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INTERNATIONAL R&D COOPERATION IN THE EU: A SOLUTION TO THE TECHNOLOGICAL DISADVANTAGES OF SMALL NATIONAL ECONOMIES?

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ABSTRACT: It is often claimed that small national economies have technological disadvantages in producing new technology. This disadvantage is said to be due to the small size of the domestic market, which reduces the expected returns on R&D investment. In addition, limited resources do not provide the critical mass necessary to produce new technology. As a consequence, small national economies are forced to follow a strategy of strong technological specialisation. The small amount of knowledge capital also limits the extent of technological spillovers.

This paper analyses whether international R&D cooperation can alleviate the technological disadvantages of small economies. In countries such as Finland and Austria, this question is gaining increasing importance since they joined the European Union. It is also necessary to work out which policy measures are required in addition to international R&D cooperation in order to reduce the technological disadvantages of small national economies.

The paper shows that participation in international R&D cooperation without additional national policy measures does not save resources. Diversification of the technological supply is also not possible in the short run. Furthermore, broad participation in future projects of the EU requires less technological specialisation in a small economy. The efficient exploitation of the results from R&D cooperation and the support of internal diffusion also require additional investment in order to build networks and to generate demand (adaption) for the new technology.

KEY WORDS: R&D cooperation, technological specialisation, small economies, technology diffusion, Austria, Finland

1. INTRODUCTION

The technological disadvantages of small national economies derive from the relationship between R&D investment and the size of an economy. Here the size of an economy refers to the size of the market, the extent of the resources available for R&D investment, and the amount of the knowledge capital.

The paper explores the possibility that cooperation in the European Union (EU) will alleviate the technological disadvantages of small national economies in R&D activities. Does R&D cooperation save resources and reduce the strong specialication of technological activities? Finally, what measures will reduce the technological disadvantages and improve the utilization of the project results from R&D cooperation in the EU?

2. HYPOTHESES ON THE TECHNOLOGICAL DISADVANTAGES OF SMALL NATIONS

In the theory of endogenous technical change, the level of R&D investment by a firm depends on the expected returns and costs (Nelson/Winter 1982, Krugman 1991). The arguments about the technological disadvantages of small nations depend on the relationship between R&D investment and the size of an economy. Here, size refers to the size of the market, the extent of the resources available for R&D investment, and the amount of knowledge capital.

1. Hypothesis: The smaller the market, the lower the expected returns from R&D investment.

2. Hypothesis: At a given (expected) cost of innovations, the more resources available for R&D investment, the more innovations can be produced. The small country disadvantages arise from the lack of critical mass and the disadvantages of scale in the production of new technologies (Walsh,V. 1987, p.58).

3. Hypothesis: Small economies have a smaller amount of knowledge capital than in a larger country. The technological spillover are therefore smaller and consequently, the productivity of the R&D investment of a firm is less influenced by the R&D investment of other firms (Grossman/Helpman 1993, Ch. 3).

These technological disadvantages from being small are, however, only valid for a closed economy. For example, the small size of an economy does have a negative impact on the technical change because the expected demand determines the expected returns of the R&D investment. For the European economies, for instance, the export markets are of importance, not merely their own domestic market. The strong export orientation entails, however, higher information costs in comparison to a domestic market orientation.

The negative effects of having a small amount of knowledge capital on the productivity of R&D investment are also not valid for small open economies. In this case this disadvantage can be offset by the international diffusion of knowledge.[1] However, the international diffusion also requires the use of resources (for example R&D investment, see section 4.2. of this paper).

Consequently, only the second hypothesis has an effect on the technological activities of small open economies. For a given cost of innovation, the fewer innovations come from having a smaller amount of resources for R&D investment. Therefore, small open economies are forced to specialise technologically (Walsh 1987, p.37). A strong technological specialization causes some additional risks for a small economy. If the demand for the technologically sophisticated products in which the country is specialised suddenly falls, is it not easy to build another technologically sophisticated product. Investments in new technology have to be large and take a long time. The strong technological specialisation of small economies in "high tech" industries implies even more risks, since it can retard innovations if the solution of research problems requires knowledge in many different areas (OECD 1991, p.42).

