national technology programmes, participating organisations as well as the R&D projects themselves) get access to international re-

search markets, institutions, business opportunities, and other relevant resources? *How internationally successful are the programme and project outcomes?*

Second, how well are the Finnish structures, operations and operators integrated to the international context – in this case particularly, *how competitive are Tekes and its technology programmes in the international arena, measured as their ability to attract the interest of the best institutes, the most advanced development projects and the most competent companies and researchers to join them?*

Several levels of internationalisation could be distinguished. These include, inter alia the *systems level*, the *institutional level*, the *operations level* and the *substance level*. Here the systems level refers to the collaborative functioning of a national or regional innovation system as a whole, the institutional level to Tekes strategy, operations level to the various mechanisms available and actions carried out for internationalisation (in particular the technology programmes) and finally the substance level to the actual focus, content, quality and impact of international activities. As far as it concerns internationalisation at the systems level, this falls out of the scope of this evaluation.

Equally, one can categorise the intensity of internationalisation into several stages, first being the *awareness of international developments and openings*, the second carrying out *international collaboration* and the most intense being the full *international integration* of activities, mechanisms or strategies. To these ends, Tekes and its technology programmes are likely to have different roles. The assumption was that Tekes, due to its participation in international networks and organisations, is reasonably well aware of European and other international technology policy related operations and developments and tries actively to position itself within that context. The degree of international integration of Tekes (e.g. the opening of national funding for foreign participants) will depend on national technology policy decisions and the progress of European Research Area (ERA) in that respect.

For the Tekes technology programmes, the awareness of other similar programmes and like competence abroad is crucially essential in particular at the programme definition stage. How well that is

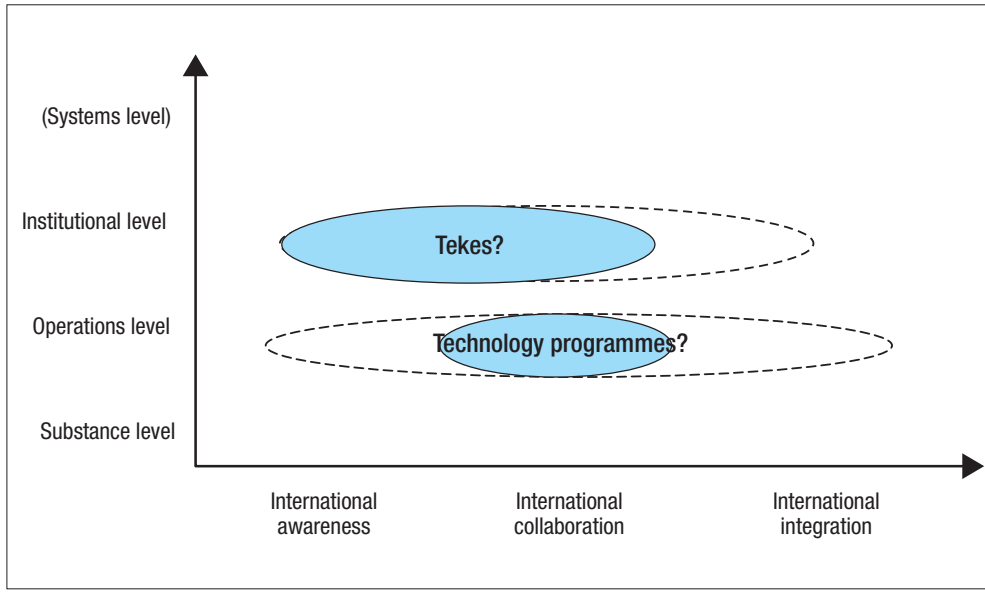

Exhibit 1. Dimensions of internationalisation for technology programmes

gathered and systematically analysed and taken into account is one subject of the assessment. Similarly the question of how far and by what means should the programmes seek for closer international integration is at the core of this evaluation. The hypothetical set up is illustrated in Exhibit 1.

The co-operation of Tekes with other Finnish organisations in support of companies and their R&D activities has been thoroughly evaluated by the ministry of trade and industry in 2001.[1] The suggestions[2] made have been addressed and followed on by MTI. Further suggestions for increased co-operation to this end were also made in the recent international evaluation of the innovation support system of Finland.[3] The evaluation at hand builds on the findings and suggestions made in earlier evaluations, with a specific perspective of Tekes technology programmes.

The general assumption in this evaluation was that national technology programmes and their internationalisation processes are dependent on their operational contexts. To this end, the evaluation had to take into account a number of contextual or framework conditions, which presumably would explain the nature and possibly also the success of the internationalisation. The assumed more indirect conditions related to the *type of programme* (cluster, innovation enhancing, targeted vs. umbrella), the *geographical focus* of co-operation (differences in cultures and traditions, market conditions, similar funding mechanisms, etc.), as well as to whether there had been *previous programmes or policy actions* among the players.

The directly impacting operational framework for internationalisation was assumed to relate to the reasons and *rationale for internationalisation* (e.g. up-grading of Finnish expertise in order to sustain competitiveness), to the *nature and ways how the knowledge is transferred* within co-operation (up-stream vs. downstream) and to the *legal and policy conditions* regulating and directing the international co-operation in Tekes.

These framework conditions would theoretically set the conditions, incentives and limits to the international co-operation, which could be seen and analysed by the volume, nature and quality of internationalisation activities in technology programmes and their impact to programmes, their participants, the research substance, business, etc. This outset of the general operating conditions for internationalisation has been loosely illustrated in Exhibit 2.

1.3 The evaluation subject – issues being evaluated

This evaluation focuses on those Tekes technology programmes (alongside with other measures at Tekes) that have been or will be concluded during the period of 2000–2004. Altogether 64 technology programmes fulfilled that criterion, of which seventeen were still ongoing and 42 had evaluation or final reports available for the evaluation purposes. Complementary documents, such as programme proposals and presentations were also made available.

1 Kansainvälistymisen edistäminen – suomalainen intressi. Yritysten viennin ja kansainvälistymisen edistämisen (VKE) -toimikunnan mietintö. KTM 16/2001

2 In short, the relevant suggestions relate to building up a national strategy for international competitiveness based on knowledge and information, better exploiting the international growth potential of SMEs, keeping internationalisation as part of national enterpise and competitiveness policy, enhancing the set of public services available for the support of internationalisation of SMEs, intensifying the collaboration of Tekes, Finpro, Finnvera and TE –Centres, and in particular including the promotion of internationalisation more closely to the technology programmes of Tekes by networking with other operators.

3 International evaluation of the innovation support system in Finland, MTI 19.5.2003

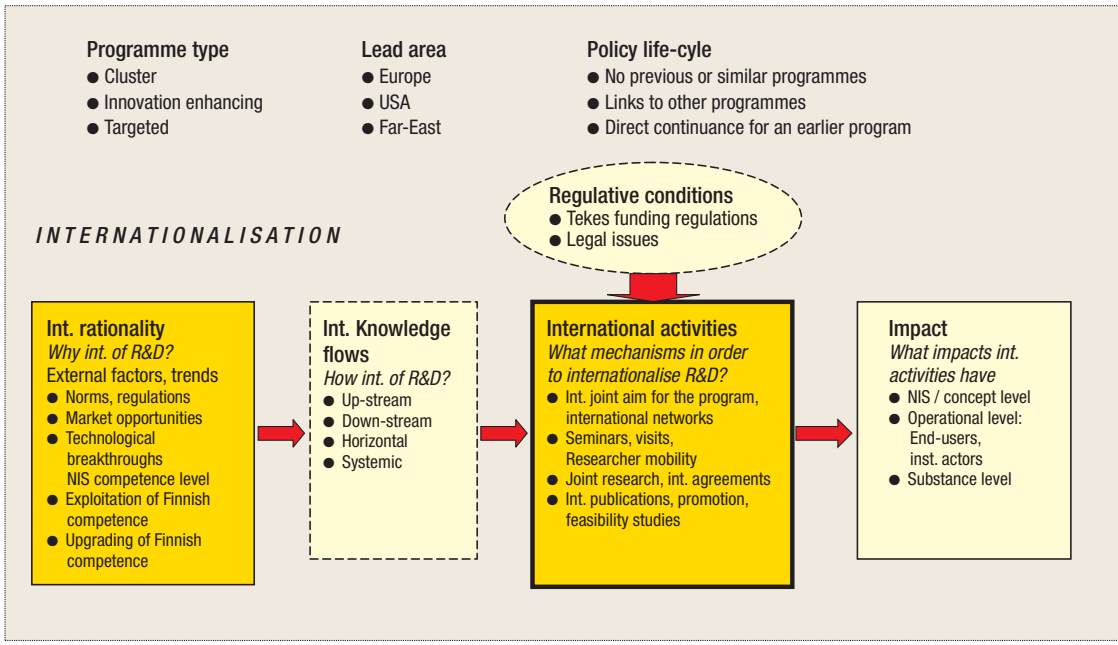

Exhibit 2. Operational conditions for internationalisation in technology programmes

The general assumption was that internationalisation questions are relevant throughout the programme life-cycle:

1. The definition and objective setting of a technology programme (industrial needs, technological visions, market and societal opportunities, available structures and competence, the foreseen added value of the programme)
2. The structure, design, initiation and set-up of the programme (targets), including their focus and the financial framework and rules for participation. Expected foreign participation.
3. The implementation and coordination of a programme. The linkages to international networks (EU FP, IRC, EUREKA,…). The programme calls and project evaluations. Promotion of international collaborations. Financing of international participation.
4. The exploitation of programme results and outcomes, as well as programme follow-up.

Part of the assessment focused on the flexibility of the regulations concerning the use of Tekes funding in the preparation and execution of international projects and programmes. As compared to the funding principles of the Academy of Finland, for example, these regulations differ significantly. To certain extent, the project selection criteria and funding regulations concerning foreign participation compose one practical definition of national interest in technology programmes.

An overriding feature to this evaluation is the employment of several complementing methodological approaches. This was deemed necessary for reasons of complexity of internationalisation as a phenomenon, as well as for the large size of programmes covered by the evaluation. The various steps taken during the evaluation process are illustrated in Exhibit 3.

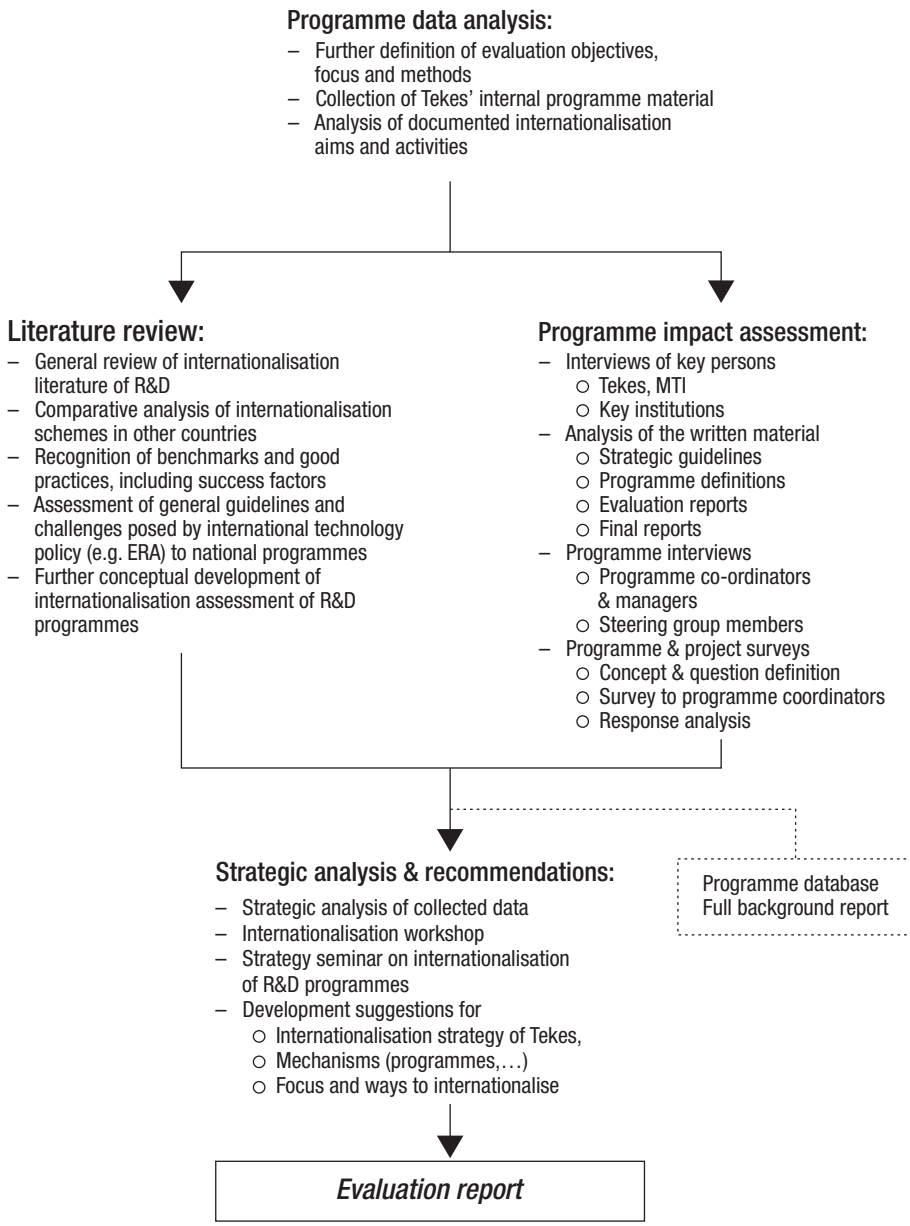

Exhibit 3. The evaluation process

2 Internationalisation of R&D – trends and issues

2.1 Trends impacting internationalisation

The economic and technological globalisation has catalysed internationalisation of research and development work, innovation and the technology-based businesses. The reasons behind this development are logical: internationalisation, competition and co-operation help improve the quality of research, reduce overlaps in the supply of knowledge, pool existing resources into larger entities and focus them on important activities in each organisation. It is also in the best interest of any singe actor, whether a researcher, a research group or an institution, to make full use of all opportunities available on a global basis, regardless of the national origin of those opportunities. By gathering and combining resources across national borders it is possible to address problems and achieve results, which would otherwise be beyond the reach of any single organisation.

There are two main reasons why internationalisation is important in European innovation policy, too. One is the globalisation of the economy, in which the interplay between corporate R&D and the various national contexts in which it operates becomes one factor influencing location more generally. National Innovation Systems therefore compete to attract and retain corporate R&D. The other is the strong political drive towards European integration – which we can perhaps see as much as an attempt to create a new nation as a movement towards true internationalisation.

2.1.1 Multinational companies and the location of R&D

The rate of global expansion of multinational companies (MNCs) has been increasing since the 1960s and has progressed through several distinct phases.[4] From the 1960s to the late 1970s, global expansion was primarily concerned with setting up manufacturing and sales units abroad. This was followed by a phase of providing design and development support to overseas units until the mid-1980s. Subsequently, multinationals have become more sensitive to the idea of exploiting the national innovation systems and sophisticated markets of the countries in which they locate. Many have therefore strengthened their R&D capabilities abroad.[5] At the same time, product line responsibilities have increasingly been decentralised to units overseas.

Since the mid 1990s, however, multinationals' R&D activities have tended to undergo consolidation and streamlining. The results have been two-fold: increased competition among R&D units (and thus increasing concentration of research activity); and increased emphasis on application-oriented research and development. Fundamental research has tended to be squeezed off the corporate research agenda, leaving many companies more dependent on external knowledge sources than they were previously. These external sources include the public sector, R&D networks and associations and mixed arrangements involving both, such as the MediaLab or the campus-based 'competence centres' appearing in a number of countries for fundamental research.

4 Alexander Gerybadze and Guido Reger, 'Globalisation of R&D: recent changes in the management of innovation in transnational corporations', Research Policy, Vol. 28, Nos. 2-3, 1999

5 Frieder Meyer-Krahmer and Guido Reger, 'New perspectives on the innovation strategies of multinational enterprises: lessons for technology policy in Europe, Research Policy, Vol. 28, No. 7, 1999

So far, patterns of internationalisation show a tendency for 'Triadisation' rather than globalisation of R&D.[6] That is, the international R&D effort is concentrated in the 'Triad' of the USA, Europe and Japan. European firms are most active in internationalising R&D[7], followed by the USA and Japan (undertaking 58%, a third and 10% of all internationalised R&D respectively).[8] Within the Triad, research is further concentrated[9] within existing agglomerations. Anecdotally, it appears that the 'Triad' for this purpose may be expanding to include parts of China, as foreign companies begin to locate aspects of R&D there.

The traditional production-led view of international research suggests that overseas research is concerned with the support of local manufacturing units and the adaptation of products to local markets.[10] Underpinning this explanation is Vernon's product cycle hypothesis.[11] Vernon argues that companies develop products in response to home market needs and that products are initially manufactured locally to supply these markets. However, through the duration of the product life cycle, costs of production become increasingly important in competition and firms shift their manufacturing units abroad to access more advantageous factors of production, often cheap labour. Production (of standardised products) therefore 'trickles down' from high- to low-cost locations and from sophisticated to less sophisticated markets. This makes space for innovation in the home market, and the multinational 'rolls over' into new generations of products. In due time, local R&D units are set up to support overseas manufacturing operations, but are primarily concerned with adapting products to local tastes and standards. Process based innovation is common and is often regarded as subordinate to research in the home nation.

Vernon's account was not a bad one in its time and place – 1960s USA – but the realities he described have been changing and the behaviour he describes is no longer the only one – though it is still, in modified form, important. In the current literature, such international research linked to international production is being described as **home-base exploiting** (HBE).[12] In other words foreign research units are concerned with exploiting technological capabilities that are developed at home.

A second view of international corporate R&D location involves a learning role for foreign-based research, accessing new knowledge and capabilities. International research is about the exploitation of global science and technology[13] rather than the firm's existing capabilities, and is described as **home-base augmenting** (HBA).[14] In this case, national resources (in the form of research capabilities) are not adequate to meet firm requirements, so multinationals are forced abroad in search of international resources. For example, Patel and Pavitt

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6 Frieder Meyer-Krahmer and Guido Reger, Op Cit; Walter Kuemmerle, 'Foreign direct investment in industrial research in the pharmaceutical and electronics industries – results from a survey of multinational firms', Research Policy, Vol 28, Nos. 2-3, 1999; Maximilian von Zedtwitz and Oliver Gassmann, 'Market versus technology drive in R&D internationalisation: four different patterns of managing research and development', Research Policy, Vol. 31, No. 4, 2002

7 This is mostly in connection with intra-European internationalisation

8 Pari Patel and Modesto Vega, 'Patterns of internationalisation or corporate technology: location vs. home country advantages', Research Policy, Vol. 28, No.s 2-3, 1999

9 Celine Rozenblat and Denise Pumain. 'The location of multinational firms in the European Urban', Urban Studies, Vol. 30, Issue 10, December 1993; John Cantwell and Simona Iammarino, 'Multinational Corporations and the Location of Technological Innovation in the UK regions', Regional Studies, Vol. 34 Issue 4, June 2000

10 Walter Kuemmerle, Op Cit

11 Raymond Vernon, 'International Investment and International Trade in the Product Cycle', Quarterly Journal of Economics, LXXX, May 1966; Raymond Vernon, Storm over the Multinationals: The Real Issues, New York: Macmillan, 1977

12 Walter Kuemmerle, Op Cit Frieder Meyer-Krahmer and Guido Reger, Op Cit; Daniele Archibugi and Simona Iammarino, 'The policy implications of the globalisation of innovation', Research Policy, Vol. 28, Nos. 2-3, 1999

13 Frieder Meyer-Krahmer and Guido Reger, Op Cit; Daniele Archibugi and Simona Iammarino, 'The policy implications of the globalisation of innovation', Research Policy, Vol. 28, Nos. 2-3, 1999

14 Walter Kuemmerle, Op Cit

note that Japanese and German firms have been forced to seek skills in the US in high technologies and molecular biology.[15]

It seems that small country-based multinationals tend to be early movers into both production-based (HBE) and learning-based (HBA[16]) Internationalisation of R&D – driven by the limited size and resources of their home countries.

Quantitatively, however that HBE sites are dominant with 75% of multinationals' technological innovations abroad being made in fields where firms have home advantage.[17] For example US firms go abroad in the computer industry, Germany, Switzerland and UK in organic chemicals and pharmaceuticals and Japan in image and sound – all fields in which they are technologically strong at home.

The location choices of HBE and HBA sites reflect their differences in function.

Kümmerle's survey (Exhibit 4) shows that HBE R&D sites are significantly more likely than HBA ones to locate close to an existing factory and an important market. HBA sites are significantly more likely than HBE sites to locate in close proximity to a university.

In recent years, however, in many industries the pattern of competition has been changing. Product cycles are becoming shorter and this has increased the need for timely product development. As a result, research focus has become more 'near-to-market' and there is increased need for integrated design and manufacture. The role of the production-led (HBE) foreign-based research unit has therefore become more important to business strategy.

Exhibit 4. Location characteristics of R&D Sites[18]

Location characteristics	HBA facilities	HBE facilities
Site in proximity to a university	52	20
Site in proximity of existing factory	11	46
Site in proximity to important market	22	79
Site location chosen because of host-country government pressure	6	11

Some have argued that 'dynamic-value' drivers are becoming more important than static cost considerations when it comes to location decisions. That is, firms are becoming more interested in factors that encourage innovation such as leading markets and innovative clients. Many companies are allocating responsibility for product lines to different subsidiaries around the world. Qualitative motives such as learning from technological excellence, lead markets and dynamic interactions in the value chain are becoming more central to driving location choices than static cost considerations.[19] Of particular importance is that a widening range of countries is interesting because they provide strong innovation stimuli and good innovation environments. It is by no means any longer automatic that the US market is the best place to do everything, as was implicitly assumed in Vernon's analysis. In the sense of product line responsibility, and at least the **development** work that goes with it, multinationals may often be thought of as having multiple 'home' countries. Their choice of 'homes' is deliberate, and may change over time.

15 Pari Patel and Keith Pavitt, 'National systems of innovation under strain: the internationalisation of corporate R&D, Electronic working paper series, paper no 22, SPRU, University of Sussex, May 1998

16 Christian Le Bas and Christophe Sierra, 'Location versus home country advantages in R&D activities: some further results on multinationals' location strategies', Research policy , Vol. 31, No. 4, 2002

17 Pari Patel and Modesto Vega, Op Cit

18 Walter Kuemmerle, Op Cit

19 Ibid; Alexander Gerybadze and Guido Reger, Op Cit

These shifts obviously have important implications for decisions about locating R&D. One is that, as the importance and complexity of the R&D done in production (HBE) locations increases, so does the importance of a high-quality higher education and research sector in determining plant location. However, while a strong knowledge infrastructure is important, it is not **sufficient** to determine plant location. The quality of other aspects of the innovation system – on both the supply and the demand sides – also becomes more important. The presence of a world class research capability is more likely to attract learning (HBA) R&D. But the ideal learning investment from the company perspective is one in a market from which the company can also learn. For both types of R&D, national investments in the knowledge infrastructure can therefore be helpful, but are not likely to be decisive, in securing inward investment of R&D.

2.1.2 Knowledge-intensive internationalisation

The two most relevant theoretical frameworks for understanding firm internationalisation are the process theory of internationalisation and the 'new venture internationalisation' framework. An understanding of these is important for understanding the potential internationalisation effects of technology programmes. The process theory takes the position that internationalisation represents a move to the unknown for the firm, as the firm ventures from its familiar domestic business domain to new cultural and institutional environments. Because of this, the decision to internationalise is not taken lightly. Rather than venturing to the international markets early on, the process theory suggests that firms initiate their internationalisation processes gradually and late, and even then by moving first to neighbouring countries and using relatively simple and manageable forms of operation, such as direct and indirect exports. As the firm gradually gathers experience from foreign markets, it becomes more confident and can move to more distant countries and use more complex modes of operation.

The **new venture internationalisation framework** takes a slightly different approach. Rather than testing the water first with their toes, many new ventures, particularly in dynamic and knowledge-intensive sectors are able to take even quite bold steps and choose their target markets and modes of operation by using the size of opportunity, rather than manageability, as their main selection criterion. New knowledge-intensive ventures are able to do this because of the entrepreneurial vision and competencies of their management, and they are also forced to move fast if they are to take advantage of rapidly opening and closing windows of opportunity.