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[1] The international technological spillovers are not limited geographically. In principal they can be utilised in all countries, see Grossman/Helpman 1993 4.ed, p.167

3. FINLAND AND AUSTRIA IN EU´S COOPERATIVE R&D PROGRAMMES

3.1. Research and Technology Policy of the EU

The objectives of the Community´s research and technological development policy are to promote scientific and technological excellence and to increase the international competitiveness of the European industry. European cooperation in research and technology is mainly justified by the creation of critical mass in research, and by the external effects of the R&D cooperation. The Union´s cooperation in research and technology is not a substitute for national policies on technology, because most of the research still takes place in the national countries (EC 1994, p.2; von Schwerin,O. 1995, p.18-19).

In order to achieve its technological objectives the Community establishes specific programmes, which are organized according to technological areas and financial resources, into a comprehensive framework programme (Table 1 and Appendix 1). Within the single programmes, international projects are supported which include industrial or academic participants from at least two member countries. The participation in the projects is not organized by fixed national quotas, but by competition between the potential partners. Only projects in basic research, and in the pre-competitive phase of the innovation process, are supported. The development of generic technologies, like information and communication technologies, are especially important (von Schwerin,O. 1995, p.18).

The budget of the fourth framework programme (1994-98) amounts to 12.3 bill. ECU which is divided among four main areas of activities, as shown in Table 2. The diffusion of modern technologies in Europe increased in emphasis in the fourth framework programme. Appendix 1 shows the specific programmes in the area of the first activity, i.e. the support of the scientific-technological basis of European industry.

Table 1: Fourth technological framework programme

Area of Activity	billion ECU
1. Research, technological development and demonstration programmes	10.686
2. Cooperation with non-member countries and international organisations	540
3. Dissemination and application of research findings	330
4. Stimulation of the training and mobility of researchers	744
Total	12.300

Source: EC. General Information, p.32

3.2. Participation of Finland and Austria in the Framework Programmes

Until the end of 1993, Finland and Austria as EFTA countries could only participate in the third framework programme according to the rules for third countries, where the financing for participation in the projects came from the national sources. The Finnish share came to about 1% on the total financing of the third framework programme (1990-94) and Finnish firms, or institutions, participated/participate in about 440 projects. The intensity of Finnish participation almost reached the political target of 1 percent of the projects (according to the Technology Development Centre (TEKES)). The Austrians took part in 140 projects of this programme (as of Feb. 28, 1994 according to Bureau for International Research and Technology Cooperation (BIT)).[2)] Both in Finland and Austria the participation of research institutes and universities is much higher than that of industry (Ohler, F./Polt, W. 1992, p.6 about the Austrian participation in the first and second framework programmes).

In conjunction with the formation of the European Economic Area in 1994 Finland and Austria paid a membership fee for the framework programme, which was independent of their actual participation in projects. They had no direct influence on the content of the framework programme, but the right to consultation and information. In 1994, the Finnish share of financing for the framework programme was 1.2%, or over 31 million ECU (Hallantie 1995, p.36). Since 1995, Finland and Austria, as member states of the European Union, can also

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2) The comparability of Finnish and Austrian figures is not guaranteed, because the sources and the methods are different. However, Finnish particiation is probably about twice that of Austrian participation.

influence the content of the technology programmes.[3)] The right to participation in the decision making of the EU was one of the most important arguments in the EEA countries for applying for full membership. The yearly fees of Finland and Austria to the framework programme cannot be calculated any more, because the financing takes place within the total budget of the EU. Finland´s share of financing of the fourth framework programme in 1995 comes to 1.38%. It is expected that participation in projects will be higher be than earlier (according to TEKES).