The two theories suggest two completely different models of internationalisation: one slow and gradual, one rapid and proactive. One of the two theories has been developed in the context of low- to medium technology sectors, whereas the other has been modelled primarily using knowledge-intensive sectors as an example. This does not mean, however, that the mode of internationalisation would necessarily depend on sector technology intensity. The two models do suggest quite different policy implications, however. Whereas the traditional process model emphasises, at least initially, indirect and direct exports, the new venture internationalisation model tends to advocate the use of much more complicated modes of international entry, such as alliances and R&D-intensive collaborations.

From the resource-based perspective, two different modes of internationalisation can be distinguished, depending on whether the resources necessary for the creation of value-added can be found within national borders, or whether the critical resources are dispersed across several countries. In the previous case, an industrial firm can generate the entire value-added domestically, and then export the resulting products and services. In this, **home-base leveraging** mode of internationalisation, the firm is faced with a relatively easier coordination task, as the resources and activities to be coordinated lay primarily within national borders. This means, for example, that the organisation can be staffed with employees of the same national and cultural background, thereby facilitating internal communication and coordination.

However, if the critical resources are not confined within national borders, the coordination task becomes more complex, as the creation of value-added outputs requires the international coordination of resource inputs. In this, **home-base extension** mode of internationalisation, the internationalising firm needs to extend the scope of its organisation to include also foreign units. Therefore, the modes of internationalisation are more hands-on and require greater organisational skill.

The distinction between "home-base leveraging" and "home-based extension" modes of internationalisation also carries implications for policy. If the firm generates its entire value-added using domestic resources only, then its export success will depend on the quality of those resources. This is also one essential aspect of Porter's well known "diamond" model, which emphasises the importance of domestic demand conditions for industrial success. If the resources are dispersed internationally, exports are often not the only or even the main mode of internationalisation – rather, the firm must develop a relatively complex, international web of operations, which then generates its value-adding outputs.

What, then, are the implications of the different modes of internationalisation for the design and implementation of national technology programmes? An overview of the received literature suggests that, in fact, relatively little is known about the relationships between internationalisation and technological development. In most frameworks, technologies are treated as an enabling component of internationalisation: technology is created in one place and then used to fuel the firm's international expansion. This thinking is visible in both the process and new venture internationalisation frameworks, as well as in the "home-base leveraging" framework. This thinking is, however, also quite restrictive and simplistic, and mostly applicable in situations where the domestic conditions are sophisticated enough to generate outputs that can be sold internationally. It does not explain, for example, why a number of Finnish software firms have considered it necessary to establish a subsidiary in Silicon Valley.

A largely ignored notion of received internationalisation theories is that internationalisation can be as much, and sometimes even more, about the generation of new technologies and other value-added outputs, rather than about the exploitation of them. It s against this light that the exodus of many a Finnish software firm to Silicon Valley becomes more understandable: in order to be able to develop the required technology outputs and to access the critical resources and knowledge externalities, it is sometimes necessary to migrate across the globe, simply to stay in the game.

Internationalisation, then, can be as much about the generation of new technologies as it is about the exploitation of domestically generated technological outputs. This point is emphasised by some recent empirical studies that show that internationalisation itself can, in fact, provide a boost for a given firm's technological development activities. Innovation and internationalisation are positively associated, but the direction of causality can, in fact, work both ways.

There are many reasons why internationalisation can provide a boost for technological learning. As the internationalising firm enters new markets, it also faces more varied environments. Greater knowledge variety is often associated with faster learning. Also, the very process of developing competencies to manage increased organisational complexity may boost the firm's dynamic ability. Finally, internationalising firms, by virtue of getting closer to their foreign customers than traditionally exporting firms, will also have more opportunities to learn about their customers' real needs and apply these to their product development activity.

A final aspect of internationalisation and technology concerns the dynamics of international knowledge flows. Because national technology programmes target both firms and universities, it is necessary to distinguish between **upstream** and **downstream** modes of internationalisation. We use the term 'upstream internationalisation' to refer to a situation in which a Finnish firm or a research institution connects to foreign sources of technology and R&D.

Upstream internationalisation is very much, but not exclusively, about the sourcing of foreign technologies[20]. Downstream internationalisation, for its part, refers to a situation in which a given Finnish firm or research institute connects to customers and technology users abroad, in an effort to sell more technology outputs to these. Also horizontal internationalisation activities can be identified, in which firms and research institutions interact with their counterparts in an effort to create mutually beneficial shared resources, such as new technological standards.

The distinction between upstream, downstream, and horizontal internationalisation activities is important for understanding the dynamics of internationally interacting innovation systems. For one thing, different internationalisation activities – upstream, downstream, and horizontal – are associated with different kinds of technology and knowledge flows. Whereas upstream activities are helpful in generating access to foreign sources of technology and in 'importing' foreign-based inputs of 'raw' technologies to Finland, downstream activities are important, not only for the exports of knowledge and technology outputs, but also for the 'shaping' of Finnish-based technologies so that these become more amenable to international diffusion.

Knowledge-intensive products and services, such as those associated with new technologies, are often quite context-dependent, in the sense that to provide a source for value creation, they need to fit with their context. It is not at all evident that, for example, a technology item developed in one national context could be rapidly and easily applied in another, perhaps different, context. This is because of the so called 'social shaping' of technologies, which is particularly visible at the user interface. Different national contexts and different cultures may differ in the ways things are done, and it is sometimes important to link such impulses to domestic technology development activities.

As a summary of the brief theory review, we can observe that:

- the traditional **export** model of internationalisation, while still relevant, does not represent the only possible mode of internationalisation, nor does it necessarily always represent the most relevant one, especially where knowledge-intensive sectors are concerned
- the **new venture** mode of internationalisation, often in evidence in knowledge-intensive sectors, is both more demanding and requires different forms of support than the traditional export-oriented and gradual mode of international expansion. Programme activities that fit one mode may not be optimal for the other. Traditionally, internationalisation support has very much focused on export support, and the more demanding forms of internationalisation have tended to be less in the focus of support initiatives
- the links between internationalisation and innovation are **complex and reciprocal**. In other words, internationalisation is not only about commercialising technologies developed in Finland. Depending on the sector, also other motivations, such as resource access and control, technology development, and the development of shared network assets can be relevant. Also, while innovation often drives internationalisation, there is also considerable evidence of an opposite effect, when internationalisation itself boosts learning and innovation within the internationalising firm
- where technology programmes are concerned, it is not sufficient to focus on direct firm-level internationalisation outcomes only. Because technology programmes target both firms and research institutions, it is of equal importance to include those, too, in the analysis of technology programme internationalisation effects
- in analysing internationalisation effects and outcomes, it is important to distinguish between **different types of knowledge flows** (upstream, downstream, and horizontal), since these may be associated with different kinds of motivations, activities, and benefits at the project level.

20 Here, 'sourcing' refers to both the acquisition of technology and R&D inputs from foreign parties, but also to joint research and development activities with these (co-creation).

Also, the different mechanisms may vary in terms of their impact on the dynamic of the national innovation system

The review of project-level empirical data on technology programme internationalisation effects has been designed to take the above observations into account.

2.1.3 European Integration and Internationalisation

Internationalisation and European integration of R&D has been a goal of the developing European Union since the days of the coal and steel community. At this stage, there is very little literature that examines internationalisation in innovation **policy** and, as far as we can determine, none that duplicates the mission of this report.

Most of what has been written about policy has been generated in the process of launching the ERA concept. One key study[21] mapped cross-border co-operation within national programmes of research and technological development among the EU and EEA member states. It identified 3 types of programmes

Category one programmes, which explicitly foresee participation by non-residents. These accounted for about 10% of the programmes surveyed, and were found in Denmark, Germany, France, Luxembourg, Austria, the UK and Norway. Foreign participation was generally foreseen in cases where it would add value to the national effort, and was generally subject to limitations – especially that foreign participants could not lead consortium projects. Implicit criteria also tended to limit the extent to which foreign participation would be permitted.

Category two programmes that do not explicitly exclude non-residents. These accounted for the bulk (perhaps 80%) of programmes in operation. The role of non-residents could generally be considered case by case, but there was a general assumption that programmes were national in character and that the issue would therefore not arise.

Category three programmes, which explicitly excluded non-residents. Amusingly, in many cases, the exclusion resulted from conditions applied to European structural funds.

There appeared to be a number of factors which determined a programme management team's interest in cross-border projects. These included

- **The maturity of the public research funding system**. Category Two programmes with an international outlook are more evident in the larger economies and those with long-established public research systems
- The Agency or **programme's primary purpose**. There was a clear split between those programmes dealing with scientific issues[22] (more European Partnerships) and those programmes dealing with issues of interest to a geographically more immediate group (e.g. cost-shared applied research programmes directed to national competitiveness or technology transfer programmes directed to SMEs).[23]
- The level of **management autonomy** of Agency officials and independent programme management organisations (e.g. *Projektträger*). In countries like Sweden or France or the UK programme managers work within tight financial controls but high degree of autonomy

21 Technopolis, VDI-VDE-IT, IKEI and Logotech, Cross-Border Co-operation within National RTD Programmes, report to DG XII, Brighton: Technopolis, 1999

22 Science typically deals with fundamental issues that are understood by small numbers of individuals who for a variety of social and intellectual reasons will seek out their specialist counterparts across the globe; these international communities can be found in say mathematics or plant genome research.

23 National research programmes that underpin national policy or government services (for example occupational safety and health) operate a more corporate model of programme management than is the case with programmes administered by say Research Councils. The former will tend to prize customer-service issues (reliability, timeliness, etc.) at least as much as scientific quality or technological novelty. Indeed, the UK Ministry with responsibility for national planning regulations commissions research of a deeply practical nature within a framework of what is called 'scientific adequacy'.

- The experience and **philosophy of the programme manager** and his or her immediate advisers (e.g. Programme Steering Committee). We found Agencies in a number of Member States and EEA countries where Category Two programmes with an international outlook were run alongside Category Two programmes – in similar disciplinary areas – where the management team indicated that non-residents were not eligible to participate

While national programmes, in practice, were not internationalised, there were and are a large number of multi-lateral programmes, generally focusing more on research than innovation.[24]

A review[25] of eight countries found strategic rhetoric across the board, and in some cases there had been some institutional adjustments. However, no country has a strategy towards internationalisation. At the same time there is neither consensual problem definition within the administration, nor integrated sets of measures, nor a horizontal unit for ensuring coherence. Overall, the international instruments are an appendage of the nationally oriented strategies, and not a horizontal dimension or integrated part of it.

The report gives a sense that the growing use of more complex instruments – sometimes known as Multi-Actor, Multi-Measure programmes – such as various kinds of competence centres are causing some degree of internationalisation in innovation policy 'by the back door.' Such instruments deal with various kinds of clusters and networks, whose shape is determined more by economic reality than administrative decision and which are therefore much more likely to have an international dimension.

In 2002, the monitoring panel for the Framework Programme found that the European Commission itself "lacks a coherent strategy for international co-operation" and that "three years after the ERA initiative was launched, most member states do not appear to be prepared to participate fully". Member states, especially the smaller ones, were "not enthusiastic" about ERA, nor were they content with the new instruments of the Sixth Framework Programme.

The available indications, therefore, are that the EU policy drive for internationalisation, especially in the context of ERA, has not led to strategic change at the level of the EU and EEA 18. As the example of Estonia illustrates, it has probably been more directly influential in the Accession States. Since they are radically restructuring their research and innovation policies as they enter the Union, current Commission thinking and programmes are much more influential for them than for longer established EU/EEA members – especially as for them the Commission's ideas are accompanied by a fat cheque.

2.2 Finnish policy for international co-operation in R&D

Internationalisation features increasingly prominently in the national strategies of all knowledge-intensive societies. Because of the pervasive nature of the economic and technological globalisation trend, it is important for knowledge-intensive societies to devise and implement global innovation strategies addressing such issues as global knowledge sharing, sourcing and liaisons. In the knowledge-intensive global economy, no country can survive in isolation. This conclusion holds particularly for small and open knowledge-intensive societies such as Finland.

In Finland, the public promotion and steering of research and development is largely the responsibility of the national funding and expert organisations such as Tekes, Sitra, and the Academy of Finland, together with other public and private sector operators. To large extent, this applies for the internationalisation of research and development, too. Although the general principles for international re-

24 Technopolis, The Evolution of Multilateral Public RTD Schemes in Europe, report to the European Commission DG XII, Brighton" Technopolis, 1999

25 Jakob Edler, Patries Boekholt and others, Internationalisierungsstrategien in der Wissenschafts- und Forschungspolitik: Best Practices im internationalen Vergleich, Bonn: BMBF, 2001

search co-operation are defined by the Science and Technology Policy Council and often adopted by the Ministerial Council for EU affairs or the Government itself[26], the practical definition and implementation of internationalisation of Finnish R&D remains in the hands of these expert and funding organisations.

The national R&D support organisations are faced with an important number of internationalisation challenges, such as the opening-up of national research programmes; rapid increase in international grant applications and in international mobility of researchers; increasing emphasis on international co-operation skills and their upgrading; rapid internationalisation of funding instruments; and the increasing need to develop selective and flexible R&D decision-making due to expanding international cooperation and competition. Maintaining a position of leadership in international R&D networks demands new kinds of thinking and attitudes, new knowledge and new skills from national R&D operators.

The key elements of current national strategy for promoting internationalisation and international co-operation in the field of science, technology and innovation are concisely formulated into the latest review of the Science and Technology Policy Council of Finland:[27]

> *A systematic aspiration to create innovations cannot be limited to the national setting and traditional international cooperation. Internationalisation must proceed at the level of the innovation system as a whole, and Finland must be able to internationalise its own operations and its national science and technology institutions.*
>
> *The challenges work both ways. What Finland needs above all in order to be able to compete for competent researchers and research resources, projects and business enterprise research and development with other countries is quality. On the other hand, Finnish players must be equipped to take part in and make use of cooperation openings.*

According to the Council, internationalisation of R&D at European level is notably influenced by growing international co-operation due to the enlargement of the EU, the creation of European Research Area (ERA) and its implementation through the Sixth EU Framework Programme. The objective of the ERA is to raise European scientific and technological performance and, through it, the industrial and economic competitiveness of the European continent so as to match the World's leading-edge standards. This is done primarily by enhancing research and researcher training in fields of prime European interest, as well as by facilitating researcher mobility across the Member States.

The European Research Area can provide an important mechanism for intensifying co-operation and network building at the European level and, ultimately to improve the quality and competitiveness of European education, research and knowledge-intensive businesses in relation to the other major economic areas in the World. From the Finnish perspective, the developing and intensifying European research can also provide opportunities to further boost the Northern Dimension of the EU, including bilateral cross-border and Nordic cooperation, the first example being the preparation of a Nordic Research and Innovation Area (NORIA), for which a plan has been adopted by the Nordic Council of Ministers in fall 2003.

Although European research co-operation represents the largest area of multilateral agreements for Finnish research, the co-operation interests of Finnish research and business institutions are not limited only to Europe. Particularly Finnish companies, but perhaps more increasingly also the Finnish research institutions and universities have important interests for example in North America and in the Far East. Without neglecting the importance of increasing European research co-operation, there are many regions, countries and continents outside of Europe providing interesting co-operation possibilities in rapidly developing business environments and World-class resources for R&D collaboration. This gives a good reason

26 e.g. The Finnish Policy Guidelines Regarding EU R&D activities, Committee for EU Affairs, MTI 1995

27 Knowledge, Innovation and Internationalisation, STPC 2003.

to consider ways and strategies for extending our national efforts in internationalisation of R&D also beyond the more familiar European context.

2.3 Tekes' strategy for international co-operation

While internationalisation of R&D has mainly been driven by business and industry, also public organisations have been active in this area. Government intervention to support internationalisation of R&D is typically justified by market failure, systemic failure, and structural rigidity arguments.

Tekes' strategy for internationalisation of R&D is not a publicly available document. It is a set of practically applied guidelines and principles, with an aim to promote the competitiveness of Finnish business life and industry by facilitating international co-operation and internationalisation. Tekes facilitates international collaborative efforts of its clients and offers for that purpose several services, as well as financial support.

The four mechanisms featured in the internationalisation strategy of Tekes are: *selective project funding*, *national technology programmes*, the *promotion of innovative activity*, as well as the *development of the innovation environments*.

International co-operation is closely linked to Tekes' technology programmes: Tekes plays an active role in the preparation and co-ordination of both national and international R&D programmes in Finland. Furthermore, the relative importance of international R&D projects of Tekes has grown over the past years. In 2002 Tekes funded 2017 projects, of which 754 carried an international element (37%)[28]. In terms of funding, more than half (55%) of the funding of research projects and almost half (45%) of company projects were international.

Internationally conducted R&D projects also tend to be larger than purely domestic projects. The total value of international projects funded by Tekes was 196 million euros in 2002, representing already more than half of the total project funding of Tekes (51%). The largest countries of collaboration are EU /EEA (52%), USA (27%) and Japan (5%). Of these, the share of EU / EEA and USA have grown the fastest.

Regarding the purpose and content of international collaboration, the most important element has been the **exchange and sourcing of information** in Tekes R&D projects, which has been present in approximately half of Tekes-funded international R&D projects. Approximately half of such exchanges were exchanges of information (two-directional), while the second half represented organised sourcing of information (one-directional) from abroad. The second most important international R&D element (roughly every fourth international Tekes project) has been **a joint project or joint venture**. The remaining Tekes-funded international projects (about one fourth) have concentrated on **researcher mobility** & exchange, **technology transfer** and other forms of international R&D collaboration.

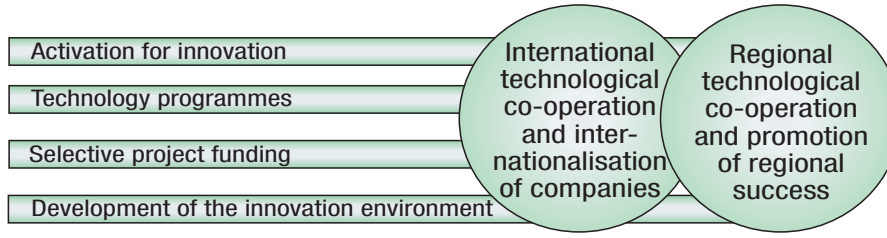

Exhibit 5. International activities in Tekes strategy

28 According to Tekes Annual Review 2003, the respective numbers for 2003 are 2196 projects, of which 808 international.

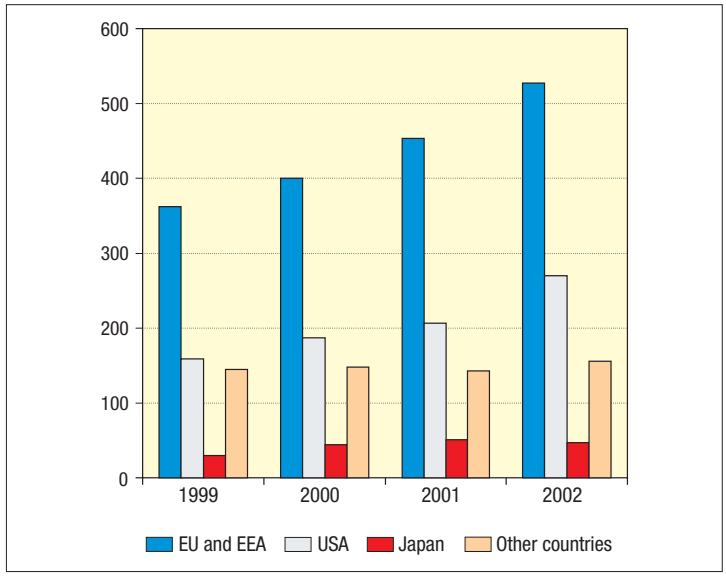

Exhibit 6. Number of international co-operation projects funded by Tekes by Country groups[29]

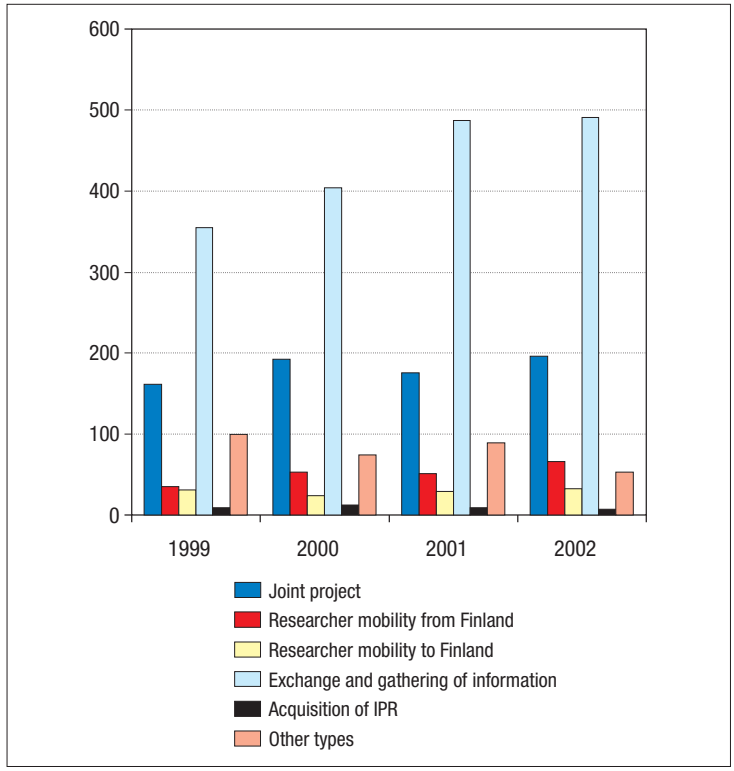

Exhibit 7. Number of international projects funded by Tekes by type[30]

29 International co-operation in technology 2002, separate report by Tekes 22.5.2003

30 Ibid.

In addition to the international collaborations mentioned above, Tekes also supports the preparation of proposals for international R&D programmes. These supportive actions concern EU Framework Programme (in FP6 the integrated programmes, Networks of Excellence, STREP, CRAFT, as well as Coordinated Actions and Special Support Actions), the EUREKA, COST and ESA collaboration as well as other European R&D collaboration. Alongside the European research collaborations, Tekes has signed direct collaborative agreements with operators in the USA, Japan and China.

There are three foci in the strategy for internationalisation and international collaboration in Tekes:

1. For the **European R&D networks** (EU FPs, EUREKA, COST, ESA) the main aim is to maintain current good participation level, while improving the quality of participation and intensifying networking and mutual exchanges.
2. Towards the currently **leading technological regions** (USA, Japan) the main aim is to increase collaboration and to strengthen the existing networks.
3. Towards regions of potential or **rapid technological development** (South Korea, China, Israel,…) the main aim is to assess and monitor the development of innovation environments and to collaborate in clearly focused fields.

Within the Finnish national system of innovation, Tekes works in close collaboration with other national organisations supporting export, internationalisation and international co-operation – namely, Finpro, Finnvera, and Finfund.

Tekes and Finnish researchers have in general been reasonably successful in international arena. The statistics indicate (September 2003) that Finnish researchers were participating in more than every tenth EU proposal (four times our relative volume, in total 4 994 participations) and the success-rate remains steadily above the EU average (31%), being institutionally highest for the large companies (32%) and research institutions (32%) and for programmes in the Fusion (100%), Fission (49%), Inco (44%) and Growth (39%).

2.4 Internationalisation from the perspective of R&D and innovation

The development of Finnish science and research on a wide front is directly linked to the international co-operation pursued, its extent and quality.[31] The expansion of Finnish research during the 1990s improved the chances of taking an active part in international top-level research and exploiting its results. Alongside EU co-operation, one important channel for this is participation in international science and technology organisations and their projects. These represent a substantial part of top international research in both qualitative and quantitative terms. Since Finland does not always have the physical and intellectual resources needed for major projects in either the production or utilisation of knowledge, this further emphasises the need to consider large-scale participations case-by- case. To this end, there is a more general policy regarding Finland's participation in international organisations and large-scale projects currently under preparation.

The international networks, in which Tekes participates, as well as the direct bilateral agreements with foreign operators, have several expected benefits according to their type and focus. In short, they are to provide:

- elements of **foresight and strategic vision** for Tekes, the programmes and other Finnish operators (e.g. NISTEP, IFTF)
- **new expertise**, knowledge and understanding for the benefit of basic research in Finland (e.g. NIST, COST)
- **access** for Finnish researchers in global standard **research programmes** and projects (e.g. Berkeley, MIT, Stanford
- challenging co-operation and **alliances for applied research** and standards (e.g. IMS, NEDO, NI)
- opportunities for **joint** product and process **development** and joint ventures (e.g. ESA, CERN, CRAFT, EU FP)

31 in Knowledge, Innovation and Internationalisation, Science and Technology Policy Council of Finland, 2003.

- possibilities for direct **technology transfer** and diffusion (e.g. EUREKA, IRC)
- **access to business intelligence** and international markets (e.g. UCLA)

2.5 The nature and role of technology programmes

Tekes technology programmes are used as funding instruments to direct national research and development efforts of enterprises, research institutions and universities into selected technologies, priority themes or similar missions. Compared to broad, openly managed research programmes and networks, Tekes technology programmes are in principle target or mission oriented schemes.

According to recent analysis by Tekes, technology programmes have become increasingly important instruments for the implementation of national technology policy.[32] In 2003 Tekes was running 33 technology programmes and participating in nine jointly funded technology or research programmes that were co-ordinated by other organisations. Roughly 60% of the Tekes annual budget was allocated through technology programmes (i.e. 222 million euros in 2002).

During the 1980's Tekes technology programmes were focused on accessing and managing rapidly developing technologies for industrial purposes, such as electronic and telecommunications and materials technologies. Later in the 1990's the scope of technology programmes has been broadened and other issues, namely the changes in competitive environments of enterprises or regulatory issues have been included into the topics of technology programmes, too.[33] Many technology programmes in fact cover a much broader mission than just technology, for example enhancing the development and competitiveness of an industrial cluster. More recently elements of foresight, as well as internationalisation have been emphasised with regard to future technology programmes.

Altogether 385 (43%) of the 895 projects funded during 2002 under Tekes technology programmes included international activities. Exhibit 8 shows that Tekes R&D projects funded under the technology programmes have a stronger orientation towards international co-operation than their counterparts outside the programmes.

The size and focus of Tekes technology programmes varies considerably across the programme portfolio. The duration of programmes is usually between 4–6 years and their budgets range from few millions euros to over two hundred million euros. Tekes typically funds around 50% of the programme budgets.

From participant perspective, the benefit of joining a technology programme instead of applying for so called 'free funding' is not with an increased possibility of getting funding,[34] [35] but rather with the networking and spill over effects of other similar projects under the programme. Programmes also identify areas of industrial, economic and even societal relevance and provide an operational context for joint research activities.

Funding allocated to technology programmes has increased significantly over the years. At the same time the average size of a research project has increased, while the average number of projects under one programme has remained more or less the same. The role of large enterprises has similarly increased in technology programmes. Already more than half of Tekes R&D funding for large enterprises is directed through technology programmes.[36]

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32 In search of new generation technology programmes, R. Gustafsson, E. Ahola, J. Kuusinen and P. Pesonen, Tekes 135 / 2003 (in Finnish)

33 Ibid.

34 Ibid.

35 NB. The acceptance rate for project applications within technology programmes is the same or somewhat lower than for project applications outside technology programmes.

36 In search of new generation technology programmes, R. Gustafsson, E. Ahola, J. Kuusinen and P. Pesonen, Tekes 135 / 2003 (in Finnish)

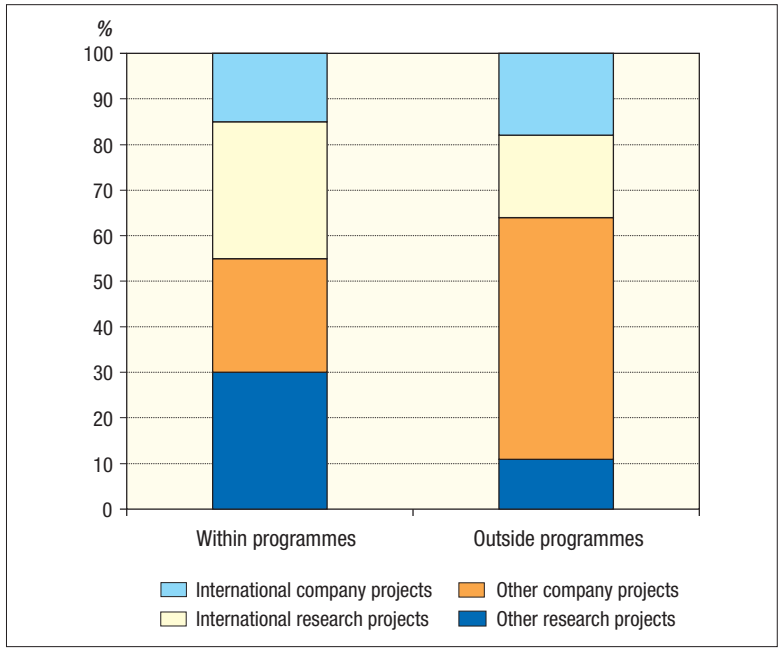

Exhibit 8. Share of international projects within and outside of technology programmes.[37]

Large national operators, typically public research institutes, have traditionally had an instrumental role in the definition, preparation and running of internationally collaborative research projects and programmes. Most clear has been the role of the Technical Research Centre of Finland (VTT) in EU Framework Programmes (FP). This was particularly the case when Finland was not yet a member of the EU and still under the FP4 and FP5. However, the situation has lately changed in the direction that VTT's central role as a co-ordinator has diminished, for many reasons. Yet the importance of national preparation and co-ordination by large, experienced institutes can be expected to be ever more important for the integrated projects of FP6.

Universities and research institutes have always played a key role in the initiation and co-ordination of Tekes technology programmes, too. They typically have the competence, resources and interest to initiate and run technology programmes, in particular compared to smaller enterprises. More than 60% of Tekes funding for research institutes and universities is channelled through technology programmes.

Tekes has developed several service concepts to support the technology programmes. The internal services include such as the TULI – activities which searches and promotes new research-based inventions into commercial activities or the VARA – preparatory funding to facilitate the preparation of international projects. Due to the fact that programmes vary significantly in their nature and mission, services are also sourced outside of Tekes.

37 Projects funded during 1-6/2003.

According to Tekes services analysis for 2002, external services were used in 184 Tekes projects, of which 47% concerned market studies, 30% internationalisation, 18% the transferring of technology to Finland, 3% transferring technology from Finland and 2% localisation. Only 13% of enterprises indicated that they had not carried out any internationalisation studies in Tekes projects.[38]

The providers of internationalisation services for technology projects during the first half of 2003 (121 projects) were Finpro (22%), small and medium-sized companies (17%), domestic consultants (15%), Universities (11%), international projects (9%), foreign consultants (6%), other research institute (5%), polytechnics (5%), large companies (3%) and international contractual co-operation (2%). The majority of Finpro's services (18 of 28 projects) focused in internationalisation support and the rest in market surveys.

38 International R&D co-operation in 2002, Special report, Tekes 22.5.2003

3 Comparative experience from other countries

3.1 The case study countries

In dialogue with Tekes, six case study countries were selected that appeared likely to provide relevant examples of policies and mechanisms for promoting internationalisation of R&D. Most of the selected countries are small, since the industrial and economic logic for internationalisation appears more pressing in small than large countries. The case selection consists of the following countries:

- *Sweden* – a Nordic analogue for Finland, with a strong internationalist tradition but, like Finland, having joined the Union relatively late
- *Germany* – the largest member of the Union and one of the founding countries
- *Switzerland* – a comparatively R&D intensive, small economy that has traditionally been host to the headquarters of many multinational companies and that has therefore long had a need to act internationally
- *Ireland* – a small economy that has developed rapidly on the basis of foreign direct investments, and that is now trying radically to restructure its knowledge infrastructure and attract inward R&D investment
- *The Netherlands* – a medium-sized, very open economy that hosts several significant multinational companies
- *Estonia* – one of the most dynamic of the Accession States, with close links to Finland.

3.1.1 Sweden – strong tradition in international collaboration

Sweden experiences a series of difficult challenges in innovation, notably what is now being called the 'Swedish Paradox': namely, that high and rising R&D investments by the state and industry have not been accompanied by super-normal levels of GDP per person. In parallel, the realisation is finally dawning in policy circles that the internationalisation of major Swedish companies poses real questions for the economy and therefore for innovation policy.

Actual policies only partially tackle these issues. Very significant efforts have been put into devising and implementing linkage mechanisms between universities and industry, in an attempt to increase the valorisation of Sweden's state investment in R&D. At the same time, in continuing to work under the 'Swedish model,' core funding and other state funding to the research institutes has been falling in real terms. A significant shift in policy has led to the creation of 'regional growth agreements' between the central state and the counties (Län). The regions have acquired more power over spending on innovation interventions in the regions. In addition, the 'Öresund contract' with Denmark has set up an additional regional innovation programme aiming to integrate the Copenhagen and Lund/Malmö region now that the bridge across the Öresund has linked Sweden and Denmark.

In general, then, policies are focusing on

- Continued development of the national innovation system
- Inward investment (largely handled by the Invest in Sweden Agency. While this is studying how to integrate an innovation dimension into its work, little practical change in its instruments has so far been achieved
- Reinforcing the university sector, at the expense of the institutes
- Technology watch in selected leading countries (through ITPS)
- Opportunistic exploitation of international programmes.

In practice, internationalisation is not a major item on the Swedish innovation policy agenda – even if many practitioners believe it should be. A major interest in internationalisation questions is as a way

to defend corporate R&D activities in Sweden against being exported by multinational companies.

The innovation agency VINNOVA has established an international secretariat, and is in principle trying to 'mainstream' internationalisation within its normal funding instruments. The commitment to traditional international programmes remains unchanged, and there is continuing interest in small-scale bi- and multi-lateral programmes within the Nordic area (Finland and via the Nordic Council of Ministers). However, acute shortage of money means that there has in practice been little change compared with previous practice. The main new commitment is to ERA-NET, which provides a low-cost way to progress towards internationalising programmes.

The geographic focus of Swedish internationalisation is Europe, but there is a persistent theme of making sure that contacts are also maintained with other parts of the world, despite the European push represented by the European Union. Within Europe, links are most strong with the Nordic neighbours, and considerable effort is being devoted to reviving the older links with the Baltic States.

3.1.2 Germany – increased attention at internationalisation

The major innovation policy challenge seen for Germany is to enhance its international competitiveness through continued internationalisation. One sixth of BERD is performed by foreign multinationals. Germany wants to remain a top league player in the global knowledge society. Hence, research and innovation have been given priority by the German Federal Government. Co-operation between universities, research institutes and companies (in particular SMEs) has to increase, and the innovation networks need to involve more international partners. Moreover, it is important to have highly qualified personnel: there are skill shortages in key technologies, especially ICT. Therefore, a 'brain drain' must be prevented (and converted in a 'brain gain'). Germany has to become a more attractive location for R&D.

A ten-point internationalisation strategy was published by the government in 2000, covering
1. International co-operations
2. ERA
3. Common R&D infrastructure
4. European higher education area
5. Promoting experience abroad
6. Marketing the education system
7. New markets
8. Research on global problems
9. Standards and norms
10. Improved R&D monitoring

Germany already has a strong national support structure for the Framework Programmes, via the EU-Büro, and continues to participate strongly. New effort has been put into marketing aspects of the research and innovation system, and more generally place marketing for Germany, especially via the Internet. Mobility programmes are offered to attract academic faculty and students from abroad and a 'green card' scheme tackles the labour shortage in ICT through immigration. The organisations that traditionally support industry with applied research and advice, such as the Industrial Investment Council, the AiF and the Fraunhofer Society, increasingly advise smaller firms on how to do research and business abroad. Re-establishing research and industrial links with Eastern Europe is a particular focus, but there are also contacts with the rest of the world. Schemes such as PRO-INNO that help SMEs access and work with research institutes have been opened up so that foreign as well as German researchers and research institutions may be used, but it remains a condition that the companies supported be in Germany.

3.1.3 Switzerland – from headquarters to R&D attraction

Before the rise of Sweden and Finland, Switzerland typically used to lead internationally in the share of GDP devoted to R&D. Growth in this indicator has, however, stagnated. While Switzerland remains a 'headquarters economy' for multina-

tional firms, there are growing policy concerns about the potential for these companies to disinvest in R&D in the country. Switzerland has long been highly dependent upon expatriate researchers. Traditionally, too, policy has focused on research and education measures, and been rather non-interventionist in relation to innovation. Instead, the aim has been to keep economic and legal framework conditions very friendly to industry.

Internationalisation in basic research and education was identified as a policy priority by the government in 2002/3, but there has been little new in the way of programmes or instruments as a result. Scholarships are available for foreign students, as an increased mobility measure to help assure the supply of scientific manpower. Switzerland participates fully in the Framework Programme, and has the normal representation in Brussels and partner search facilities available. SMEs can receive support in entering and participating in the Framework Programme. The Swiss Talents network and database maintained by the Science Agency links expatriates, while Swiss Houses support Swiss universities, which co-operate with universities abroad. However, given the low priority given to innovation policy in Switzerland, there are no meaningful internationalisation measures to consider.

3.1.4 Ireland – a renewed approach to international R&D

In stark contrast to Switzerland, Ireland's rapid economic development has been strongly based on industrial policy and substantial investments in innovation measures. Business expenditure on R&D remains low, however, with 80% being done by foreign-owned multinationals. Ireland has few research institutes and the universities have been badly funded for a long time. As Irish GDP per head has risen to average EU levels, so the country's traditional labour cost advantage has disappeared. Both retention of existing foreign direct investment and the attraction of new investment are important policy issues, as is strengthening the capabilities of the indigenous firms.

Following a Technology Foresight exercise at the end of the 1990s, Ireland has embarked on a very bold and expensive set of investments, upgrading the physical infrastructure of the universities and making massive investments in strategic research in biotechnology and ICT through the new Science Foundation Ireland. SFI is an agency of the industry ministry. Its first intervention was to offer very large grants to foreign-based researchers willing to move to Ireland and establish research groups. These have been followed by smaller grants, open to both nationals and those abroad. A central plank of the strategy followed here is to make the knowledge infrastructure so attractive as to induce foreign multinationals to locate R&D facilities in Ireland. Other instruments include inward mobility schemes for individual researchers and others with key skills, and reduced fees for non-EU post-graduate students. There is an innovation support programme aimed specifically at strengthening the capabilities of Irish branch plant – with the aim of reducing their 'footlooseness'. Low corporation taxes in Ireland mean that the tax breaks for R&D expenditures are less valuable to companies. Multinationals can therefore, like indigenous companies, benefit from direct R&D subsidies. An old programme helping Irish companies to identify and acquire technologies from abroad (typically product designs) is still in place, but has been declining.

A result of the new investments is to reduce Irish participation in the Framework Programmes. There appears to be more money available than the system can absorb. The reduction is probably healthy in that, before the new investments, the Framework Programme was the principal source of external R&D funding for Irish universities.

The Irish strategy is in many respects unique in Europe (though there are some similarities with Singapore). It involves very large risks – the new research measures are planned to cost about three billion euros over 2000–2006. However, the leap in knowledge intensity that is being attempted is also very big, and may be necessary in order to sustain high Irish living standards in industrial markets, and markets for research talent, that are increasingly international.

3.1.5 The Netherlands – from open approach towards specialisation

Since The Netherlands hosts a number of significant multinationals, globalisation has meant that for some time there has been a policy concern that corporate R&D might migrate away from the country. Business expenditure on R&D is nonetheless low by international standards and innovation performance is sluggish. There are important labour shortages among knowledge workers, and – in policy – there is a growing recognition of a need for specialisation in what is a comparatively small country. The main policy challenges are seen as being

a. Improving the climate for innovation in the Netherlands and making it more attractive for innovative activities (by domestic as well as foreign firms). One of the concerns is that multinational companies with their headquarters in the Netherlands will (increasingly) locate their R&D activities elsewhere.
b. Increasing the number of companies that innovate (including SMEs), and make the Dutch economy more dynamic. This will also contribute to the attractiveness of the Netherlands as a location for R&D.
c. Exploiting opportunities for innovation by creating more focus and mass in strategically important fields. This will contribute to creating a good position of the Dutch R&D system in international networks and international programmes.

Innovation measures are aimed at raising the quality and focus of existing national institutions, backing winners among potential technological priorities, increasing policy co-ordination between the national and EU level and promoting inward mobility. The internationalisation aspect is tackled through several, largely incremental, changes

- Extensions to the international network of Science and Technology Attachés
- Attracting foreign researchers and easing immigration restrictions for key knowledge workers
- Extending the cope of the IOP innovation instrument – which links industry with research institutes – to allow the use of foreign institutes
- Linking the Dreamstart company start-up measure with equivalents abroad.

3.1.6 Estonia – small and dynamic, also in internationalisation

Since Estonia's independence from the Soviet Union in 1991, the country has rapidly and effectively privatised and liberalised much of the economy, attracting significant foreign investment. Economic development has been swift. However, a cost of the transition has been the closure of many R&D facilities and a brain drain of researchers. Estonia today is largely a branch-plant economy and needs to increase the knowledge intensity of production in order to remain competitive as wages and other costs rise. It is important to embed the foreign companies more firmly into the economy, and to increase Estonian-owned business' international networks and activities. Business expenditure on R&D is low, overall, and needs to rise.

The 'Knowledge Based Estonia' strategy for 2002–2006 focuses on updating the knowledge infrastructure and increasing competitiveness. Structural funds provide an opportunity to upgrade the knowledge infrastructure. Policies – especially the setting of a low corporation tax rate – continue to promote foreign direct investment, as a way to access both economic activity and technology. Estonia has for some time been participating in the main European co-operation programmes and has aligned its national R&D priorities with those of the Framework Programme. Considerable effort is being expended to import and adapt current EU innovation policy practices (e.g. science parks and competence centres) to Estonian circumstances.

The strategy is accompanied by a set of internationalisation measures including

- Traditional supports to foreign direct investment, such as a place marketing organisation with several international offices offering information, identification and selection of sites, support for developing infrastructure needed for investments outside the main cities, support for employee training and services to link investors with local suppliers and contractors
- Grants and soft loans for R&D, for which both foreign and indigenous firms are eligible
- Partner search and technology transfer services, partly through the national Innovation Relay Centre

- Support and training for organisations seeking foreign partners for R&D – both inside and outside the Framework Programmes
- Supports for generating R&D infrastructures, competence centres and science parks.

An innovation awareness programme will be launched during 2004, and a scheme to attract back researchers who emigrated during the 1990s is being considered.

3.2 Trends and practices

Interviews with policy makers in the above countries included a set of questions about their qualitative impressions of national policies with regard to internationalisation. The key drivers for internationalisation were pressures caused by the changes in global markets, coupled with the opportunities to exploit and upgrade national competences. Changes in technological opportunities were not seen as so important. Opinion was sharply divided about whether the need for internationalisation was driven by changes in regulation or legislation, which were seen as important in Estonia in the Netherlands, but not elsewhere.

Participation in international networks was seen as the most normal way to promote internationalisation – suggesting that the most important way internationalisation measures are being put in place is through evolution of the traditional European networks, not least the Framework Programmes. This reinforces the impression from the case studies that the policy push for internationalisation from the EU level is stringer than that from the national level. Naturally enough, national policy makers favour national goals. Internationalisation is only interesting in so far as it serves those national goals. It was important to visit other countries, to conduct studies and analyses and to agree joint goals in international networks. Bilateral arrangements were less normal. The Swedish response suggested that much less internationalisation activity was taking place than would be desirable.

All the countries had the EU as a central focus of their internationalisation activities, but the USA was nearly as important. There were variations in the more specific focus, with Sweden and Estonia focusing on the Baltic and Nordic region and Germany having a broader focus on the accession states in addition to recognising the need to act globally. Ireland has very strong links with the USA (where there are more Irish people than in Ireland) and traditionally receives significant amounts of money from the USA as well as from the EU, to support economic development and research.

The country sections suggests that
- There is a fairly high level of activities aiming to promote inward investment and inward mobility of researchers
- In contrast, there is little specific activity aiming to help nationals expand their activities abroad. What there is focuses on representation and often has a high scientific (as opposed to innovation) content, such as is the case with the Swiss Houses
- The great weight of internationalisation activities continues to lie in the area of the established international networks and programmes, and national supports to participation in them. A small number of national networks focused on individual people (such as Swiss Talents) was also evident
- Mainstream R&D and innovation funding activities continue only marginally to be touched by explicit changes directed at internationalisation through cross-border arrangements. However, within the mainstream category lies a set of activities that aims to strengthen both the capabilities and the attractiveness of the national knowledge infrastructure, and this clearly has an important international dimension.

The country cases also suggest that evolutionary, rather than radical, changes are happening in policies and instruments. There is still no evidence that states are developing or taking thought-through positions on how they intend to specialise within the ERA, even if some countries are beginning to acknowledge that there is a need for such specialisation. Cross-border funding is still very unusual, and it may take some time to build up enough

ERA-NET experience before states are willing to move further in this direction. There is increasing willingness to exploit foreign knowledge infrastructures in the interest of national organisations, by including them as partners in programmes that help improve firms' capabilities. This is done by making the funding rules more permissive. We found no new cases of formalised variable geometry: the cases we identified (Swedish-Finnish bilateral programmes and the Nordic Council of Ministers) are already well established.

The more important changes respond to economic globalisation rather than 'policy push'. The perceived increase in the mobility of multinationals' R&D activities underpins the trend to increasing the amount of activity devoted to securing foreign direct investment. The measures used are partly traditional (place marketing, actual help with starting up, subsidy). However, they are paralleled by activities that selectively strengthen parts of the knowledge infrastructure, notably through measures like competence centres that strengthen the university component of the knowledge infrastructure. In practice, so far, only Ireland has a clear ability to link these two activities. Noticeably, the new measures relate to universities and not to research institutes. These are actually tending to internationalise in response to the internationalisation of their markets and to flat or declining core funding from the state.

Mobility schemes, which attract foreign researchers, are becoming more important. They are set up in response to skill shortages or to the need to strengthen the knowledge infrastructure. Collectively, they imply increasing competition for various levels of research labour. This may be especially acute in relation to people senior enough to establish research groups with the size and capability to alter the performance and attractiveness of individual countries' knowledge infrastructures. The US academic market is already prepared to pay very high prices for such people, and there may need to be an upward adjustment in Europe in order to compete for such people.

Competence Centres, which mix longer-term industry and university research, appear to be an important ingredient in creating points of critical mass and specialisation within the knowledge infrastructure. They are needed to support specific industrial groupings or clusters and play a role in determining the location of multinationals' R&D. In some contexts (Sweden), they fill part of the space that could otherwise be occupied by research institutes. While the presence of large government research establishments (e.g. VTT) means there is less pressure to create competence centres, their flexibility and the longer-term nature of the links they build between research and industry mean they should probably considered, as an important complement to existing Finnish structures and as a significant contribution to the international competitiveness – and internationalisation – of the Finnish knowledge infrastructure.

The really radical variant of such a policy of specialisation and development of the knowledge infrastructure to increase its industrial relevance and attractiveness is that followed by Ireland. The Irish approach is radical, in part, because it is rapid: involving very visible changes over a short period of time. The longer (but still rapid) evolution of the Finnish knowledge infrastructure concerned with ICT is less visible, but has nonetheless created significant focus. The Irish example suggests that it may be possible to diversify the knowledge and industrial base through significant investments in the knowledge infrastructure. Such a bet would have to be significant in size and broadly supported within society, but by developing and connecting Finnish capabilities to the international industrial and research communities it could support the needed diversification of the Finnish high-tech economy.

Some of the small-scale actions seen abroad may also be useful. In particular, networks of people may be helpful ways to bind expatriate Finns better to the home country, promoting research and industrial linkage and helping to harvest the benefits of an expatriate community that sometimes – or eventually – comes home.

4 Internationalisation in Tekes technology programmes

4.1 Internationalisation in the programme process

National competencies in research and industrial clusters in different countries have typically their inherent strengths and segments, which optimally complement counterparts in other countries. These would logically provide a good basis for designing and running international technology programmes without much risk for large conflicts of interest.