3.3. Size of Finland and Austria Relative to Other European Countries

The measurement of the size of a country that is relevant for the production of new technologies should include both the demand and supply aspects of the production of technology. According to the concept of the product life cycle, both the share of the R&D investment of the total investment, and the demand of technologically sophisticated products relative to total consumption are associated with the level of per capita income. In an open economy the expected returns of producing new technology depend on the economy's own level of per capita income and of the export market´s per capita income. On the other hand, the potential resources for the production of new technologies depend on the economy's own income level per capita (which determines the share of R&D investment) and the size of the population. Therefore the size of the GDP measures the potential resources. However, a high level of GDP may result from a large population at a low level of per capita income. This is why comparisons of the size, which is relevant for the production of new technology, should be implemented only for countries at a similar level of per capita income.

The relative sizes of countries, as shown in Table 2, are able to explain the different interests of the small, technologically developed countries like Finland and Austria, and of the technologically less developed countries like Portugal and Spain in the common European technology policy.

[3)] This paper concentrates on the framework programmes and does not deal with the projects of EURATOM, in which Finland and Austria also became members.

Table 2: Indicators of the size of selected European countries in the year 1993

	Population (million)	GDP (US$ billion)	GDP (US$ in bill. PPP)[4]	GDP per capita (US$ PPP)
Finland	5.066	83.8	79.0	15,599
Austria	7.990	182.1	152.4	19,038
Portugal	9.865	85.7	103.1	10,451
Spain	39.140	478.6	520.5	13,298
Germany	81.190	1911.1	1504.3	18,528

Source: OECD 1995, Main Economic Indicators, Paris.

Germany can be identified as the largest country because of both a high GDP and per capita income. Therefore, the demand for technologically sophisticated products is expected to be high, and the industrial structure is expected to be technologically modern. In comparison with another country with high per capita income, Austria, the difference in GDP shows the absolute size of the resources that can potentially be invested. Finland and Austria have a small GDP but the high per capita income and the strong export orientation indicate a high demand for technologically sophisticated products. The production of technological sophisticated products is, however, concentrated in few products.

In Spain, the GDP is higher than in Austria or Finland, but the level of per head income is lower. According to the theory of the product life cycle, this is associated with a low (domestic)[5] demand for technologically sophisticated products, and with a industrial production of mainly standardized products. The size of Spain which is relevant for the production of new technologies is probably not very large. Especially Portugal shows a small size when measured with both the level of GDP and the per capita GDP.

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[4] Purchasing power parity (PPP) rates for the dollar are derived from special conversion tables for currencies.

[5] The orientation on the growing export markets of high tech products is theoretically possible, but not easy, in practice, mainly because of additional information costs.

The size of a country should be positively correlated with the level of the R&D investment (Table 3). The level of R&D investment in the four countries (no figures for Portugal are available) are as expected associated with their size. Germany has the highest level of R&D investment, followed by Spain, Austria, and then Finland. The comparison of the R&D investment of the firm Siemens allows us to put the limits of the resources in small economies in perspective. The (worldwide) R&D investment of Siemens came to 7,5 billion DEM (4,5 billion US$) in the business year 1993/94. This is almost the amount that Finland and Austria spent together on R&D in 1993.

Table 3: Gross domestic expenditure on R&D (million US$) [6]

	1991	1992	1993	1994
Finland	2663.4	2315.6	1866.3	
Austria	2483.0	2836.7	2878.1	3172.4
Spain	4613.8	4892.3	4050.0	4047.7
Germany	44906.6	49138.9	47395.6	

Finland: 1991: Tutkimus- ja kehitystoiminta 1991, 1992: OECD. Main Science and Technology Indicators (MSTI), 1993: Tutkimus- ja kehitystoiminta 1993; Austria: MSTI; Germany: MSTI; OECD 1994/12 and 1995/2, Main Economic Indicators. Paris, for the exchange rates.

In Spain, the high level of the GDP was a result of the large population. The comparisons of the per capita R&D expenditure shows the effect due to the size of the population: the per capita gross domestic expenditure on R&D in Spain (103.5 US$) was much lower than that in Austria (360.2 US$).