International co-operation has been naturally in-built for academic research and the highest standard research is by definition international. As far as the technology programmes serve research institutes and university research, international context is by far the most relevant one. Large companies, on the other side, are usually already operating in many countries and continents. This is at least the case of a small country, since domestic markets are seldom sufficient to provide for large, continuous growth. What applies for academic research often applies to companies' competence too – highest standards and best competence are often found and tested in international markets.

Today, the challenge of internationalisation is relevant and topical to smaller companies, too. Regardless of company size, the demand for high quality is a crucial competition factor, which affects smaller companies at least in two ways. First, companies need to search for state-of-the-art technologies, experts and expertise more broadly than domestically to be able to provide good quality services and products. Second, even domestic cus-

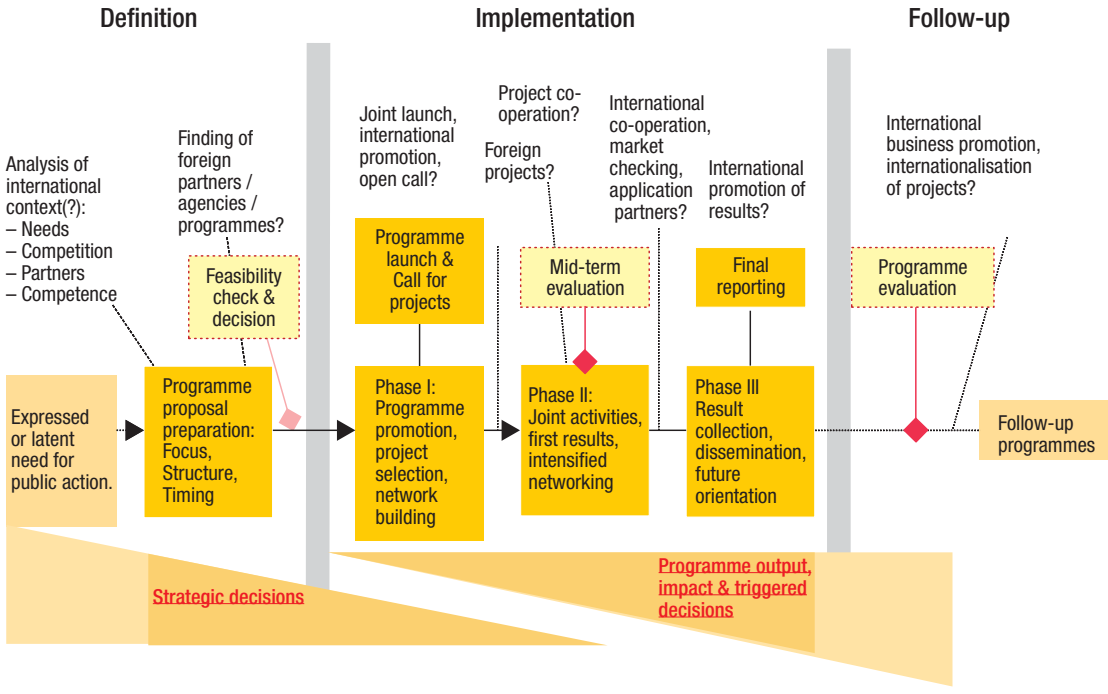

Exhibit 9. Aspects of international co-operation in technology programmes

tomers tend to open calls for tenders more broadly than just for domestic providers. For public services this is ensured by legal regulations and for private sector, it is the demand for highest quality and good value for investment that is the driver. So whatever the sector or field, purely domestic markets rarely exist any more.

How does the internationalisation factually take place at technology programmes? To address this question, we have here distinguished three stages in the process or a life cycle of a programme; first is the ***definition stage***, which may take up-to one year, then comes the programme ***implementation stage*** lasting typically for 3–4 years and after the formal completion of the programme comes the ***follow-up stage*** without any distinct time frame. Furthermore, the second programme stage is here divided into three consecutive phases, i.e. *programme promotion, project selection and network building* (phase I), *joint activities, first results and intensified networking* (phase II) and *result collection, dissemination and future orientation* (phase III). The continuum of a technology programme through these three stages is described in Exhibit 9, together with some key internationalisation questions related to each programme stage. The following chapters will explore these questions more deeply, while also reflecting some general findings from the programmes evaluated.

4.1.1 Design and definition of programmes

In each stage of the programme, there are issues and openings for international co-operation, and as the programme progresses, the number of such openings typically increase.

Tekes technology programmes are mostly mission-oriented programmes – they are initiated and designed to respond to some technological, market or societal need, whether latent or expressed, top-down or bottom-up. In principle, the same should apply to international co-operation. The need for internationalisation and public intervention should be clearly defined. Moreover, internationalisation should not be an aim by itself, rather a means to achieve other aims, such as access to new technologies or larger markets, gaining economies of scale through larger research volumes or shared resources or to be able to observe important development trends among leading research units, etc. This should apply at least for the project level co-operation.

The technology programmes vary significantly among their aims, structures and activities for international co-operation. Some programmes are clearly research oriented, some aim at strengthening of a national industrial cluster, some others at promoting international competitiveness of Finnish companies. In this respect, the technology programme concept is very broadly defined. The same applies to the internationalisation aims, to what kinds of tools and instruments they apply for it and how the internationalisation has been designed and resources allocated to it.

Few technology programmes are international by definition – internationally integrated programmes. That is, programmes that have been planned and initiated to jointly tackle technological or competitiveness related challenges in more than one country. The design and preparation of internationally integrated technology programmes is significantly more challenging than purely national ones. The topic of a programme must be truly relevant to all, operation methods and administration clearly defined and mutually adaptive, not to mention the challenges related to combining different linguistic and cultural backgrounds. Most often the greatest challenge for launching an international joint programme is funding – to be able to collect and commit in the partner country a comparable amount of applied research funding for the same topic and within the same time frame. When successful however, internationally conducted technology programmes appear to be more ambitious in their content, and perhaps also of higher standard than merely national ones.

From the perspective of possibilities for and potential impact of international co-operation, **many of the key decisions of technology programmes are made at the definition and design stage of the programme**. Why a programme is being launched,

how it is constructed and resourced. The same applies in particular to international co-operation; what kind of role is foreseen for international co-operation at programme or project level, how well have international challenges been identified, studied and addressed in the programme design. How are they organised? Is the programme targeted merely to national operators or to a more broad audience? Many of these questions relate back to the initial role of technology programmes and Tekes itself – who and what do they serve at the end.

4.1.2 Implementation

In the beginning of a programme implementation, internationalisation is often linked to promotion of the programme as such, to increase the international awareness of the programme and Finnish competence and thus ultimately to facilitate the finding of appropriate partners and projects for project-level collaboration. If the programme is carried out in parallel with foreign or international programmes, the calls for project proposals may be mutually synchronised.

Depending on the programme, analyses of potential competencies and markets abroad are launched latest at the implementation stage. Many examples exist on how these can be organised; typically sending an analyst abroad, outsourcing a study or by organising called benchmarking visits by the programme participants. Towards the end-part of the implementation stage, the aims of international collaboration tend to focus more on promotion and exploitation of research results. This is often the phase when interest and openings for international collaborations in technology programmes begin to build up.

Once the programme has been launched, its aims, including the ones for internationalisation, are usually checked and discussed when the results of the mid-term evaluation are at the hands of the programme steering group. This provides a good opportunity to see, whether stronger emphasis should be put to internationalisation or if it should be redirected or carried out in some particular manner. **Redirection, however provides mainly for fine-tuning or corrective measures**, since most of the major decisions should have been done already at the earlier stages of the programme.

An appropriate timing and future orientation of technology programmes are important, even critical to their attractiveness and effectiveness towards companies and research units. To these ends, Tekes technology programmes are often considered successful. The closer to commercialisation the programme focus is, the more critical the time factor usually gets. Thus international collaboration of enterprises should primarily stem from their own objectives and schedules, rather than from those of the programme.

In comparison, other available instruments for international research co-operation, such as EU framework programme, COST, Eureka, etc. usually require longer preparation and co-ordination times, and thus may be less responsive to strategic research needs. Different time span may also make them, as instruments for international research co-operation, less compliant with national technology programmes.

International co-operation is most fruitful when the level of competence is clearly high, all participants have a clear role and interest for their participation and are able to provide an input to the co-operation which is in balance with other partners' interests and inputs. Each participant must be able to provide an added value in exchange of his own benefit from the co-operation. From this perspective, it would appear to be questionable to promote international co-operation in technology programmes in situations where there is not sufficient national competence to be provided in exchange.

Further education in universities and the theses of graduate and post-graduate students are often closely linked to national technology programmes through study topics, funding and timing. Besides the increased expertise and findings, the research produces many new and eager specialists, with up-to-date information and a well over average communication skills in foreign languages – a source of educated and motivated workforce for in-

ternational research co-operation. This seemingly remote link between technology programmes and international co-operation can be quite significant benefit in practice.

4.1.3 Follow-up and building-up of partnerships

Programmes have their own time span – a life cycle – from definition and set-up to launch, implementation and completion. In cases when programme level international contacts and co-operation have been built during the programme, this is deemed to end with the completion of the programme, at least in an organised manner. The programme manager, who in most cases is the person responsible for international contacts, will take up other tasks and international co-operation may continue on project level at research units, if the true interest remains for that.

There are also obvious reasons why international co-operation does not appear any stronger in technology programmes. International co-operation is risky, resource demanding and requires many skills, too. The short term benefits of collaboration may not always appear sufficient for ensuring the necessary commitment. On the other hand, benefits of international co-operation will certainly not be gained if the step has not been taken. Potential partners will need to be identified and collaboration proposed and tested, in order to have the option of benefit. A bonus to this relies in the fact that **international collaboration often brings unexpected openings and increased experience that may bring benefits later on**.

4.2 Documented internationalisation

The following chapters present the nature, objectives, activities and possible outcomes of internationalisation, as they have been reported in different technology programme documents. The idea for presenting this data is, first to give an overview of the internationalisation in technology programmes, second to complement and integrate survey and case study findings with more formal evidence and third, to review how internationalisation aspects are documented compared to how they appear on the basis of survey findings.

The material reviewed includes mainly three types of documents: Final and evaluation reports published by Tekes, web-based descriptions on programmes, and preparative programme proposals submitted to the board of Tekes. Final or evaluation reports were available for 42 programmes. Short, web-based descriptions were available on every programme. Programme proposals or preparative memos were available on 18 programmes. In the latter two sources, however, there was relatively little information on the internationalisation activities carried out by the programmes, since these documents focused mostly on programme background and aims. Thus, for the remaining 22 programmes the documentation was not considered sufficient to allow a full analysis and comparison with other programmes in respect to programme activities.

4.2.1 Objectives and rationales of internationalisation

An average programme in the evaluation sample has 55 projects and a budget of 27 million euros. The variation in programme size is high because of the varying nature of Tekes' programmes: the small, focused programmes have only a dozen projects with a total budget of approximately 5 million euros, while the largest programmes may have nearly 200 projects and a budget of 150 million euros. As may be expected, this difference in size and complexity appears to have implications for the management of internationalisation in the programmes. In larger programmes internationalisation seems to be supported by the programme with a set of general services offered for participants. Examples of these include exports clinics and monitoring of international market, standard and technology developments. In smaller programmes the internationalisation support for projects seems to be more direct, as the programme is able to or-

Exhibit 10. Rationalities for internationalisation

Rationality for internationalisation	Frequency	Percentage of programmes
Norms, regulations	13	20 %
Market opportunities or pressures	14	22 %
Breakthrough in technology	3	5 %
Exploitation of Finnish competence	21	33 %
Upgrading of Finnish competence	25	39 %

ganise activities and benchmarking visits targeted to the needs of individual projects.

Of the 64 programmes, 37 have stated internationalisation objectives. Quite often, the lack of internationalisation objectives appears to be related to an understanding according to which Finnish actors already possess the leading expertise in the world and, thus, there is no need for international collaboration. In other cases the lack of internationalisation objectives seems to be associated with a very domestically oriented programme mission. Examples of such are programmes that aim to increase networking among domestic actors or to impose a change on the domestic business environment.

The rationalities for internationalisation were recorded according to the categorisation based on the framework described in section 1. Because the rationalities are not mutually exclusive, each programme may have more than one rationality. Of the sample programmes, 10 programmes appear to have no rationale for internationalisation, approximately half of the programmes have a single rationale and the remaining programmes have more than one. The frequencies of different rationalities and their relative portions are presented in Exhibit 10.

The most common rationale for internationalisation was related to upgrading Finnish competence, with approximately 40% of the programmes focusing on this aspect. The notably low frequency of technological changes as the driving force can be explained by its definition: this category includes only cases in which technological breakthrough or a paradigm shift was stated. Moreover, developments in foreign markets as the main reason for internationalisation (22% of programmes) are closely intertwined with technological changes, thus blurring the distinction between the two. In effect, the category related to technology may be viewed as a special case of a market-oriented internationalisation rationality, in which there is a technological discontinuity present and the associated markets are still taking shape.

One fifth of the programmes are influenced by changing internationalisation regulations and norms, which brings fourth a need for a distinct set of internationalisation activities. Quite often changing regulations appear to be associated with the fifth rationality for internationalisation, i.e. exploitation of Finnish competence (33% of the programmes), as the nature of internationalisation in the programme is to utilise Finnish expertise to conquer foreign, deregulating markets.

4.2.2 Activities supporting internationalisation

In order to analyse programme implementation in terms of internationalisation, 11 categories of internationally oriented activities were formed in the database. These classes of activities are presented in Exhibit 11 along with their frequencies. The percentages are calculated as the portion of the 42 programmes for which sufficient data was available.

Exhibit 11. Activities supporting internationalisation

Activity supporting internationalisation	Frequency	Percentage of programmes*
Internationally shared aim	8	19 %
Participation in international networks and research programmes	15	36 %
Joint research projects	23	55 %
International agreements between participants	5	12 %
Seminars with international participants or speakers	21	50 %
Finnish representation in international fairs or seminars	21	50 %
International visits, study trips, benchmarking visits	14	33 %
Participation in international committees, standardisation forums, etc.	6	14 %
International mobility of researchers	12	29 %
International programme promotion or marketing	8	19 %
International monitoring, feasibility and market studies	17	40 %

*Calculated as the portion of the 42 programmes for which sufficient data was available

The most common activities appear to have been the inclusion of joint research projects, participation in international seminars and invitation of international experts as consultants or seminar speakers, which were stated for approximately half of the programmes. As for the joint research projects, the presented number includes all the programmes for which at least one joint project was reported. Of these programmes, approximately two thirds also involved projects that received funding through international research networks such as COST.

International monitoring, feasibility or market studies were reported as part of programme activities in 40% of the programmes. These studies were usually carried out as support projects that were initiated by programme management to provide general information for programme participants. International visits were reported in one third of the programmes. In most cases, these were study trips or benchmarking visits carried out by the programme supervisory board or by the programme coordinator alone. In some instances, larger seminar trips were organised for a wider audience of programme participants. As for the international mobility of researchers, it is likely that only a small portion of the activity has been reported in the programme documents, as this is mostly a project-level activity.

The remaining four activities reflect a higher level of commitment for internationalisation, since these are activities that were mainly undertaken only when internationalisation is central in the programme. In one fifth of the cases, the programme mission was shared with parallel international programmes or foreign national programmes. It appears that in these cases the international interaction was much stronger and joint R&D was undertaken more extensively with foreign actors than in programmes that originated mainly from domestic needs alone. In few cases the programme was organised in close cooperation with a foreign policy-making body already from the start, which often involved a bilateral agreement between Tekes and the foreign party. In other cases programmes

were conceived nationally but at similar times, which offered increased possibilities for joint research and knowledge exchange between the programmes. Approximately one fifth of the programmes, usually of export-oriented nature, promoted the programme or Finnish competence and products internationally. This included both the publication of marketing material targeted for foreign markets as well as promotion of programme and Finnish actors in fairs and conferences.

The final activity, participation in international standardisation work, was reported by six programmes. This activity usually took place in internationally oriented programmes in technological or scientific fields in which Finns have high-level expertise. Such activities generally received positive feedback from evaluators as they usually proved to be very fruitful forums for knowledge exchange and for influencing long-term developments.

4.2.3 Geographic focus areas

Over 70% of the programmes had activities directed on foreign markets or actors at least to the extent that they organised a benchmarking visit or a study trip abroad. This indicates that **many programmes had international aspects even if they were not stated among programme aims** at the outset of the programme. **For two thirds of the programmes Europe or regions of Europe were among the geographic focus areas of internationalisation.** U.S. and Canada were focus areas in half of the programmes, while 45% had some activity towards Far East. In Far East, Japan was usually the country of interest, but also China seems to be receiving increasing attention. In addition to these primary areas of interest, five programmes reported activities towards other regions, Russia being the most common. Exhibit 12 summarises the geographical focus areas in the sample programmes.

Exhibit 12. Geographic focus areas

Geographic focus area	Frequency	Percentage of programmes*
Europe	29	69 %
North America	22	52 %
Far East	19	45 %
Other	5	12 %

*Calculated as the portion of the 42 programmes for which sufficient data was available

4.2.4 Impact of internationalisation

The analysed documentary material includes **relatively few assessments on the success of internationalisation** in the sample programmes. Moreover, the diversity of view-points found in the evaluation reports complicates the analysis on the success of international activities. Some general remarks can be given, however.

According to the evaluators, **activities supporting internationalisation have not been very pronounced in many programmes, and thus the impact has remained relatively low**. Especially participant companies wished for more internationally oriented activities to be included in the programmes. This seems to result from a generally low priority given for internationalisation at the programme level.

Those programmes that were conceived and organised according to the sector's needs for internationalisation right from the initial stages, appear to have been able to generate increased readiness for internationalisation. This seems to manifest itself mostly through programme level impacts: increased international recognition of Finnish industries, increased scientific visibility, established international contacts between programme manage-

ment and foreign actors and increased participation in international standardisation work.

However, at the project level the impact of the programmes has been less pronounced. The programmes have not been able to generate many success stories in terms of internationalising Finnish companies. As for research groups, the programmes usually strengthen existing contacts, but the impact on the establishment of new, lasting collaborative relationships has been less notable. This is understandable, though, as researchers within the scientific community usually already have contacts with each other.

5 Profiles for international co-operation

5.1 Analysis of case programmes

A set of technology programmes has been selected as case examples to allow deeper exploration of typical internationalisation mechanisms or profiles in technology programmes. The purpose is not to form a representative collection of internationalisation types, rather to provide some descriptions and insight of typical internationalisation processes.

In accordance with the evaluation steering group, the case programmes were to include as many types of technology programmes as possible. It was thus considered that a set of 5–10 programmes would be large enough set to describe the key differences, and small enough set to allow deeper analyses within the evaluation time-frame. The cases were to cover some programmes that had been recognised as internationally active, as well as programmes where internationalisation plays not as recognised role. At the end, altogether nine case programmes were included in the case description.

FFUSION2 programme was selected to represent programmes with clearly international research context. iWELL and NAVI were selected to represent collective, cluster type technology programmes which have large interest groups and challenging, long-term objectives. iWELL with more societal needs and NAVI – with more standardisation and framework development aims. iWELL was also known for having initiated programme-level collaboration with Japan, which was considered rather unique.

As a comparison to larger, umbrella type of programmes, KENNO was selected to represent a precise, narrowly focused programme with a specific aim for internationalisation. KESTO, on the other hand, was selected due to its broad, almost global technological challenge and a specific Finnish approach to it, while PRESTO and GPB were selected to represent programmes with clearly stated internationalisation aims. Both were trying to up-grade Finnish competence with an expected impact on industrial competitiveness.

SPIN was selected for many reasons. It was a programme with clear and in-built internationalisation aims. It was strongly enterprise-driven and aiming to exploit strong Finnish competence in certain segments of software business. Internationalisation was known to be a key challenge for small software companies and SPIN had been carrying out many activities to this end.

TESLA and NAVI were programmes, where a key driving force had been a paradigm shift in technology and international market. In the former, the European electricity distribution market had been opening and created a need for new, more advanced technologies. TESLA was boosting the Finnish industries in keeping up with the lead of this development. In NAVI the development was going the other way. Mobile telecommunication advancements created opportunities for new global markets. NAVI collected the Finnish actors together and facilitated a collective development of system architectures and close monitoring of international developments.

For each of the case programmes, complementary documentation to published reports was collected (internal programme proposals, programme presentations, etc.) and the programme managers were invited to participate in an internationalisation workshop at Tekes. This was followed on with interviews of programme managers, the relevant Tekes programme co-ordinators, some steering group members. Qualitative information on the selected case programmes was complemented with survey questionnaires targeted to the steering group members and to all projects carried under these programmes. The various pieces of information were then collectively analysed. The following chapters explain briefly the context and key issues of the international process in each case programme.

Exhibit 13. Selection criteria for case programmes

	Selection criteria for case programmes	FFUSION2	GPB	iWELL	KENNO	KESTO	NAVI	PRESTO	SPIN	TESLA
Programme type	**Enterprise driven** / oriented programme		✓		✓	✓	✓	✓	✓	✓
	Research driven / oriented programme	✓		✓		✓	✓	✓		✓
	Collective / **umbrella** programme		✓	✓			✓		✓	
	Narrowly **focused** programme				✓	✓		✓		
International aspect	Programme had been **recognised** for its strong international aspect / success	✓		✓					✓	
	Internationalisation was a **specific objective** of the programme	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Internationalisation was **built into the structure / mission** of the programme	✓	✓				✓	✓	✓	
	Large variety of actions were carried out to promote internationalisation						✓		✓	
Competence	Programme aimed at **increasing / exploiting Finnish lead** in competence against the international leading-edge		✓	✓		✓	✓		✓	✓
	Programme aimed at **up-grading / complementing Finnish competence** with the international leading-edge	✓			✓	✓		✓		
Triggering trends	The triggering trend related to **changes in** international **norms, regulations or standards**									✓
	The triggering trend related to **changes in** international **markets**		✓	✓			✓		✓	✓
	The triggering trend related to **changes in technology**			✓	✓		✓	✓		✓
	The triggering trend related to **big science development**	✓								

5.2 Comparison of profiles and practices

The section herewith provides a short comparison and synthesised outcomes of the nine case programmes. *A more comprehensive description of the key issues for internationalisation in these programmes is presented in Annex 4.*

On the basis of programme documentation and analysis of the selected case programmes, it appears that Tekes technology programmes form at least five distinct categories in their approach to internationalisation. The categorisation reflects the rationale for internationalisation, which in most case programmes seems to follow rather directly from the overall programme mission – internationalisation is seen as a means to some end. The categories are by no means mutually exclusive, as many programmes include goals of more than one of these categories. *No particular distinction has been made between multilateral and bilateral in-*

ternational collaboration, as the essence of this typology is in the rationale (i.e. foreseen benefit) of collaboration. Thus for example bilateral programmes can fall within any of the following programme types.

5.2.1 Big science programmes – internationalisation as their raison d'etre

Very large scale research, which addresses global challenges and is perhaps not feasible to be conducted by one or few countries alone, is often called big science or mega science. These are typically collections of long-term research projects and may include substantial physical or virtual infrastructure developments. Examples of such projects can be found in life sciences, space sciences, environmental sciences and in this case nuclear physics, among others.

The mainstream and focus of action in big science programmes is on fundamental research. There is however, often a reasonably large request for applied research, testing and even high quality purchasing connected to it, particularly in the development of research equipment and facilities. It is often the latter part, which is interesting for smaller technology-based companies particularly as a point of reference.

From the point of view of domestic interest and benefit from big science programmes, it is of utmost importance that Finnish competence in basic and applied research, as well as in development and related business is of sufficient high quality in order to fully contribute to and gain from the international research. These programmes are far to demanding for the purpose of merely up-grading domestic expertise and too costly to be followed merely for possible future benefits. At best, the domestic technology programmes have been designed to parallel or integrate with their international counterparts, with the addition of more national interest, such as activating domestic industries and further disseminating the outcomes of research. The FFUSION2 programme presents a good example of such.

5.2.2 Internationalisation as a means for adopting, up-grading and complementing expertise

Programmes which aim to upgrade Finnish competence seem to be strongly influenced by the needs of large, internationally operating companies. These companies are usually well-established in the global markets. They have strong linkages to international customers and suppliers. Thus they rarely need support for market-oriented internationalisation. Rather, they may need access to the best research expertise in the world.

This is often the situation in mature industrial sectors that have traditionally been strong in Finland. There are increasing pressures from global competition, and thus the pertinent question is how to strengthen the domestic competence base in which most companies still conduct a large part of their R&D activity, and from which the companies could draw technology-related competitive advantage. Furthermore, large established companies often have a good understanding of international markets and the associated technology development needs.

In these situations technology programmes can be viewed as instruments for directing research activity to the needs of sectors' central companies. Technology programmes function as "focusing devices" for guiding research efforts and resources into the few topics that are considered most relevant. Even though large companies are very influential in programme set up, the core of the programme may consist of well-focused technology development projects conducted by research institutes and universities. These programmes usually do not emphasize support projects that aim to generate generic knowledge to support and steer technology development efforts.

This technological focus makes possible the identification of existing or complementary knowledge also abroad. As for programme structuring, this makes it easier to actively initiate international R&D networking as the experts within the given field are known by researchers themselves. International collaboration is mostly initiated by research groups, not so much by companies. It ap-

pears that the role of programme management in the internationalisation of this type of programmes is not so much to actively participate in the internationalisation – so called "hands-on" internationalisation – as it is to facilitate project-level internationalization through encouragement and allocation of programme funding for research exchange programmes, participation in international congresses, etc.

In these types of programmes, internationalisation is seen as a means for achieving or supporting technological leaps in Finland. The forms of internationalisation at the operative level depend on the availability of complementary expertise abroad. If Finnish competence is very strong in comparison to abroad, international collaboration may not be among programme objectives, as it serves no purpose.

Comparing this conceptual type of programme internationalisation to the case programmes, it appears that KENNO, KESTO and to some extent PRESTO seem to resemble it. Both KENNO and KESTO take place in traditional industrial sectors in which Finnish companies have an established, international presence. They face increasing global competition that creates needs for developing more knowledge-intensive products in order to respond to this threat. Presto is somewhat different, as the technology and the related markets are still emerging. The technology is horizontal in the sense that it may offer benefits in many industrial sectors, and the programme aims for synergistic development of this technology. Yet the central actors in the programme are internationally operating companies with long research traditions. The goal of the programme was to complement Finnish competence with foreign expertise – thus the programme is similar to the two former. In all of these programmes the foreign centres of excellence were already known or they could be identified rather easily. Thus the programmes were able to actively support internationalisation already from the beginning of the programme. Moreover, also the context of TESLA technology programme is similar to the three other programmes, but in this case it was considered that the attempt to complement domestic competence with international expertise would not provide sufficient benefits compared to the costs and increased complexity that internationalisation brings to the programme. As a result, the programme remained largely domestic.

In the GPB programme, internationalisation was viewed as a management capability, not so much as a concept that comprises networking with research groups, suppliers and customers across borders. The programme aimed at up-grading the international competence of (mainly smaller) Finnish enterprises. It was not, however necessary to seek all the leading expertise from abroad, since it was largely in the hands of domestic lead companies. Similar situation may be common also in other technological fields, industries and particularly programmes aiming to develop business methods.

5.2.3 Exploitation – supporting SMEs to global markets

Internationalisation as exploitation of Finnish competence is usually central in programmes that attempt to support the growth of companies in some relatively new field of technology. Tekes' role as the catalyst of such interventions appears to be strong. The programmes are initiatives that aim to strengthen developing businesses and to support the creation of new businesses in a promising technology field. In these programmes, Tekes role is to correct market-failure and activate companies for R&D that supports entry into international markets.

Quite naturally, the main customers of such programmes are smaller companies and research groups that are considered to have internationally exploitable expertise. The programmes are aimed for the support of SMEs rather than established companies. There are usually a large number of SMEs and research groups involved, as the programme often attempts to bring together all the actors within the given sector or technology field. The involved technologies and objectives of the participants are much more diverse as in programmes that aim for upgrading of Finnish compe-

tence. As a result, the programmes are often structured as large umbrella programmes that aim to serve the needs of a diverse set of programme participants. International growth is usually at the centre of these needs because the size of the Finnish markets is only a fraction of global markets. In comparison to the programmes upgrading competence, internationalisation seems to be a higher priority in programme goal-setting. However, it appears that R&D oriented internationalisation of both research groups and companies are not emphasized in this type of programmes. The role of research groups in programme is either to develop technology that can be exploited internationally or to provide supporting knowledge for the participant companies. In both types of research projects, awareness of international markets and technology trends is crucial.

Often SMEs not only lack financial resources for internationalisation as is the case for research units in upgrading-oriented programmes, but they may also lack sufficient knowledge of international markets and customers as well as competence for the management of the internationalisation process. Thus, there is a strong need for individually designed, hands-on guidance from programme management, but also a large number of companies and research groups that are in need for this knowledge. The question is, how the programme can most efficiently offer tailored support for a large group of participants. As for steering the direction of technological development efforts, the role of programme management is often less notable.

Due to resource constraints, the provision of tailored support services, e.g. export clinics, appears to be quite limited. This direct support from programme management may also be complemented by the utilization of parallel programmes and services, such as the Global Software programme in the SPIN technology programme. Otherwise the support remains at a rather general level: programmes carry out market studies and provide opportunities for contacting international actors through organising international seminars, study trips and meetings. Furthermore, also the promotion of Finnish competence is common in this type of programmes. However, direct, significant promotion of individual programme participants is often impossible in larger programmes, and thus the activities usually concentrate on the promotion of the industry as a whole.

Obviously, the size of the programme affects how internationalisation is managed in the programme. In smaller programmes, it is easier to provide hands-on support for participants. In larger programmes, in turn, the impact on sector activation is more pronounced, but the programme is able to offer only financial incentives and general advice to its participants, but not as much tailored support.

Within the selection of case programmes SPIN and IWELL are best examples of this programme type. They both aim to activate businesses in some nationally significant technology area that offers opportunities for growth in SPIN, there were active attempts to provide the participants with contacts, market knowledge and management know-how. In IWELL, the support structure was less pronounced, but towards Japanese markets there were significant attempts to establish contacts in international seminars. The programme also organised a number of studies on Japanese markets.

5.2.4 Programmes responding to regulatory changes – benefiting from opportunities

International regulations provide a context in which there are large, abrupt market and technology changes that cut across nations. For actors operating in a small, receptive country such as Finland, this creates opportunities. The regulative environment provides a signal that certain changes are going to take place. Even through the details of these changes may not be known, there is an increased likelihood that there is going to be a shift in international demand of technology, and thus an opportunity for conquering international markets. This provides a rational for initiating a technology programme. Thus, in programmes responding to

regulative changes there seems to be an element of exploitation among the programme objectives.

However, even though the regulative trend provides a signal for initiating technology development, it may also increase the uncertainty involved before the legislative bodies have reached a conclusion. As the legislation proceeds, this uncertainty decreases rapidly. The remaining uncertainty usually concerns the impact of the regulation on international markets, i.e. when and how the legislation will be implemented in national contexts.

The programme structure is largely influenced by the level of uncertainty involved in the regulation and its effect on technological choices. When there are many competing technological choices and the associated uncertainty is high, there is also the possibility for influencing the decision in favour of domestic companies. Such was the case in the NAVI programme. The issues related to standardisation of navigation technology were central for the development of markets. The programme provided a platform for both monitoring this development as well as influencing it. Because the technology was still emerging, there were many competing technologies. The programme was structured to provide mostly general knowledge on markets, user-needs and standardisation rather than for the development of specific technological solutions. The programme aimed to build up a domestic navigation technology network, which offered a beneficial forum for interaction among the Finnish actors. Moreover, the technology programme provided a platform for collectively and more credibly influencing standardisation work. The programme had a role of decreasing the risks involved in the development of navigation technology. This was achieved through an innovative structure, which consisted of an architecture of 12 support projects, many of which produced knowledge on international environments.

In the TESLA programme, the impact of regulatory changes was already to be seen in Finland. The technology development needs could be identified in the domestic setting, and thus the programme was oriented for the development of technology according to domestic needs. However, as later recognized, it may have been beneficial to clarify the needs of international markets in this regard more broadly. In the TESLA programme, the expected regulatory changes were known, but their impact and timing of enactment in different national markets was not sufficiently explored. It appears that also the TESLA programme would have benefited from a support architecture which would have provided the actors with more accurate information on current and expected needs in international markets. With this knowledge, also the research projects could have been managed with a more market-oriented approach.

In sum, central to this type of programme is the abrupt development trend which provides opportunities and a direction for public intervention, but also increases uncertainty associated with the technology choices within the given field. It calls for support projects which provide up-to-date knowledge on international developments as well as draws actors together. However, the programme may be less directed for international R&D networking as well as providing support for the management of internationalisation. This type of internationalisation activity seems to serve both SMEs and larger companies, the latter particularly when the markets are developing very rapidly.

The features of the above typology are summarised in Exhibit 14.

Exhibit 14. Appearance and relevance of internationalisation profiles.

	Big Science programmes	**Up-grading Finnish competence**	**Exploiting Finnish competence**	**Regulatory & other changes as drivers**
Objectives	To access large scale, top research programmes and infrastructures.	To complement Finnish technological competence with foreign expertise.	To support Finnish companies to enter and succeed in international markets.	To exploit international opportunities resulted by regulatory changes.
Mechanisms	National parallel or internationally integrated programmes. Integration with basic research programmes. International research funding mechanisms. Seminar & conference participations. Researcher training and mobility.	Preparatory studies on technological expertise abroad. Technology oriented benchmarking visits. Inviting foreign experts as seminar speakers. Facilitating networking through the steering group. Encouragement for international joint R&D projects. Technology transfer projects.	Preparatory studies on market needs and structures abroad. Selecting a steering group with international contacts. Selection of projects aiming at international applications. Application oriented benchmarking visits. Participations in international fairs. Support by outsourced internationalisation / export services.	Analysis & dissemination of regulatory and policy developments. Gathering of information on significant international operators. Lobbying on policies, standards and legislation. Follow-up of international fairs and seminars. International network facilitation among actors.
Universities	Getting access to highest standard research. Scale benefits.	Complementary expertise from abroad. Increased possibilities for networking with domestic companies.	Increased opportunities for applied research and joint projects with SMEs.	Providing and developing framework expertise. Foresight expertise.
Research institutes	Possible spin off applications. Expertise gains. System and infrastructure development.	Up-dating the competence base. Enlarging customer base. Applied research projects.	Development and testing of new applications.	Development and testing of new applications, infrastructures. Development of norms and standards.
Large firms	Technological breakthroughs and radical innovations. Access to competent human resources.	Enlarging the competence base. Developing a network of competent suppliers.	Strengthened supplier base.	Significant international business opportunities. Increased first-mover advantage.
SMEs	Benefits for few advanced companies.	Up-grading domestic and international competence.	Immediate business opportunities.	Supplier possibilities. Decreased uncertainty regarding technological options.

6 Generation of internationalisation impact in technology programmes

6.1 Impact assessment methodology

Two mail surveys were carried out in an effort to collect comprehensive, primary data from Tekes technology programmes. The **first survey**, the project survey, focused on individual **projects within the 9 case programmes** that were subject to a closer evaluation. The target population of the project-level survey consisted of altogether 438 projects – 186 research projects and 252 company development projects – within the 9 case programmes. The questionnaires were mailed to the project leaders with a cover letter from Tekes. Up to two reminder messages were sent to the responders through email, each approximately two weeks after the previous contact. This process produced altogether 157 responses, which corresponds to a response rate of 36%.

The **second survey**, the programme survey, was sent out to the all the 64 technology programmes, with the purpose of providing overall information and leverage to the issues found from the project surveys. Hence, **the issues raised in the following analyses are mainly based on the responses of the project survey**.

The programme-level questionnaires were sent to **four respondents per each programme**: the programme coordinator, the Tekes internal coordinator of the programme, and to the steering committee chairman and vice chairman of each programme. The mailing process was similar measures to that of the project-level survey. Of the 238 respondents 130 returned a filled questionnaire, which corresponds to a high response rate of 55%. The questionnaires were designed to allow multivariate analysis of the relationships between the predictor, mediating and outcome variables. The statistical analysis methods used included descriptive statistics, confirmatory factor analysis, bivariate correlations and multiple linear (OLS) regression tests.

6.2 Implementation of the technology programmes

This review concerns the unit-level implementation of the technology programmes surveyed. Project selection issues are presented first, followed by analysis on how the projects were defined during the selection process as well as analysis of unit-level understanding of the programmes' internationalisation objectives. As regards the unit-level implementation of the projects, the following aspects were surveyed: project supervision and monitoring; interaction breadth; interaction frequency; programme-level social capital; internationalisation activities; international social capital; strengthening of community identity.

6.2.1 Proactive adaptation to programme selection criteria

In earlier evaluations, unit-level awareness and adaptation to programme selection criteria has been found to constitute an important influence on unit-level technological learning.[39] The current analysis of project selection suggests that the **surveyed programmes depicted reasonably high adaptation impact amongst the participating firms and research institutions**. Thus, it is possible that technology programmes with a strong emphasis on internationalisation will influence the

39 See for example: Targeted technology programmes: A conceptual evaluation, Tekes 13 / 2003

internationalisation by firms and research institutions, as these modify their research and development agendas so as to enhance the fit with programme selection criteria. This impact appears, understandably, more visible amongst research institutions than amongst firms. Given the importance of Tekes in funding research, it is not surprising that universities and research institutions be accustomed to adapt to Tekes programmes. For firms, whose development work is driven more by customers, the impact is likely smaller.

Given the adaptability of universities to Tekes programme designs, the impact observed here is, in essence, a supply-side impact that affects the production of technology. **It may well be that the bulk of the internationalisation impact of Tekes' technology programmes is delivered through the supply side.** This would suggest a central role for universities and research centres in Tekes programmes geared towards internationalisation

6.2.2 Influencing project content

Who influences the content and objectives of the projects? This question is important, as the shaping of technological projects impacts their context-dependency and, potentially, their commercial viability outside the context according to which they have been shaped. Thus, the context in which the project is shaped, may influence its potential for international diffusion. Therefore, we asked the respondents to divide 100 points to different potential influences according to their relative influence on project content. The results are shown in Exhibit 15.

According to the results, there appeared to be quite little cross-border influence on project definition. This may be a sign that Tekes technology programmes, while traditionally strong in connecting (domestic) demand and industrial needs to research activity, may not yet be optimally geared to

Exhibit 15. Bodies influencing project definition

Influence on Project Definition	Project type	N	Mean (%)	Significance of mean difference (2-tailed)	
Ourselves, based on our internal needs	Research	80	17,5	0,000	***
	Firm	77	39,3		
Ourselves, based on general trends in the sector	Research	80	23,7	0,865	
	Firm	77	23,1		
Tekes personnel	Research	80	5,6	0,534	
	Firm	77	4,9		
Technology programme coordinator	Research	80	7,0	0,007	**
	Firm	77	2,8		
Technology programme steering group	Research	80	6,0	0,001	***
	Firm	77	1,9		
Our domestic partner	Research	80	29,3	0,000	***
	Firm	77	16,2		
Our foreign partner	Research	80	9,9	0,154	
	Firm	77	6,0		
Other	Research	79	1,0	0,026	*
	Firm	77	5,7		

linking to foreign demand and cross-border industrial needs. If this is true, then the ability of Tekes projects to generate technologies optimally geared toward international diffusion may be unnecessarily constrained.

The service role of research institutions is clearly evidenced in our data: domestic partners dictate, on average, some 30% of the content of research projects. The influence of Tekes and technology programme on project definition appears to be about right. Inevitably, technology programmes should exercise some influence on project content definition so as to enhance cohesion between projects.

6.2.3 Programme objectives

The project-level understanding of the objectives of their respective programmes was also queried. The project-level understanding of programme objectives is important, because it likely influences projects' orientation toward the technology programme, and its activities within it. It is likely that projects will work focus more on objectives that they perceive as important at the programme level.

Overall, an expected difference between firm and research projects can be observed, with research projects emphasising upstream and firm projects downstream objectives. This difference in emphasis reflects the internal division of responsibilities within technology programmes.

Moreover, the importation of foreign-based technologies was not given a high emphasis. While this may be an appropriate situation overall, a different pattern would likely be optimal for the more narrowly targeted programmes in low-technology sectors in particular. Furthermore, the perceived importance assigned to various internationalisation goals appeared, on general, quite high, particularly if compared against influences on project definition.

6.2.4 Interaction breadth and frequency

The survey looked at interaction breadth (both within Finland and internationally), as well as interaction frequency, within the projects. Interaction breadth is associated with knowledge variety, and therefore, provides an indication of the learning environment offered by the project. Also interaction frequency impacts learning and the development of technological competencies. Both of these are important for the shaping of projects' technological content and outcomes.

Details of the distributions of various interaction types are shown in Exhibit 16. As can be seen, the overall interaction levels were not very high. On average, only some two employees of the participating units interacted regularly with personnel from other projects, and even this interaction was mostly confined to interactions within Finland. Cross-border interactions averaged only some 0,7 persons per each participating unit. These are not very high levels of interaction, and certainly not suggestive of a very high direct cross-fertilisation effects between projects at the international level. Consistent with their more explicit service role within technology programmes, research projects emerged as the more widely interacting ones within the programmes.

An analysis of interaction frequency revealed a similar pattern, with research institutions depicting higher interactions with various parties. The data on project-level external interactions pointed to a quite low level of interaction intensity overall. **The bulk of project-level interactions were carried out within the domestic sphere, and cross-border interactions were of very low intensity**. In particular, the breadth of cross-border interactions pointed to a level of interaction that may not be sufficient to exercise a significant formative influence on project content and outcomes.

Compared to the perceived importance of various upstream and downstream activities, one may question if the observed level of international inter-

Exhibit 16. Interaction types for research and firm projects (Means refer to numbers of people interacting).

Interaction type	Project type	N	Mean	p (2-tailed)	
Unit personnel interacting regularly with other projects within Finland	Research	76	3,09	0,012	*
	Firm	76	1,96		
Other projects interacting regularly with focal unit in Finland	Research	74	4,80	0,006	**
	Firm	72	2,26		
Unit personnel interacting regularly with other projects abroad	Research	67	1,06	0,028	*
	Firm	71	0,38		
Other projects interacting regularly with focal unit abroad	Research	66	1,02	0,065	+
	Firm	66	0,38		

action is sufficient to provide a balanced response to perceived programme objectives. Moreover, the low overall level of interaction suggests that not very significant formative internationalisation influence will materialise through the projects surveyed. **If less than one person per project is exposed to regular cross-border interactions, this may not be sufficient to generate significant internationalisation momentum within the participating organisational unit.** Again, the low level of cross-border interaction within the projects surveyed may be indicative of too great domestic orientation within Tekes technology programmes.

6.2.5 Unit-level internationalisation activities

The survey also inquired unit-level internationalisation activities by listing 11 different activities, as drawn from technology programme reports and interviews. The activities were classified into upstream, downstream, and horizontal activities. Upstream activities refer to the sourcing of technology, competencies, and resources necessary for the creation of new value-adding technologies for both domestic and international consumption. Downstream activities refer to the preparation of the pathway to the international marketplace and to the international diffusion of technologies by acquiring and disseminating knowledge and contacts on foreign markets and customers, international standards and regulations, and so on.

The results show that internationalisation activities employed within the programmes surveyed were quite varied and able to address both upstream-, downstream- and horizontal aspects of internationalisation. Also the internationalisation activities observed were amenable to supporting both the "home-base exploitation" and the "home-base augmenting" modes of internationalisation. The internationalisation activities appeared to vary according to the type of organisation concerned. For research projects, different modes of internationalisation activities were observed than for firm projects. This is evidence of adaptability at the unit-level implementation of national technology programmes. **Overall, the emphasis on internationalisation activities appeared quite low, even though the sampled programmes all exhibited explicit internationalisation objectives.** This suggests relatively low overall emphasis on internationalisation at the unit-level implementation of national technology programmes.

6.2.6 International social capital

International social capital constitutes an important facilitator of internationalisation efforts, because it facilitates organisation's access to, and ability to mobilise, resources residing within its network of contacts. Social capital both facilitates

an organisation's access to knowledge, as well as its ability to transfer and assimilate this knowledge. Social capital also helps to strengthen a given organisation's projected trustworthiness, thereby helping it alleviate the "liability of foreignness" that inhibits the efforts of an organisation that attempts to enter a foreign market.

Summarising the empirical analysis suggests that there appeared to have been a positive impact on international social capital by the participating projects, particularly for firm projects. The overall quality of research units' international contacts, at the end of the projects, appeared to be at a reasonably good level. The overall quality of firm units' international contacts, however, appeared to be at a modest level only, even at the end of the projects.

The analysis of international social capital, consistent with previous chapters, appears to suggest that research activities are more amenable to internationalisation than firm projects. This may be a natural consequence of the facts that: (1) research activities tend to have a longer tradition of cross-border collaboration; (2) research, by virtue of its greater focus on explicit knowledge creation, may be naturally more amenable to international collaboration than commercial activity.

Overall, technology programmes appeared to be better at connecting domestic industrial demand to domestic research than at connecting to foreign demand conditions. Technology programmes, where cross-border links are concerned, also appear to be better at linking to upstream than downstream conditions. Therefore, they may not be as effective in generating international demand pull as they are in generating domestic demand pull. **If this is true, then Finnish technology programmes may be effective at boosting the generation of internationally leading products and services only when domestic demand conditions, in terms of sophistication, are in par with international cutting-edge.** Where Finnish demand conditions do not represent international cutting edge, it may be that Finnish technology programmes may not be able to provide significant momentum for internationalisation.

6.2.7 Strengthening of community identity

According to the "communities of practice" literature, informal networks of technology practitioners constitute an important driving force of innovation. This is due to gain acceptance (as innovation is equally about invention and exploitation), suitable social practices need to be discovered that help take advantage of the innovation. For these reasons, the influence of the technology programmes was surveyed on the strengthening of community identity in their respective sectors.

Summarising the analysis suggests that the impact of the programmes on sector-specific community identity appears to have been quite strong. This impact was perceived as greater by research projects than by firm projects. Combined with previous analyses, notably on cross-border interaction, it is presumable that this community identity impact is largely confined to the domestic sphere. **Without any direct empirical evidence, there is still a reason to suspect that truly cross-border communities of practice remain few.**

6.2.8 Conclusions for programme implementation

Several conclusions arise from the descriptive analysis. Reviewing the conclusions, it is important to keep in mind that our sample only comprised technology programmes that exhibited explicit internationalisation objectives.

The first general conclusion is that, **even though reasonably high importance is attached to programme-level internationalisation objectives, tangible project-level exposure to direct internationalisation activities and influences remains small**. Our analysis suggests that only clearly less than 10% of project content was directly influenced by interest groups outside Finland's national borders. This suggests a quite small formative cross-border influence in project definition, even though the programmes, in themselves, appear to have been quite impactful in terms of their steering impact that is materialised through

the overall definition of programme-level internationalisation objectives.

Also the projects' ongoing exposure to cross-border influences was surprisingly small. On average, only less than one person per project was regularly involved in cross-border interactions during the implementation of the projects. This may be insufficient to generate significant internationalisation momentum within the participating projects. In addition, the overall importance associated with project-level internationalisation activities appears moderate at best.

The second general conclusion is that **research institutes appear to depict greater internationalisation readiness, and they also appear more amenable to internationalisation activities and related impact generation**. This suggests that the programmes surveyed are stronger in strengthening upstream internationalisation links (links between participating Finnish research institutions and foreign influences) than in strengthening downstream internationalisation links (links between participating Finnish firms and relevant interest groups abroad). Research institutions also appear to be more centrally positioned within the programme participant community, and they appear to develop stronger social assets (such as shared community identity and social capital) that facilitate the creation of organisational learning and performance benefits. This general pattern is likely due to the fact that research projects focus more on the generation of codified knowledge that is intended for public dissemination, and that is more easily transferred across national borders. Perhaps for this reason, research activities have a stronger tradition of international collaboration.

The third general conclusion concerns the general pattern of cross-border knowledge flows within the surveyed programmes. The observed patterns suggest that, in general, **cross-border formative influences on the creation of new technologies are mostly mediated through Finnish research institutions and universities**. At least where national technology programmes are concerned, the general pattern appears to be that Finnish research institutions and universities, through their exposure to cross-border collaborations, operate as a conduit of such influences to the Finnish industry. The primary interactions of the participating Finnish firms, on the other hand, seem to be confined to the domestic sphere, mostly to domestic research institutions and industry. At least in the survey data, the evidence of direct formative cross-border influences on firm-level R&D activities is very limited.

The fourth general conclusion concerns Tekes' relative strengths in domestic and cross-border activities. Traditionally, one of Tekes' greatest strengths is in linking domestic industrial demand conditions to domestic research institutions. Tekes generally excels in identifying development needs within the domestic industrial space and in developing policy initiatives that serve to rectify the observed gaps. However, **where cross-border links are concerned, the evidence on Tekes' ability to link domestic players to demand conditions outside Finland's national borders is quite limited.** Even though the range of programme internationalisation activities observed should be sufficiently broad to cater to a "home-base extension" mode of internationalisation, the dominating daily pattern in the surveyed programmes appears very much aligned with the "home-base leveraging" mode.

This general pattern appears to have two important implications. It may be that Tekes technology programmes are helpful in catalysing the generation of globally leading technologies only when the Finnish demand conditions represent global state-of-the-art in terms of their sophistication. It may be that where the Finnish demand conditions are lagging behind global state-of-the-art, Tekes technology programmes, in their current form, may not be efficient in operating as conduits to alternative sources of sophisticated demand. Furthermore, given the current nature of EU-funded programmes, it is doubtful whether EU programmes can bridge this gap, either. It may well be that to really amplify formative cross-border influences in Tekes technology programmes, Tekes may need to start admitting foreign-based participants to them.

6.3 Organisational and internationalisation outcomes

This section summarises first the general organisational outcomes from the projects, such as organisational learning, new product development, and changes in the units' technological distinctiveness. After this descriptive analysis, a review of internationalisation outcomes is presented.

6.3.1 New product development and IPR

Altogether 87% of the projects indicated that they had influence on the development of new products or services during the project. On average, the number of new products being developed was 2,6. This suggests good effectiveness of the projects in new product development. However, only 25% of the projects applied for any kind of intellectual rights protection (patents, trademarks, copyrights, etc) for the products developed.

Confirming the different roles of firms and research institutions regarding the development of public and private knowledge, the results show that research institutions appeared relatively more active in new product development, whereas firms were more active in applying for IPR protection devices. Overall, the patterns observed testified of reasonably good new product and IPR development efficiency, and they also suggested differing roles for research and firm projects in this regard.

6.3.2 Direct organisational learning outcomes

So as to get a comprehensive picture of the generation of organisational outcomes within the projects, the survey inquired about a range of learning outcomes. It showed that the most pointed learning outcomes concerned the creation of new technological competencies and enhanced technological competencies. Market knowledge acquisition, on the other hand, appeared less in evidence, notably where international market knowledge was concerned. The respondents also reported quite good impact on enhancing internationalisation readiness and the internationalisation process itself. Consistent with the general pattern in our data, research units reported slightly greater internationalisation benefits, even though the differences were only marginally significant.

Overall, the various organisational benefits appeared to be driven by technological competence development and learning. This applied to research and firm projects alike. It seems like the driving force for organisational benefits, including internationalisation benefits, is technological competence development. This means that firms derive corollary benefits from the programmes concerned through enhanced technological competence. This reflects a pattern in which technologies are developed domestically, and then leveraged for international expansion. Such a model should work well in sectors characterised by highly sophisticated domestic industrial demand. However, this mode may work less well in situations where such demand is missing.

The general pattern, that technology programmes more readily speed up upstream than downstream internationalisation efforts, is consistent with this finding. As concluded in the previous chapter, the primary pattern of international knowledge flows appears to operate from upstream to downstream, or from research institutions' international collaborations to domestic firms. As a simplifying generalisation, "raw" technologies appear to be 'outsourced' from abroad through inter-university research collaborations, and these outputs are then modified by Finnish universities to suit Finnish industrial needs. The results of this filtering process are then leveraged for internationalisation purposes. As observed in the previous chapter, such a process should work fine, provided that the Finnish industrial demands represent international cutting edge in terms of their sophistication. However, this process may not work optimally, if the Finnish industrial demand lags behind the international standard. In such situations, the "home-base leveraging" mode of internationalisation is not sufficient, and "home-base extension" modes are required as a complement.

6.3.3 Extent of international operations

The survey measured changes in international operations by asking the respondents indicate the extent to which their organisations were engaged in various kinds of cross-border activities immediately before and immediately after the project. The operational dimensions were designed to fit both the firms and research institutions and universities. A comparison between research and firm projects is shown below.

According to above, the participating organisational units had, on average, experienced a slight expansion in the operational dimension of their operations during the project. On average, the number of foreign sources of income increased by one, meaning that the unit started to generate income from one additional foreign country. The share of foreign income increased by an average of 8% in firm projects, which is significantly more than in research projects. Also the percentage of personnel focusing on cross-border activities increased in firm projects significantly more than in research projects. The same pattern could be observed for countries where the unit did technology-intensive sourcing and procurements, ones that incorporated a significant technology development component.

Firm projects depicted, on average, a greater extent of international operations than did research projects. This is due to a few firms in the sample that exported to a very high number of countries. For example, the median number of income-generating countries (other than Finland) was three for firm projects and one for research projects, thereby pointing to a smaller general difference between the two samples.

Exhibit 17. Changes in the extent of international operations

Change in...	Project type	N	Mean Change	Mean at the End	Median at the End	p (2-tailed) for Mean Change	
Number of countries where the unit had income from	Research	49	0,61	2,77	1	0,409	
	Firm	70	1,04	11,03	3		
Percentage of income generated from abroad	Research	51	1,67	6,73	3	0,044	*
	Firm	67	7,72	33,67	17,5		
Number of countries where the unit had personnel in	Research	50	0,26	1,02	0	0,834	
	Firm	73	0,19	3,81	0		
Percentage of personnel focusing on cross-border activities	Research	48	1,88	7,56	0,05	0,040	*
	Firm	65	4,92	22,33	13,5		
Number of countries where did technology-intensive sourcing	Research	43	0,21	0,84	0	0,037	*
	Firm	69	0,91	2,24	1		
Number of countries where did standard sourcing	Research	42	0,29	1,50	0	0,399	
	Firm	66	0,65	2,71	1		
Number of countries where had technology collaborations	Research	46	0,87	2,38	1,5	0,741	
	Firm	69	1,12	3,61	1		
Number of countries where sold products and services	Research	46	0,65	1,92	0	0,326	
	Firm	69	1,30	10,01	3		

$p < 0,001$***; $p < 0,01$**; $p < 0,05$*; $p < 0,1$+; 2-tailed tests

Numbers of countries are indicated Finland excluded

Overall, the data suggested moderately positive internationalisation developments during the course of the projects. The variance was quite significant, though, particularly for firm projects. Thus, it seems that while research institutions are generally more amenable to internationalisation, successfully internationalising firms can achieve internationalisation rates that are beyond the reach of research institutions.

6.3.4 Resource fit for internationalisation

Technology projects impact the participating firms' resources. Particularly within technology programmes with explicit internationalisation objectives and activities, it is possible that the project may contribute to a change in terms of the resource base's susceptibility for internationalisation.

The empirical analysis confirmed this expectation: it showed a quite clear improvement in the participating firms' resource fit for international expansion. On average, the firms had experienced an improvement of one scale increment in this regard. One average, the firms' resource fit for international business was at a mediocre level at the end of the projects. The highest score was assigned to the firms' own subjective judgement regarding whether further expansion would make more sense in the international business domain, as opposed to domestic business domain. This is a positive sign, because it reflects the firms' strategic intent, which constitutes an important influence on subsequent action.

6.3.5 International orientation

Unlike often assumed and believed, organisations are not always rational when they choose their strategies. More often than not, organisations cannot rationally analyse their operating environments because of the difficulty to predict future, and because of an information overflow: the amount and ambiguity of the information available often simply makes sensible analysis virtually impossible. For such reasons, objective conditions are often not decisive for strategic choice: rather, it is the organisation's *beliefs* regarding such conditions.

Exhibit 18 summarises the responses of the survey respondents to statements concerning their own competence to expand internationally. The measures of statistical significance refer to a comparison between firm and research projects.

Both firm and research projects reported increased confidence as regards their own competence to manage further international expansion. While firm projects started from a lower level of self-assessed competence, their self-assessments were al-

Exhibit 18. Assessments regarding own competence to expand internationally

Statement	Project type	N	Mean at Start	p (2-tailed)		Mean at End	p (2-tailed)	
It would be easy for us to expand our cross-border activities	Research	68	3,93	0,005	**	4,68	0,395	
	Firm	68	3,28			4,49		
I am confidend that we would succeed if we tried to expand internationally	Research	66	4,20	0,088	+	4,97	0,192	
	Firm	68	3,78			4,68		
We have sufficient competence to expand internationally	Research	70	4,37	0,008	**	5,24	0,057	+
	Firm	68	3,66			4,83		
We have sufficient resources for international expansion	Research	69	3,61	0,008	**	4,26	0,022	*
	Firm	68	2,93			3,64		

$p < 0{,}001$***; $p < 0{,}01$**; $p < 0{,}05$*; $p < 0{,}1$+; 2-tailed tests
scale from 1 (completely disagree) to 7 (completely agree)

most on par with research projects at the end of the project. At the end of the projects, both firms' and research units' assessments were either moderate or moderately positive. While research units continued to Exhibit slightly greater confidence even at the end of the projects, one should keep in mind that it is easier and less resource consuming to expand research activities internationally than it is to enter foreign markets.

In all aspects of the internationalisation competence, the improvements were statistically significant. **The analysis shows, therefore, that the projects were associated with moderate to good improvements in the participating units' self-confidence, and that this self-confidence approached a moderate to good level at the end of the projects surveyed.**

6.3.6 Intensity of international operations

The intensity of the participating units' international operations was also surveyed. As in previous analyses, the analysis was able to indicate a moderate increase in the intensity of various operations, even though the increases appeared, in general, less marked than in the case of resource fit and self-confidence measures. The differences between firm and research projects were also compatible with the difference between upstream and downstream operations. Overall, the intensity of international operations appeared moderate or moderately weak for most aspects. The notable differences were international R&D collaboration and participation in international networks and programmes by research institutions (an upstream operation) and interna-

Exhibit 19. Intensity of international operations

Statement	Project type	N	Mean at Start	p (2-tailed)		Mean at End	p (2-tailed)	
International technology procurement	Research	63	2,94	0,139		3,44	0,343	
	Firm	72	2,57			3,18		
International materials and standard component procurement	Research	60	2,90	0,218		3,25	0,195	
	Firm	72	2,57			2,88		
International R&D collaboration	Research	64	3,50	0,003	**	4,56	0,000	***
	Firm	72	2,67			3,42		
International sales and other income generation	Research	61	2,18	0,000	***	2,64	0,000	***
	Firm	72	3,32			4,32		
International recruitment	Research	63	2,32	0,353		3,03	0,025	*
	Firm	72	2,10			2,40		
International funding applications	Research	63	3,40	0,000	***	4,17	0,000	***
	Firm	71	2,23			2,49		
Participating in international networks and programmes	Research	67	4,04	0,000	***	4,85	0,000	***
	Firm	72	2,72			3,47		
Following international standards and regulations	Research	61	3,51	0,415		4,34	0,975	
	Firm	72	3,28			4,35		
Operating units abroad	Research	61	1,36	0,000	***	1,61	0,001	***
	Firm	71	2,31			2,58		

$p < 0,001$***; $p < 0,01$**; $p < 0,05$*; $p < 0,1$+; 2-tailed tests
scale from 1 (completely disagree) to 7 (completely agree)

tional sales for firm projects (downstream operation). These forms of operations could be regarded as moderate or moderately strong.

Overall, the pattern revealed above is compatible with the previous analyses. It shows that the perceptions regarding the feasibility of further internationalisation appear slightly more positive than the actual intensity of various international operations. This may signal two things: either perception precede action, or effecting international expansion may have turned out more difficult than anticipated.

6.3.7 International contact extent and quality

The survey also analysed the extent and quality of the participating units' active international contacts both before and after the projects. The results indicate that, research institutes reported, in general, more upstream links, while firms reported more downstream links, consistent with the patterns observed in previous analyses. Overall, research institutions exhibited greater international networking than did firms.

Moreover, the results indicate that, in general, research institutions appeared to have built higher

Exhibit 20. Assessment of the projects regarding their programmes' overall internationalisation impact on their sectors

Sector Effect	Project type	N	Mean	p (2-tailed)	
Sector operators approached international cutting-edge	Research	72	5,04	0,099	+
	Firm	67	4,73		
Sector operators increased their lead over ilternational competition	Research	73	4,41	0,490	
	Firm	67	4,54		
Sector operators' internationalisation competencies enhanced	Research	73	5,07	0,166	
	Firm	67	4,82		
Finland better known for its technology	Research	73	4,58	0,345	
	Firm	67	4,37		
Links between Finnish and foreign operators intensified	Research	73	4,81	0,036	*
	Firm	67	4,36		
Sector better adapted to international standards	Research	72	4,53	0,462	
	Firm	67	4,36		
Sector better exploits international opportunities	Research	71	4,68	0,359	
	Firm	67	4,46		
Sector better adapted to technical change	Research	71	5,06	0,096	+
	Firm	67	4,75		
Foreign sources of technology used more effectively	Research	69	4,84	0,071	+
	Firm	67	4,45		

$p < 0{,}001$***; $p < 0{,}01$**; $p < 0{,}05$*; $p < 0{,}1$+; 2-tailed tests
scale from 1 (completely disagree) to 7 (completely agree)

quality into their international contacts than had firms. However, firm projects depicted higher improvements in international contact quality than did research institutions.

6.3.8 Participants' assessment of overall internationalisation impact on sector

Finally, the respondents were asked to provide a general assessment of their respective sectors. These evaluations represent a 'grass-root' level assessment, one which probably largely reflects the projects' own experiences with their technology programmes.

The above indicates that participants' assessments were moderately positive. There also appeared to be general agreement between research and firm project opinions as to the general impact of the programmes. Overall, the respondents considered that their respective sectors had approached international cutting-edge, and that the various operators' internationalisation competencies had been enhanced. Also the sectors' adaptation to technical change was considered positive. Overall, the responses suggest a moderately positive, albeit not a revolutionary impact.

6.3.9 Conclusions regarding organisational and internationalisation outcomes

A few general conclusions appear to arise from the preceding analysis. Perhaps the most important conclusion is that in the programmes surveyed, internationalisation benefits appear to be partly driven by technological learning benefits. This reflects a situation in which the participating organisational unit first develops new technologies under the technology programme, and these technologies are then leveraged for international expansion. This would be consistent with the "home-base leveraging" mode of internationalisation. As pointed out earlier, this mode works well as long as the Finnish home base is up to international standard. Where this is not the case, it seems that technology programmes, in their present form, may not be fully able to make up for the gap with their present configuration.

Second, in spite of the observed shortcomings concerning foreign influences on technology formation, the direct internationalisation impact generated during the programmes appears satisfactory, albeit not revolutionary. Clear, if not very large, increases could be observed for both the extent and intensity of several aspects of international operations, suggesting that even quite modes exposure to direct international influences during the project may generate internationalisation benefits. The observed increased may also be partly due to the projects' adaptation to programme selection criteria.

Third, statistically significant, if modest, improvements could also be observed in the participating firms' resource fit for internationalisation, in the general international orientation of the participating organisational units, as well as in the international social capital possessed by these. These are important conditions for internationalisation. While clear in the statistical sense, however, the increase was also quite modest in absolute terms.

6.4 Influences on internationalisation impact generation

Above, we have reviewed organisational and internationalisation outcomes. An important question is: what influences those outcomes? To find this out, a series of correlation and regression analyses were carried out. The analyses focused on two aspects: first, on the extent of international operations; and second, on the intensity of international operations.

6.4.1 Influences on extent of international operations

Bivariate correlations between the extent of international operations and various programme activities reveal that project duration does not appear to be associated with change in the extent of international operations. Second, the strongest influences appear to operate through changes induced in the unit's international orientation, as well as through changes induced in the unit's resource fit for internationalisation, as well as changes in the international contact quality of the unit. Furthermore, the various programme activities appear selectively associated with change in internationalisation extent. Notably, downstream activities (review of unit's internationalisation needs and abilities; direct marketing activities) appear associated with increased export share of sales. Also IPR protection activities were associated with these. The general observation, however, is that international marketing and etablation activities appear associated with the broadest increases in the extent of international operations.

6.4.2 Influences on intensity of international operations

Several interesting bi-variate correlation patterns can be observed regarding the influences on the intensity of international operations. First, as above, the most significant and consistent correlations are between the change of international operation intensity and: (1) change in resource fit for internationalisation; (2) change in international orientation of the unit; and (3) change in international social capital possessed by the unit.

Second, the technology programme's impact on domestic social capital build-up and on domestic community of practice does not appear associated with the generation of internationalisation benefits. Third, there are numerous direct correlations between programme's internationalisation activities and increase in internationalisation intensity, suggesting that internationalisation activities do help in promoting internationalisation in technology programmes

6.4.3 Conclusions from correlation analysis

The most important conclusion from the above analysis is that internationalisation effects are associated with four sets of influences within national technology programmes.

Cognitive influences on the unit's international orientation refer to the perceptions of the participating unit as regards the feasibility and attractiveness of internationalisation. These are, essentially, strategic orientations, as perceived by the unit itself. It appears that the more a given technology programme is able to convince its participants of the feasibility of international expansion, and to instil an "international strategic orientation", the more the units will focus on such activities. Here, it is essential to realise that we are referring to the participating units' cognition. It is essential that the programmes boost the participating units' motivation to internationalise and their belief that they can succeed in their internationalisation efforts.

Resource influences on the unit itself. Each technology programme exercises some kind of formative influence on the resources controlled by its participating organisational units. Here, we refer to the competencies of the personnel, its products and services, its brand and reputation, and its established network relationships. The greater the formative influence that the programme manages to exercise on its participants' resources, the greater the resulting internationalisation benefits will be. Note that here, too, we are talking, in part, about perceptions. If a given firm or research institution participates in an internationally oriented technology programme, its resources may change, but the participant may also discover new aspects about its own resources. For example, the participant may discover that a given product or service could sell well abroad. Thus, the

task of technology programmes consists of partly assisting its participants to enhance the international dimensions of their resources, partly of helping its participants to realistically assess their own internationalisation potentials.

International social capital. Internationalising firms and research institutions need to be able to access and mobilise resources through their domestic and international contact networks. The better the quality of the unit's international contacts, the better it will be able to leverage these in its internationalisation efforts.

Direct internationalisation activities. There are also direct associations between the extent and intensity of internationalisation, on the one hand, and programme internationalisation activities, on the other. The tables suggest that the more directly the activity is focused on generating upstream or downstream benefits, the greater those benefits will be.

7 Findings and implications

7.1 General findings from the evaluation

7.1.1 Relevance of internationalisation is evident and increasing

There are two major drivers encouraging policy makers to incorporate internationalisation as an issue in innovation policies. One is the increasing **globalisation of the economy**. Most companies of any size operate in an international context. Where they choose to locate R&D depends, in part, on the attractiveness of competing knowledge infrastructures, in part on the attractiveness of different markets – both as places to make money and as places to learn – as well as a number of other important economic factors.

The other major driver of internationalisation in innovation policy is **European Union policy**. However, EU member states have been, in practice, slow to promote the idea of a European Research Area via changes to their national innovation policies. While there is general acceptance that such change is inevitable, enthusiasm for it appears limited.

In practice, this means that the countries considered are gradually expanding their activities in relation to the traditional European R&D and innovation networks. Perhaps the more important changes in innovation policy and instruments are the increasing attempts to make national knowledge infrastructures attractive to major industries – both to attract new industrial R&D investments and in order to retain existing ones. Especially against the background of the Lisbon and Barcelona goals, policy-driven internationalisation measures are likely to be accompanied by increased competition among European knowledge infrastructures to win links with important industries and to obtain, and retain the best researchers.

The need for internationalisation has increased over the past few years in virtually every area of the economy. There are clear demands to increase international co-operation, both in the policy (top-down) context and in the operational (bottom-up) context of policy measures. It is generally considered that there is no more domestic technology or market conditions – **competition is increasingly global**.

7.1.2 Profiles for internationalisation differ significantly

The degree, directions and actions for internationalisation vary significantly among Tekes technology programmes. Internationalisation is seen important in almost every programme, but in different ways. Reasonably high importance is attached to programme level internationalisation objectives, while tangible project level exposure to internationalisation activities and influences remains relatively low.

Although all programmes have at least a few international projects, **only few programmes are international at programme level**, even less are integrated internationally or carried out in collaboration with a foreign counterpart. There are also technology programmes which are clearly facilitating internationalisation, but which nevertheless do not appear to be international when measured by their volume of international co-operation.

The most common **rationales** for internationalisation relate to seeking better technological knowledge from the leading developers of the world in order to **up-grade** and complement Finnish competence and experience, as well as to **applying & adapting** Finnish technological knowledge for expansion in selected foreign markets. Other rationales often relate to enhancing national participation in **big science** projects and infrastructures, as we as to adaptation to some **regulatory**, market or

technological changes which are likely to have significant impact on industries.

Research units at universities and research centres are usually well connected internationally. Although international awareness, contacts and access to expertise is built into high-standard academic research tradition, technology programmes can have a boosting effect on international co-operation.

For most small and medium-sized companies, internationalisation aims are naturally linked to their **business objectives** – e.g. how to get access to information on the application side of technologies. On the other side, large companies are international, almost by definition. Their first interest in technology programmes is usually in strengthening technological competencies. Promoting international co-operation with commercial aims in technology programmes provides little reason for them to join in.

7.1.3 Programmes as platforms for internationalisation

There is **a variety of instruments** and practices developed within technology programmes to facilitate international co-operation, covering issues from identification and analysis of technological and market situations, key actors and development trends to ways of building shared projects and exchanging research information. In this respect, technology programmes can operate as platforms for different internationalisation instruments.

Even wider selection of internationalisation **channels** (EU framework programmes, COST, Eureka, etc.) and **services** for internationalisation (Finpro, Finnvera, etc.) can be found outside Tekes technology programmes. For many international networks and international research funding channels, Tekes is, in fact, the Finnish contact point. They provide natural instruments to be used intelligently for the specific needs of technology programmes. To a certain extent, also the instruments of Finpro, Finnvera and others have been adapted to the needs of technology programmes. To this end however, there are clear benefits foreseen in further developing the joint provision of internationalisation services.

One should **not**, however, consider the international research funding mechanisms and networks **as direct alternatives** to internationalisation instruments in Tekes technology programmes. The differences in focus, timing, in the setting-up of consortia, in the required administrative and preparative work, as well as the need to ensure co-financing makes it difficult to integrate them into technology programmes and vice versa. Tekes technology programmes are relatively flexible and strategic, which gives them an important advantage over EU-funded instruments. The problem with, e.g., EU-funded projects is their heavy administration and the resulting rigidity. This hampers the efficient project-level distribution of funding. Because Tekes is more closely embedded in the Finnish context, it can administer project selection and monitoring flexibly and efficiently. This aspect gives Tekes programmes a strategic advantage over European initiatives, an advantage that should also be leveraged for internationalisation benefits.

7.1.4 Technology programmes continue to reflect domestic optimisation

The overall pattern in the reviewed technology programmes suggests that **universities and research institutions remain an important conduit of technologies to domestic industries**, and that direct formative influences on domestic technology development processes are quite small. Combined with the other analyses reported here, this means that, in essence, domestic industrial needs continue to act as the primary influence shaping technology development processes within technology programmes: firm projects interact primarily with domestic universities, and the direct cross-border interactions were quite limited.

Thus, the traditional strength of Tekes, **linking domestic research activities to domestic industrial demand, appears to dominate even the internationally-oriented technology programmes**. This

is natural, given that technology programmes were originally optimised for domestic needs, and much of the development work on technology programmes has continued to enhance this strength. The data suggests that this dominating model of technology programmes shapes also Tekes' internationally oriented technology programmes. In short, the patterns observed in the data suggest that, at present, Tekes' internationally oriented programmes are simply adaptations of Tekes' domestic programmes, and they continue to carry a strong domestic flavour. This may explain why the internationalisation outcomes of the surveyed programmes, while clear and significant in the statistical sense, were also reasonably modest in absolute terms.

Tekes' technology programmes have, historically, been optimised to take advantage of advanced domestic demand conditions, for example, in forest-based and engineering-based industry sectors. As pointed out earlier, this model works well for internationalisation purposes as long as the domestic demand conditions are sophisticated enough. In such cases, the internationalisation successes can be quite significant, as evidence by, e,g., the internationalisation success of Finland's forest-based industry sectors and that of the IT cluster: in both cases, the domestic demand conditions have been very sophisticated, enabling Finnish firms to develop World-beating technological advances.

However, the traditional model may not work as well in sectors where the domestic demand conditions are less sophisticated. In such situations, it is important to connect to foreign sources of sophisticated demand. The empirical analysis suggests that the current programme model may not be optimally geared to conveying such influences from abroad.

The selective internationalisation of Tekes' technology programmes, therefore, appears to remain a challenge for Tekes. By this we refer to the design of technology programmes that are, from inception, designed to be truly international. Achieving 'true' internationalisation in selected programmes would mean changing some of their fundamental planning parameters, for example, by allowing foreign-based participants to technology programmes (e.g., foreign-based suppliers or users of Finnish companies' technologies, in technology programmes geared to optimising cross-border value chains), by actively involving foreign-based agencies in the design and implementation of cross-border technology programmes, by extending the need and feasibility analysis of Tekes technology programmes to cover also foreign suppliers, customers, and research institutions, as well as by designing and implementing activities geared to fostering the formation of cross-border communities of practice.

Tekes can also enhance the internationalisation impact of its programmes through indirect measures. For example, one indirect measure to foster cross-border communities of practice could be simply to coordinate national technology programmes internationally, so that they would be implemented at approximately the same time. When activities are carried out in parallel in different countries, this will result in synchronised technology inputs in national firm populations, which should facilitate the cross-border acceptance of new technologies.

7.1.5 Project-level internationalisation outcomes depend on both direct and indirect mechanisms

The analysis suggests that project-level internationalisation outcomes depend on both direct and indirect mechanisms. By direct mechanisms, we refer to programme activities that explicitly attempt to speed up the internationalisation processes of their participants (e.g., assisting in foreign market research). By indirect mechanisms, we refer to mechanisms which either make internationalisation easier for the participating unit, or which influence the unit's posture toward internationalisation.

The correlation and regression analyses suggest that **direct internationalisation activities can be effective in promoting internationalisation**. The more explicitly a given measure was designed to boost either upstream or downstream internationalisation, the greater the resulting internationalisation outcomes were found to be. Different activities varied in terms of the scope of their interna-

tionalisation impact: while some activities appeared to be helpful in boosting downstream internationalisation, others appeared more effective in boosting upstream internationalisation. The general conclusion is, however, that internationalisation activities are helpful.

The analysis also suggests that Tekes should be alert to the more subtle mechanisms through which technology programmes may help enhance internationalisation. The analysis has uncovered numerous such mechanisms:

- it appears that Tekes' technology programmes may exercise a significant steering impact on domestic R&D activity simply by making their objectives well known. As firms and research institutions apply for Tekes funding, they often shape their projects' goal setting in such a way as to enhance their likelihood of getting selected. Thus, Tekes may influence unit-level internationalisation by simply assigning explicit internationalisation goals to technology programmes and making these well-known to the Finnish industrial and research communities
- internationalisation benefits appear to be partly driven by technological learning. The extent, to which such benefits are materialised within technology programmes, may thus depend on how their technological content itself is shaped: greater international influences on technology programmes' technological content are likely to translate into greater unit-level internationalisation outcomes
- technology programmes can also influence the participating organisations' international cognition and international strategic orientations. Because international expansion is a planned activity, the focal organisations' perceptions regarding the feasibility of internationalisation will exercise a strong influence on its internationalisation efforts. Technology programmes can influence those perceptions in many ways, for example through promoting internationalisation role models, through exposing participants to direct internationalisation influences or through providing training in dealing with international relations.
- technology programmes can enhance the "international resource fit" of their participants' resources through a number of activities, such as providing internationalisation training for the participating units' employees, by facilitating the access of the participating units to distribution, marketing, manufacturing, and technology resources abroad, by promoting international contact networks and close and repeated cross-border interactions at the project level, by applying international standards and performance norms to R&D projects and by providing assistance in international marketing efforts.

7.1.6 Highest impact through targeted research projects

It is difficult for technology programmes to generate added value to international co-operation of individual projects, as far as their content is concerned. The added value of a technology programme is often materialised through encouraging and facilitating international co-operation, through closer networking between the participants, increasing the awareness of the field of industry or research on target areas, as well as through the improved credibility of the participants as selected members of a national technology programme. **Funding of international co-operation has not been considered to be a major challenge**, although the efficiency of joint internationalisation activities is appreciated.

The project-level impact assessment suggests that **research institutes possess greater internationalisation readiness** in technology programmes, as compared to companies. Reflecting the strong tradition of internationalisation in research, they also appear more amenable to internationalisation activities and related impact generation. **Overall**, reflecting the traditional design of national technology programmes, **research institutes appear to have a central role in conveying cross-border knowledge inputs and formative influences to domestic industrial R&D activities**. The cross- border knowledge flows materialised in Tekes technology programmes appear to be conveyed through research institutes' international links and collaborations, and these flows are then converted to domestic industrial R&D through their collaborations with Finnish companies. The evidence of direct cross-border influences on domestic industrial R&D through technology programmes was quite limited.

The knowledge flow patterns observed in the project-level survey data suggest the dominance of supply-side influences in cross-border technology flows. The limited cross-border influences on domestic industrial R&D suggest a gap in connecting to foreign sources of sophisticated industrial demand. Thus, the success of project-level internationalisation, at present, appears to be dependent on domestic demand conditions. Where such conditions are not in par with international cutting-edge, the internationalisation impact delivered through Tekes' technology programmes may be constrained.

The patterns in the project-level empirical data also suggest the **continuing dominance of the so called "home-base leveraging" mode of internationalisation**, in which most of the value-adding resources for technology development are national, and the results of nationally-shaped technology development processes are subsequently leveraged for international expansion. In the data, there was only little evidence of the so called "home-base extension" mode of internationalisation, in which value-adding inputs and technology development processes are coordinated across national borders. Given the general trend toward greater globalisation, we see a challenge for Tekes in terms of moving toward a more extensive implementation of cross-border collaborative R&D activities.

7.2 Policy implications and recommendations

7.2.1 Explicit strategy for international co-operation

At the end, much of the success of international co-operation relies in the hands of individual **persons**, whether scientists, business leaders or programme managers inside and outside Tekes. Without neglecting their important role, the suggestions herewith focus mainly on the facilitation of internationalisation in Tekes technology programmes.

The role of **public intervention** should be **very clear** in international co-operation. This is necessary for Tekes itself to design and allocate its resources correctly and in particular for foreign partners to understand what objectives Tekes is thriving for with the international collaboration.

A clear strategy should be designed and applied for internationalisation in Tekes, on the basis of national technology policy guidelines. For the efficiency and effectiveness of international co-operation, and ultimately for the competitiveness of Finnish research and industries, the aims and approaches for internationalisation in technology programmes should be well elaborated. As the aims of internationalisation differ in programmes, so do the appropriate mechanisms, thus different strategies should be applied to different kinds of programmes.

While the articulation of an explicit strategy is beyond the scope of this evaluation, we suggest that the strategy should aim to distinguish between upstream (supply side), downstream (demand side) and horisontal activities. Whereas upstream activities, such as research collaborations, might be dominant in science-based sectors or 'big science' programmes, downstream activities often provide important formative influences for industrial R&D in engineering-based sectors (e.g., software). Also horisontal activities, such as peer-to-peer collaboration for the development of technological standards, are important when they facilitate the creation of shared resources for internationalisation.

While **a healthy national interest should always be kept in mind**, future competitiveness should not be hindered by aversion of risk or not investing ambitiously in promising fields of competence. Vision, expertise and the highest standard quality are keys to competitiveness. These can be achieved and sustained only through international peering, collaboration and competition. This is difficult, expensive and risky, and a small country cannot reach sufficient volumes and top-levels in very many areas. For technology programmes, this would imply that areas of strategic national competence should be selected and promoted.

For areas of prime national competence, basically all efficient measures should be considered to ensure competence development. This would include **linking and outsourcing of complementary expertise**, as well as facilitation of commercialisation to the extent sufficient. The aim should be to build so strong competencies that they would interest foreign expertise as well as suppliers and customers to come to Finland. When it comes to collaboration, it is often the pro-active partners that are the most likely to benefit.

For areas of large, but not prime national interest, available internationalisation instruments should be applied smartly. A general aim could be to achieve such a level of competence that allows Finnish actors to **access and liaise** with top-level expertise and to exploit this knowledge effectively. Different strategies could be applied for other fields of potential interest, including awareness building, international monitoring of development trends, etc.

7.2.2 Competitiveness through open programmes

The general idea behind national technology programmes relies on an assumption of promoting national competitiveness by strengthening the technological advantage of domestic actors. However, **the closer the technological level is to the global standard, the more broadly one must search for the competencies** and be able to apply them. More and more technological fields in Finland are reaching the global standard and will require new approaches for their promotion.

The decisive question to this end is how to define the **national interest**. The Finnish national strategy in building and sustaining of a welfare society is heavily built on the functioning of knowledge economy. It would thus be logical to adjust the national technology programmes to these targets. Knowledge and significant competitive advantage is always built over a long period of time. This would suggest at least two amendments for technology programmes. First, there should be **programmes with longer perspectives and ambitious agenda** behind them (even if their implementation remains the same). Second, if long-term national interest is in building and sustaining national competencies, technology **programmes should focus at developing national competencies in the most appropriate way**. In many cases, this would result in stronger emphasis and new ways for building international collaboration, including opening-up the programmes to foreign participants.

Internationalisation of technology programmes is evident and most certain to increase in the coming years. International co-operation is a reciprocal process, which will also require opening of technology programmes for foreign participants to a larger extent than today. This is necessary for gathering big enough clusters of competence, which can attract international interest and have an influence on the direction of the techno-economic development. The opening of the technology programmes is necessary not only to gain economies of scale, but also for quality and appropriateness reasons. If the objective of the programmes is really to increase technological competence, the required competence should be sought regardless of its location.

International co-operation is an appropriate mechanism as long as competencies and knowledge can be transferred and learning processes fostered. However, an important part of technological knowledge is either tacit or contextual and therefore difficult to transfer. To continuously keep up with the latest knowledge, or even better, to be part of its development, Tekes will need new ways of being present in key competence centres and extend these to its technology programmes. One example of such mechanisms is offered by Tekes' bilateral co-operation with the University of California at Berkeley.

The general rule for foreign partners to participate in technology programmes is that each country or funding organisation covers the costs their respective participants. This is sufficient, when the benefit is mutual and equally shared and such funding and conditions are available. Much too often this is not the case, and Tekes should be prepared to finance also foreign partners when there is a clear advantage foreseen for the Finnish competence de-

velopment. Typically this would mean at least partial funding of complementary research, access to important development programmes, or for getting top experts to participate in Finnish programmes.

7.2.3 Smart collaboration in technology programmes

As far as it concerns the technological content of research and company projects, purely national technology programmes hardly exist anymore. Internationalisation has a smaller or larger role in every programme. To make the best of it, each technology programme should have a **plan for internationalisation**, including, where feasible, an explicit analysis of the initial situation on an international basis, as well as an analysis of the generic development trends, a definition of the role of international co-operation in the programme including its expected benefits and beneficiaries, required resources and a set of actions to be implemented. Where sector internationalisation is an important concern, international inputs should be sought more actively in the programme planning stage, and even foreign-based participation in technology programme steering groups could be considered.

European funding mechanisms (EU Framework Programmes, Eureka, COST and others) provide unique facilitation for international research collaboration in themes of great importance. However, **harmonisation** of national technology programmes with European research funding mechanisms **does not seem appropriate**. Many reasons suggest that national technology programmes should be carried in a more flexible, forward-looking and strategic manner. These aims are not necessarily mutually exclusive. National technology programmes can be linked, connected and even integrated with European programmes and mechanisms, without harmonising them. Furthermore, it appears to make good sense to carry out national **parallel programmes** in connection with large European programmes to maximise the readiness and benefit by Finnish participants.

International integration of technology programmes is certainly something to aim for. Jointly designed and conducted programmes are the ultimate form of internationalisation in technology programmes. There are however many reasons why this may not work or turn successful. **Integration appears to be particularly challenging at the programme level**, as compared to the project level integration. In fact, unless there are good possibilities of succeeding at the programme level integration, it may be advisable for efficiency reasons to focus main part of the effort on facilitating international co-operation at project level.

7.2.4 Specifically targeted internationalisation

Many of the technology programmes have been constructed from themes and objectives of project groups and sectoral needs. Fewer programmes are constructed top-down, i.e. to address for **specific challenges** that have been identified through Tekes strategy process. Such programmes provide a good basis for building international co-operation, thus it would appear important to increase the share of strategic and precisely targeted technology programmes.

One of the key components of Tekes technology programmes is their dynamic and forward-looking nature. Particularly from the perspective of companies, but also for research institutes and universities, this provides a clear advantage over the available international funding instruments and networks. However, we believe that Tekes technology programmes would become even more interesting both domestically and particularly internationally, if they would be **significantly more international** and open to foreign participants, while still keeping their dynamic and strategic nature. In practice, this would require that the design, preparation and funding of the programmes would not be shared, but remain in the hands of Tekes.

The aims for internationalisation in technology programmes cover issues more broadly than just research and technology. In particular for smaller companies, the rationales for international co-operation often relay back to creating business oppor-

tunities and accessing new markets. Although these may be equally relevant issues to address, as are the research co-operation and mobility among university and research institute participants, there is still no particular reason, why all these should be addressed by Tekes.

Building internationally leading edge research requires vision, commitment, many years, sufficiently resources and some good luck, too. In many cases, it is much quicker, cheaper and less risky to build competencies by accessing existing expertise. In a situation where 99% of world research is performed outside of our national borders, it appears obvious that **not every technology should be developed in Finland** or promoted by Tekes. In fact, Finnish competencies could be much stronger and research funding used even more efficiently, if international co-operation and outsourcing were more actively used for this purpose.

7.2.5 Systematic implementation and follow-up to ensure returns

In order to make better use of the available instruments, it would be recommendable to distinguish more clearly the internationalisation aims of technology programmes. The typology[40] used in this evaluation could serve as one basis for the categorisation of **internationalisation profiles** of programmes and hence, for the design and efficient use of appropriate tools to support the internationalisation process.

It appears that the **amount of resources available** for the definition, preparation, implementation and also the follow-up of internationalisation activities in technology programmes provides greater challenge than the lack of awareness or ability to use the appropriate actions. In order to boost internationalisation, the first priority should be to increase the amount of resources allocated to internationalisation in each stage of the technology programmes.

As far as it concerns the available instruments supporting internationalisation in technology programmes, tools facilitating **a good analysis of international research, market and sometimes regulatory developments** are of great importance. Tekes has developed an internal analysis tool (i.e. Research Landscape*)* for analysing the relevant research programmes and developments to this end. It would appear useful to further develop this tool, in order to take into account also other relevant issues (such as domestic situation) and to match this information with substance analysis (field expert comments), as well as to complement it with other tools. The latter refers particularly to the services provided for example by Finpro for the market analyses, as well as analyses needed for the regulatory and policy developments in programmes, where these issues are among the key drivers. These tools and the whole pre-analysis process should not, however become a burden or block to processing new ideas into programmes. Ultimately, the purpose of such tools is merely to assist a good planning and preparation of technology programmes.

International co-operation, when successful, should not end at the completion of a technology programme. In fact, this is often the time when collaborations are just getting properly started. Usually there are not, however, sufficiently reasons to extend technology programmes for the sake of well-started international co-operation and in few cases this would be even possible. Continuing international co-operation can be funded under normal Tekes procedures, but it will be considered in the same line with all other coming research proposals. To improve the situation, **a specific funding instrument could be designed for the purpose of ensuring a proper follow-up** of those research and company projects, which have international co-operation continuing after programme completion. At the same instance, it should be considered whether some international efforts should be continued also at the programme level, too.

40 See Exhibit 22

7.2.6 Elaborated concepts for internationalisation

Tekes already has a wide variety of internal instruments and funding tools for supporting technology projects and programmes. A significant stock of technical and pragmatic expertise exists within Tekes, which should be well exploited. However, when it comes to international co-operation within the technology programmes, even wider set of instruments could be utilised. These instruments relate to technology transfer, marketing, facilitation of meetings and seminars, etc, as well as to foreign and international research funding and networking instruments. Optimally technology programmes should work as **platforms**, which facilitate a flexible integration of different types of research and development projects, different kinds of operators

Exhibit 21. Approaches for internationalisation in technology programmes

	Big Science -programmes	**Up-grading Finnish competence**	**Exploiting Finnish competence**	**Regulatory & other changes as drivers**
Design and definition	Selective participation with ambitious objectives. Ensuring the industrial relevance. National parallel or internationally integrated programmes. Integration with national basic research programmes.	Preparatory studies on up-grading needs and available technological expertise abroad. Internationalisation plan, with specific objectives and emphasis of domestic dissemination.	Preparatory studies on market needs and structures abroad. Key market / application oriented internationalisation plan. Collaborative design with other service providers.	Preparatory studies on policy and regulatory developments. Preparatory studies on similar programmes and developments abroad – possible joint action.
Implementation	Active promotion of and participation in international research funding mechanisms. Aim at highest quality projects and domestic competence clusters. Seminar & conference participations and organisation. Develop researcher training and mobility mechanisms.	Technology oriented benchmarking. Ensuring access to best available expertise. Aim at strategic collaboration with strong foreign partners. Inviting foreign experts and companies to programmes. Encouragement for international joint R&D projects and technology transfer.	Application oriented benchmarking. Selecting a steering group with international contacts. Selection of projects with international application objectives. Focus on credibility increasing and awareness raising. Support by outsourced internationalisation / export services.	Follow-up & active dissemination of regulatory, policy and market developments. Lobbying on policies, standards and legislation. International network facilitation among actors.
Follow-up	Ensure a seamless follow-up usually with a new programme.	Follow-up with other programmes or specific follow-up instruments.	Technology programme as a catalyst – follow-up with other (business oriented) instruments.	Follow-up with specifically targeted programmes or specific follow-up instruments.

and sufficient internal and external instruments for joint objectives. Interconnection and utilisation of external instruments should be as easy and efficient as possible, but by no mean obligatory. Similarly, the intensity of participation in other European funding mechanisms should not be considered a single measure of successful internationalisation.

In the light of this evaluation, it appears evident to refine the internationalisation objectives and mechanisms in Tekes technology programmes more specifically according to the relevant internationalisation rationales. The typology found in this evaluation could provide one good basis for that. This would suggest that at least the types of internationalisation approaches shown in Exhibit 21 be developed and employed.

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Annex 1.

List of persons interviewed and workshop and seminar participants

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Participants to the strategy meeting with the international technology policy unit of MTI, 19 November 2003

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Annex 2.

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Antares – Avaruustutkimusohjelma*, 2001-2004
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Code – Polttoprosessien mallinnus, 1999-2002
Diagnostiikka 2000, 2000-2003
Divan – Huonekalualan teknologia- ja kehittämisohjelma, 1999-2002
Elintarvikkeet ja terveys, 2000-2004
ETX – Elektroniikka tietoyhteiskunnan palveluksessa, 1997-2001
Exsite – Langattoman tietoliikenteen järjestelmäteknologiat, 2001-2003
FFusion 2 – Fuusioenergian teknologiaohjelma, 1999-2002
FIBRE – Biodiversiteettitutkimusohjelma*, 1997-2002
FIGARE – Globaalimuutoksen tutkimusohjelma*, 1999-2002
Finnsteel – Teräsrakentamisen teknologiaohjelma, 1995-2000
Geenitutkimusohjelma*, 1995-2000
Globe 2000 – Kaukokartoitus, 1996-2000
GPB – Kansainvälinen projektiliiketoiminta, 1998-2001
iWell – Hyvinvointi ja terveys, 1998-2003
Jätteiden energiakäyttö, 1998-2001
Kemiallisen massanvalmistuksen haasteet, 1996-2000
Kenno – Kevyet levyt -teknologiaohjelma, 1998-2002
Kesto – Materiaalit energiatekniikan palveluksessa, 1997-2001
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NAVI – Henkilökohtainen navigointi*, 2000-2002

* Joint programme with the Academy of Finland

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Pigmentit paperin raaka-aineena, 1998-2000

Potra – Polymeerit tulevaisuuden rakentajina, 2000-2003

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Solubiologian tutkimusohjelma*, 1998-2002

Space 2000 – Avaruuslaitetekniikka, 1996-2000

SPIN – Ohjelmistotuotteet, 2000-2003

Staha – Staattisen sähkön hallinta, 1999-2002

Streams – Yhdyskuntien jätevirroista liiketoimintaa, 2001-2004

Terve talo – Rakennustekniikka, sisäilma ja laatu, 1998-2002

Tesla – Informaatiotekniikka sähkönjakelussa, 1998-2002

TLX – Tietoliikenteellä maailmalle, 1997-2001

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UTT – Uusi teollinen toimintatapa, 2000-2004

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Vera – Tietoverkottunut rakennusprosessi, 1997-2002

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* Joint programme with the Academy of Finland

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Annex 4.

Description of internationalisation in case programmes

NAVI – a broad networking approach to internationalisation

The NAVI technology programme focused on the domestic value network related to mobile navigation technology. At the time of the programme initiation, navigation technology was a rapidly developing, emergent technology strongly influenced by international standardisation by regulatory forums such as the Location Interoperability Forum (LIF). The markets for navigation technology were still in their early development; approaching the point where commercial solutions would become feasible on a larger scale.

Finland was recognised as a market in which novel technology was rapidly adopted, and in which the infrastructure for mobile terminals was well developed. The domestic market could serve as a laboratory for testing the technology, thus improving the opportunities for domestic companies in their efforts to influence standardisation and, ultimately, to export products to international markets. However, the value network composed of the Finnish actors was also still developing, so there was a need for assembling all the central actors in the sector in order to increase their cooperation. The NAVI programme was initiated to meet this need.

The NAVI programme was a first public intervention targeted for the producers of mobile navigation technology. It had an uncommon, innovative structure where the core of the programme consisted of 12 technology and application independent support projects focusing on the needs of the value network. These horizontal research projects focused on issues such as terminology, end-user needs, standardisation and service architecture. The themes were identified by the programme steering management board, and research groups previously recognised as competent in the subject matter invited to carry out the programme. In addition, the programme invited other, on-going projects that focused on navigation technology to join the programme. The steering group accepted 24 of these more application-specific projects into the programme. These projects were not funded by the NAVI programme, however. They were funded by other, linking Tekes' technology programmes such as USIX, SPIN and AVALI as well as by EU programmes.

Due to the fact of Finnish markets being small, internationalisation was an intrinsic aspect of the programme. The programme carried out international market studies in all of the substantial markets and gathered information on the most significant international and local actors related to navigation technology. International standardisation forums were closely monitored and influenced by the programme participants. There was, however, little international collaboration at the project level. Nearly all of the internationalisation activities have been related to supporting domestic companies.

In order to increase the participation of SMEs with the programme, a NAVI Network was established. Its members were able to utilise all programme results in exchange for a membership fee. The network included also lead-firms from the sector, as well as ministries and other public organisations. The NAVI Network also initiated a project for monitoring international markets, to find and distribute important news to its members weekly. The project also included market research on the Japanese, North-American and European markets, carried out by Finpro and Mobile Zoom. The NAVI Network remains to be functional after the programme completion and continues to produce

information on international markets and organises seminars on a regular basis.

The NAVI programme was considered to be a success. It was able to bring together the whole network of domestic actors. In terms of internationalisation, the programme produced valuable knowledge for domestic companies. However, due to its nature, the programme did not have a notable impact on establishing collaborative relationships with technology sources or customers abroad, nor did it have a large impact on the international recognition of Finnish companies. The small number of pilot projects was considered the only disappointment in relation to programme objectives. This, however, should not be attributed to programme management but to the slow development of markets and the general recession that was felt especially strongly by the ICT-sector. The support projects were established before the economic downturn and, thus, they received relatively large amounts of funding. When the recession began, R&D investments decreased.

SPIN – strong business objectives as drivers for internationalisation

SPIN, Software Product INdustry, was a three-year technology programme to boost the software product business in Finland. Finnish software industry is a rapidly growing and internationally active set of enterprises. During the 1990's there had been several internationally oriented activities for software business promotion by the Finnish foreign trade association, as well as a FINSOFT technology programme.

SPIN´s main objective was to assist in the generation of new, international, product-based business. The programme was divided into three core technology areas (*internet service infrastructure, mobile communications and enterprise management software*) and to other focus areas (*e.g. computer security, entertainment, systems development tools, media technologies*). A total of 110 industrial and 14 academic research projects were accepted into SPIN, reaching a total volume of 75 million euros. Industrial projects represented a majority of these (nearly 70 million euros). Although SPIN was a large technology programme by the number of participants, the scope of objectives and activities remained relatively narrowly focused. Programme management was unusually divided among a group of coordinators, of which one was responsible for international activities.

As a basic principle, all projects to be approved in the programme had to aim at international level activities. There were also exceptionally many internationalisation activities conducted at the programme level. These included *export workshops* and *seminars*, *bilateral co-operations* (Japan, China), brochures that were used as marketing material and co-operation with simultaneously run internationalisation programmes (*i.e. Global Software Programme, Wireless Finland*). Also Tekes office in San José provided an important input to the programme.

These activities aimed at strengthening services supporting internationalisation, specialised for the software product business. Programme level activities did catalyse and facilitate international co-operation, while much of the internationalisation took place at the project level, where the core substance remains.

Software product business is rather young industry and most of the companies are very small. It is typical, however that even small and young companies in software product business invest significantly in research and development work, network actively and build alliances and distribution channels abroad. It is therefore that internationalisation provides a key challenge to the development, growth and success of the software industry.

SPIN could clearly boost internationalisation of small software companies. Participation in SPIN technology programme had brought clear benefits to the internationalisation of small software companies, in particular related to the image, credibility and general awareness of Finnish software competence. It promoted an image that the programme participants had been assessed, selected and approved by competent authorities and provided targeted and concise information about international opportunities, channels and means for co-operation for smaller companies.

The Global Software Programme was considered particularly applicable model for promoting both commercialisation and internationalisation in connection with technology programmes. It provided for sound feasibility studies and an internationalisation clinic for software companies, as well as invited customer groups and financiers to discuss the international business development possibilities with the programme participants. In this case, other available internationalisation channels such as the EU framework programme could not provide sufficiently dynamic operating conditions.

Internationalisation of a technology programme in its full meaning contains more than just carrying out international level studies or international visits. In the case of SPIN the programme aim was to develop new software products for target markets. In this respect, the co-operation was true research and development work, not merely promotion of exports. The participating companies were however in different stages in their readiness for internationalisation, which had to be taken also into consideration.

iWELL – adjusted approaches to different international markets

iWELL technology programme was launched in early 2000 as a sequel to a number of earlier well-being programmes with similar targets: to promote internationally competitive solutions and services that enable companies to benefit from their technological edge. The distinct feature of iWELL compared to the previous programmes, was its focus on the end users of the products and services. The total programme volume was around 40 million euros.

iWELL focused on the development of competitive well-being technology for world markets; therefore an international aspect was an in-built element of the programme targets. In addition to commercial and social considerations, attention was also paid on physical and mental well-being to give better opportunities for healthy and independent living. It aimed to take information and communication technology and solutions that were originally developed for production, logistics and construction sectors and to turn them into well-being applications.

The programme focused largely on solutions that could promote healthy and balanced living, suited for example to the ageing population, the disabled and those suffering from long-term illnesses. Specific programme objectives included:

1. Turning Finnish know-how in the field of well-being technology into successful commercial applications.
2. Bringing about technology and service products for the working age population.
3. Promoting new service products for the ageing population, the disabled and those suffering from long-term illnesses; e.g. personal safety and security devices, logistic services, electronic services, telemedicine and telemonitoring.
4. Stepping up research on well-being technology.
5. Facilitating co-operation between different operators to boost the domestic market for well-being technology.
6. Making Finland a pioneer in the application of new technology to social and health care.

To great extent, the construction of iWELL had been bottom-up based. The industrial sector was in its early development phase, this one aim of the programme was to activate the industrial development through networking and provision of market information. The role of the programme steering group remained somewhat distant and much of the programme co-ordination was done by the programme coordinator in collaboration with Tekes. Also the international activities of the programme relied on the initiative of Tekes.

So far, the export of Finnish well-being sector's products and services has been nominal and generated by a few large companies. The sector is dominated by public services and operators, which brings a specific nature to the market and for the international co-operation. Overall, it was considered that the market impact of the iWELL programme remained limited.

Specific market studies and analyses had been conducted on the development of well-being markets abroad, namely Japan, USA, Germany, UK, Italy and the Netherlands. Japan had been selected as the

prime co-operation direction and a test market for iWELL programme, despite the known challenges related to accessing these markets. Two benchmarking / collaboration building visits were made to Japan. Visits were also proposed towards USA, but to that end, there was not sufficiently interest among the participants. Collaboration with Sweden was carried out by inviting Swedish participants to Finnish seminars and by organising a joint seminar with Swedish healt sector representatives.

Universities and research institutes had built their own contact and connections with foreign partners, while most of the company participants did not directly benefit from those connections. Co-operation with Japan became increasingly important during the progress of iWELL. The aim was also to approach US markets, but this task turned out to be difficult. European co-operation and developments were considered interesting and more easy to approach, but not equally important in terms of market potential for well-being products and services.

The co-operation with Japanese was initiated by Tekes, but besides the support of their office at Tokyo, Tekes' services had not been used to facilitate international co-operation. Finpro provided support to building co-operation with the Japanese, for example in the '*Japan school*' seminar series organised by iWELL. Finpro also conducted market studies on the Japanese well-being sector and were managing a parallel housing project. At the end part of the programme, a Finnish-Japanese expert workshop was organised for companies and research groups interested in joint activities with Japanese partners.

As far as it concerns international research co-operation, the impact of iWELL did not turn out to be as significant as originally expected. International research co-operation, when it took place, happened mainly at project level. The programme did not bring a significant change of direction, increased or activation to that end. Also research co-operation between companies both domestically and internationally remained very limited.

iWELL was an umbrella programme for activation of a vast set of companies, research units and institutions in the well-being sector. For international linkages, co-operation and potential markets, there was not a clear strategy or plan of action for the programme to implement. Analyses were carried out of the lead markets, but perhaps more specific analyses of the needs and aims of international co-operation could have been carried out in the early stages of the programme. All in all, the internationalisation and commercialisation process in well-being sector took clearly more time to start and progress than what had been though at the start of the iWELL.

The Finnish well-being industry is still in its early development phase. Besides a few leading firms, smaller companies were not able to properly benefit from international research co-operation. To that respect, the larger, lead companies have an important role in driving the domestic and international development of the sector. iWELL programme was already able to boost the development of the industry and built close links between the various operators in public and private sectors, while much of the impact generated by the iWELL will actually realise some years after the completion of the programme.

FFUSION2 – a national programme to maximise returns of high quality research

European fusion programmes have been carried out for roughly forty years now and today, European fusion research and its relevant facilities are at the cutting edge of global development. Due to this scientific strength, European Union is also leading the leading partner in the international ITER project for constructing an experimental fusion reactor.

FFUSION2 programme is a follow-up to an earlier technology programme (FFUSION 1993-1998). Like its predecessor, the set-up of FFUSION2 programme was internationally integrated from the very beginning. The programme was designed to parallel with the EU Fifth Framework Programme (Euratom) key-action Controlled Thermonuclear Fusion, which was aiming at a safe prototype reactor in co-operation and eventually at economically

competitive fusion power station for future energy needs.

Through FFUSION2, Finnish technology development focused on areas, which strengthen fusion research know-how and the position of Finnish industry in next generation fusion reactor projects, but more importantly in applications beyond fusion technology. In basic research, the emphasis was on developing advanced scientific calculations and simulation procedures, as well as on plasma diagnostics. The key research areas included fusion plasma physics, reactor material studies and remote handling and inspection systems. The total research volume of the programme was 15 million euros, of which the share of Euratom was nearly one third (29%).

The objective of FFUSION2 was to carry out high quality scientific and technological research in close co-operation with European fusion experiments and to promote the collaboration between research institutes and industry. The underlying principle for international co-operation was to support those projects which indicated clear interest from the Finnish perspective.

Finnish research groups at VTT, Helsinki, Tampere and Lappeenranta Universities of Technology and University of Helsinki, together with the participating industries formed a research unit of the Association Euratom-Tekes. The industrial co-operation in FFUSION2 was organised separately by PrizzTech.

The association participated in the European Fusion Development Agreement's Joint European Torus (JET) and Technology Work programmes. Finnish research concerned the development of multimetal components, joints and advanced coatings for ITER vacuum vessel and in-vessel area, water hydraulic tools and manipulators for remote handling and operation. A materials testing facility developed by VTT has been placed in a research reactor at Belgium. To this end, the scientific outcomes of FFUSION2 were outstanding, as were the development of new applications and academic studies, hence Finnish research clearly contributed to the development of ITER. Altogether 160 academic publications were published, eleven doctorate and licentiate theses produced and three large-scale international conferences organised.

A unique characteristic of Finnish participation in European fusion research has also been the strong involvement of Finnish companies. Success in participation and scientific terms would probably not have been possible without a good national preparation and an active role of Tekes in the various committees as a representative of Finland.

Although fusion research is typically the kind of fundamental research which has a long time span – much longer than the 3–4 years of a technology programme – it was considered useful to break the long-term research challenges into manageable sub-topics and time periods under the technology programme. After FFUSION2, the Finnish fusion research will progress under a new FUSION -programme with somewhat amended objectives.

KESTO – a combination of exploitation and up-grading of technologies

KESTO was a research oriented technology programme carried out during the years 1997- 2001. The programme aimed at improving the international competitiveness of Finnish companies that are manufacturing equipment for energy industry, as well as decreasing the costs of energy production in Finland more generally. These aims were sought by means of developing and applying new materials- and production technologies.

The KESTO programme had its history in the energy programmes by the Finnish ministry of trade and industry, the previous LIEKKI 1 and 2 programmes as well as in the technology programme for 'application oriented use of materials'. These programmes created the broad knowledge base, which KESTO-technology programme later successfully exploited and built on.

The programme included altogether eighteen research projects and eleven company projects. The total volume of the programme was 13 million euros, of which Tekes funding covered a good half.

One key factor for the initiation of KESTO programme was the Kyoto Protocol on climate change, which brought considerable challenges for energy-generating industry and in particular for the energy generation equipment manufacturers. Since these challenges were of fundamental type, they concerned industries in all European countries.

KESTO –programme aimed at lowering the exhaust levels of power plants to improve their energy efficiency. This would require increasing the operation temperatures of power plants, where the heat resistance and durability of materials was a key factor. New, better materials would not only improve the energy efficiency, they would also increase the competitiveness of Finnish manufacturers of energy equipment.

The basis for building international co-operation in KESTO was good; the Finnish equipment manufacturers and the Finnish expertise in combined heat and temperature (CHT) generation technologies is appreciated and well known in world markets. In some fields, such as in the use of biofuels and in particular black liquor and other recovery boilers for Forest industry, the Finnish companies have been clear market leaders.

Among the participants of the programme, research centres and universities were most active to build international co-operation, since the participant companies were, in most cases already operating in international markets. Within the framework of KESTO, two large international co-operation projects were initiated. One concerning a long term exchange of researchers between the Technical Research Centre of Finland (VTT) and the Institute for Advanced Materials of EU Joint Research Centre at Petten to study the corrosion phenomenon of furnishes. Another one between the Process Chemistry Research Group of Åbo Academi and Oak Ridge National Laboratory (US) to study the corrosion of recovery boilers.

The programme steering group encouraged the projects to actively build international co-operation and to the mobility of researchers, which took place also among companies. There was, however a constant awareness of the 'national interest' in the pursuit for international co-operation in KESTO.

The mobility of researchers was planned and organised by the researchers themselves. It took place, because there was a true interest on each side. An important element for the success of programme -level visits was the extent to which the receiving partner was committed to the arrangement.

At least research institutions increased their international co-operation through the programme. In particular several COST – projects were launched. For companies, the internationalisation effects were not so significant.

According to the programme evaluation, international co-operation was generally successful, although the co-operation could have been deeper. In particular the networking effects were strong, while more clear instructions were called for the more inexperienced researchers in order to avoid harmful information leaks.

The rationale for international co-operation was two-sided. On one side, the Finnish research and industrial competence and market position in recovery boilers were very strong, which provided a good basis for building collaboration with the best international partners. The programme could benefit from good awareness of Finnish competence and from existing international contacts. The evaluation report concludes however that these Finnish participants had been mainly the donating partners in this collaboration.

On the other side, same technology was used in gas turbines with a rather different competence base. In the beginning of the programme, there was hardly any expertise in Finland on construction and maintenance of gas turbines. Particularly with respect to the maintenance, Finnish companies were dependet on foreign costly expertise. Thus the aim of the international co-operation in the programme to this end was to strengthen the basic technological competence of Finnish gas turbine operators to sufficient level.

When KESTO programme ended, many of the international contacts and co-operation activities that had been created, diminished to personal level co-operation or simply terminated. It is certain, however that the technological and market related challenge remains relevant even after the programme completion and it would appear that the same applies for the international co-operation.

KENNO – well planned benchmarking to up-grade Finnish competence

KENNO technology programme aimed at starting up industrial production of lightweight panels, as well as at promoting the use of hollow-core structures more generally with an overall budget of 14,3 million euros. Implementation of the programme meant stepping up of the subcontracting sector for manufacturing lightweight metal structures and enhanced the competitiveness of companies using lightweight metal and honeycomb structures.

Lightweight structures provide many advantages. Lighter metal structures are needed e.g. in shipbuilding, transport vehicle building and machine building industries. In addition, there is a growing demand in the construction industry for different lightweight, modular solutions. Up until KENNO, the structural design and manufacturing technology for lightweight structures has remained largely undeveloped in many industries besides aircraft manufacturing for economic reasons.

Generally speaking internationalisation was a natural and integral part of KENNO, simply due the fact the necessary know-how on lightweight structures had to be imported from abroad. At the start of the programme, practical knowledge and know-how related to light weight structure manufacturing processes was almost inexistent in Finland, and well developed particularly in USA, Japan, Germany and Sweden. Technology transfer and co-operation with foreign partners was carried out also in connection to the Finnish fighter aircraft procurement from Boeing industries.

There were several types of international activities in KENNO. Available technologies were mapped with techno-economic and patent surveys, as well as with well planned benchmarking visits to USA, Japan and Sweden. Good planning and preparation of these visits was considered important, because the technologies and methods were strongly application specific. In the case of visit to USA, a person was sent to the target area to identify the most promising sites as well as to plan and prepare the programme visits. The duration of programme benchmarking visits was typically around 7–10 days, with a dozen of participants from projects. For efficiency reasons the topics of international benchmarking visits were kept tightly focused, which in turn limited the number of potential participants. The Tekes offices in Japan and USA provided also support in the benchmarking visit preparation.

A complementary method for accessing foreign expertise was organising international programme seminars. The aim was to have a top international expert speaking in all seminars organised by KENNO. Projects were also encouraged to make study visits to partnering countries.

Despite the fact that Tekes' statistics on international co-operation do not show many international projects for KENNO, almost all company projects under the programme included some international aspects. For example a good part of the information gathering and testing was carried out abroad. The research projects were not equally international by their nature, due the strong application orientation of the research, with perhaps the exception of some friction welding (FSW) projects.

The clearly focused aim and nature of the KENNO programme made also international co-operation (i.e. organisation of benchmarking visits) easier. A publicly funded and organised technology programme provided an interest neutral framework for approaching foreign research institutes, which again acted as links to the appropriate expertise in foreign companies. It also facilitated systematic information collection and analysis, which would have been difficult to carry out by any small or medium-size company alone, not to mention its cost effectiveness to the participants. International co-

operation and contacts have remained to some extent after the completion of KENNO-programme, but merely on company or personal levels.

GPB – taking stock of large companies' experience in internationalisation

The aim of the Global Project Business, GPB –programme was to strengthen the competitiveness and profitable growth of Finnish project business abroad. The programme paid particular attention to the development and unification of project management tools and methods. GPB was rather small technology programme by it volume. It consisted of sixteen research projects and nineteen company projects, with a total research volume of around twelve million euros.

The strengthening of competitiveness was achieved by means of developing new business models and in particular new ways of operating internationally. It was focused on companies that already had international project business. Typical participants were larger companies, while also smaller companies were encouraged to participate through networking.

The GPB research projects were considered experimental, resulting in new operating models and practices, new knowledge and understanding (for example on forming project consortia or managing project risks or project portfolios). Company projects resulted also in new tools and software. Seminars, academic publications, reports and articles were also produced actively.

Much of the internationalisation in GPB took place at project level, rather than programme level. International aspect was naturally in-built in all GPB projects. Internationalisation was strongly encouraged, but clearly based on the endogenous needs and own initiative of projects. A general principle was that the programme would try to facilitate internationalisation, but not push for it.

To some extent, information on international project business and markets was collected in the programme. An interesting aspect to the GPB programme was that the main channel for internationalisation experience was in fact making make use of the existing project business knowledge shared by the participating companies.

In the Finnish context, global project business consists mainly of design and delivery of large investments abroad. Typical projects concern the set-up of factories, processes, production lines or building and construction sites. It is difficult to distinguish any single technology or particular market that operates as a driver for the project business. Instead there is a collection of key competencies, which include general business and administration, logistics, product portfolio management, etc.

Global project business is to large extent service delivery to distant locations and cultures. Thus an important element to its success is minimising the customer's apparent risk through awareness and credibility of the provider. This is true in particular for smaller companies with new products. To this end, operating as part of the programme or a larger network can provide benefits.

In the GPB case, the main rationale for internationalisation was to improve and better exploit the existing global project business competence of Finnish companies. Initially there was an aim to seek new, better knowledge from abroad, while this turned out to be rather difficult. It was discovered that Finnish competence in the current fields was internationally very competitive and rather unique. There were several initiatives to start co-operation with foreign partners, for example to Australia and Sweden, but at the end the differences in timing and funding criteria of national programmes became to big obstacles.

TESLA – building advantages in deregulating European markets

The objective of the TESLA technology programme was to improve the international competitiveness of Finnish power industry by applying new information technology to electricity distribution. The programme provided means for improving network management and use, for managing electricity procurement and sales, and for making the use of energy more effective. The total research volume of TESLA was around 27 million euros, of which company projects represented more than 18 million euros.

TESLA programme was part of a longer process of developing Finnish electricity distribution technologies. It followed on a five year EDISON programme funded by the ministry of trade and industry having largely same participants and similar objectives. The electricity distribution markets had opened during EDISON programme and many of the programme participants became in fact competitors for each other.

The objectives of TESLA had been born from two needs. Firstly, due to the opening of electricity markets the nature of electricity distribution business had changed, which resulted in a need for better risk management. Secondly, the increased competition demanded for ever-higher productivity of the distribution network. Better optimisation and management of the distribution network with information technologies and automation was seen a possible solution to both these ends. At the end, the aim of the programme was to improve the competitiveness of Finnish companies and their applications in opening European electricity markets.

The programme focused mainly on larger, over 130 kV power stations, which were more interesting also for export reasons. The beginning of the programme focused merely on technology development issues, while at the end part issues related to the opening of electricity markets also stepped in, such as preparation for dynamic tariffs. The idea was to facilitate an early start for the Finnish companies in opening international electricity markets and to that respect, the forward-looking perspective of TESLA was very important.

TESLA's reference countries regarding open electricity markets and their technologies have been USA and Japan. A study of the Nordic countries' situation was also carried out. TESLA did not, however, have many international activities built into it, despite the fact that the final aim of the programme was tightly linked to international market and technology developments. It was considered that the Finnish expertise in electricity related to information technology applications was already very strong and therefore the research was carried out mainly domestically.

Studies relating to norms and regulations of electricity distribution and applications were mainly carried out by the projects on their own initiatives. Afterwards it has been noted that these issues could have been followed and studied more closely on the programme level, as the market is strongly regulated and current situation perhaps even more challenging than what was foreseen at the launch of the programme. Feasibility and market studies were also carried out at the project level.

Only limited resources had been allocated to the programme level international co-operation of TESLA. The steering group did make a study trip to United States and Japan. Besides these, the internationalisation consisted largely of active participations in international seminars and academic publications in international journals. These have been considered to increase the international awareness of Finnish electricity distribution expertise. In particular for smaller companies TESLA provided a certain image of prestige as well as a framework for international co-operation through larger Finnish companies.

It was however also considered that at the end, there were not as many exportable applications spinning out of TESLA as was expected in the beginning of the programme. One reason may have been that research projects were not sufficiently focused according to the market needs. Finnish electricity distribution had been highly automated and many of the technical applications developed during TESLA for domestic needs were not well applicable to European markets.

PRESTO – international networking to broaden the competence-base

The objective of the PRESTO was to enhance the competitiveness of Finnish products in constantly intensifying international competition by innovatively applying existing micromechanical components and by developing new components on client needs. It programme aimed to generate new business activity in the manufacturing of micromechanical products, their assembly and design, as well as an international partner network to complement national expertise in enterprises. The total research volume of the PRESTO was 25 million euros.

PRESTO was a product- and business-oriented technology programme, which comprised of three technological sub-fields:

a. *Micro-Electro-Mechanical Systems (MEMS) technologies* concentrating on components and the design, development and production of systems based on them.
b. *Micromechanics (Micromechanical manufacturing methods)* concentrating on the design of micro and precision technology components and on manufacturing, development and production technologies.
c. *Microassembly* concentrating on the assembly of micromechanical components and products, assembly methods and related production and supplementary devices and control methods.

The programme was initially to focus merely on MEMS technologies, but prior to launching also manufacturing and assembly aspects were added to its scope. These technologies had been applied in fast growing business sectors (e.g. telecommunication equipment) and assembly had been the focus of a previous LASSI -technology programme (Light Assembly Industry 1996-1999). International technological competence had already been assessed in the pre-study by Tekes.

At the conception of the programme, there were roughly a dozen enterprises in Finland that were actively applying micromechanics in their production. These companies were very advanced, competitive and already operating internationally. To this end, the objective of PRESTO was to broaden the application-base of this expertise within the Finnish industry. This turned out to be a more challenging task than initially presumed.

One of the specific programme aims was to establish an international network for this field and this was achieved, to a large extent. Networking was facilitated by selecting members which all had strong international contact-base to the Steering Group. In fact, the LASSI-programme had already been strongly focusing on international co-operation and both the external programme manager and the Tekes programme co-ordinator for LASSI programme were part of PRESTO's Steering Group, too.

It was considered important for PRESTO to be able to recognise, follow and to make good use of the different international development trends regarding micromechanics. MEMS technologies were strongly developing in the USA, production technologies were the driver in Japan, while European applications were mainly concentrating on the assembly and automation. The Steering Group organised three benchmarking visits to Germany and one to Japan which were open to all programme participants, as well as held one meeting in Sweden. These were reasonably high-level delegations, which was considered important and useful with respect to German and Japanese business cultures. Comparative analysis between Korean and Finnish competencies had also been planned, but was never actually completed.

Project-level international co-operation was active, particularly towards USA and Switzerland, as well as through Eureka. Programme-level co-operation towards USA was planned, but in practice it turned out to be too expensive for the programme purposes. Substantial amount of international co-operation was carried out by the lead companies, while other companies were less active to this respect. Researcher exchanges were also carried out in the research projects. PRESTO had facilitated the international co-operation, while its outcomes remained at the hands of companies and researchers.

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