3.4. Differing Interests of the Member States in R&D Cooperation

The problems in cooperating in the R&D framework programmes are different for poor countries than for rich ones with a small amount of resources. Poor countries, like Portugal,

[6] The exchange rates influence these results. The effect of the exchange rates can be eliminated by using the purchasing power parities. However, the purchasing power parity prices (PPP) are calculated for the GDP and not for R&D expenditure. The use of PPP for R&D expenditure results in lower values, but the rank order of the countries does not change.

have a disadvantage when competiting to participate in a technology project. The political objective of the framework programmes is to strengthen European competitiveness in advanced technologies, so if a country does not already possess know-how in advanced technologies, it will not be able to win in the project competition of the EU. This is why the technologically less developed countries of the EU demand *juste retour* in the participation of projects in return for their membership fees (Dodgson 1993, p.169).

The problems of the small, but technologically advanced countries do not lie in the lack of advanced technologies, but rather in being specialised in only a few industries. This has consequences for competitiveness in only a few projects and for national use of the project results (see section 5.2.).

R&D cooperation by the EU allows participation in projects with a high critical mass, which cannot be afforded by a small country alone. The small countries can also expect to save national resources, and to reduce the scale disadvantages in research activities. Participation also creates additional information on technologies and on demand abroad. Access to a broad spectrum of technology programmes allow small countries to fight against the disadvantages of technological specialization (Abbing, M./Schakenraad, J. 1991, p.4-5).

4. THEORETICAL FRAMEWORK FOR THE DIFFUSION OF COOPERATIVE PROJECT RESULTS

4.1. R&D Cooperation and the Diffusion of Project Results

The organisation of R&D cooperation in the EU and its subsidiziation are mainly justified by the creation of the critical mass in research activities (reduction of wasteful research duplication) and by the existence of cross-border (international) externalities in R&D cooperation. This paper concentrates on the question of the international externalities, which is to say, on the utilization and diffusion of the results of the projects in the member states. It is the national utilization of project results which determines the economic benefits of R&D cooperation and which reduces the technological disadvantages of small economies.

The proprietary rights among the participants of a project are regulated in the corresponding project agreements, whereby the ultimate utilization depends on the activities of the single participants. The participants are either firms, universities or research institutes or all of them. The programme assumes that the project results will automatically be diffused through member countries. New technologies, or knowledge, generated in the cooperative projects are treated like a piece of information or a pure public good, so the cost of their national utilization do not play an important role (Mowery/Rosenberg 1989, p.240).

But actually, the results of the technological projects are specific for the group of the firms. They are local technical progress and only latent public goods (the concept of local technical progress, Antonelli 1995, p.4; Nelson 1990, p.198; Colombo/Garrone 1994, p.6-7). They are developed further by the process of (entrepreneur) learning and on the basis of the local knowledge of the participants. Therefore, the diffusion of the project results into the economies of the member states require additional transfer costs and investment.

The project results are usually not in their final form but must be further developed to become marketable products. The application, development, and diffusion of new advanced technology are interactive processes. The interactive models of technical progress generally point out the importance of the demand in the process of technical progress and diffusion (Mowery 1994, p.9). The development and application of the project results is connected with dynamic economies of scale (learning) which induce further productivity effects in the national economies.

4.2. Theory of Diffusion

Countries show different abilities to use the results of cooperative projects, although they have the same access to the results. The theory of diffusion (Nelson/Winter 1982) is applied for studying the utilization of project results. The diffusion of a new technology depends essentially on the same demand and supply factors as does its production. This means that the expected costs of the (domestic) development, and the expected demand for the resulting products determine the diffusion of a technology.

Determinants of diffusion

The expected costs of diffusion of a new technology depend on the features of the underlying technologies.[7] Thus, the transfer costs of a technology are the higher, the more complex it is. However, not only the complexity of the new technology determines transfer costs, but also the technological and adaptive capabilities of the national firms and institutions. The better the absorptive capacities of a firm in the corresponding technology, the better a firm is able to use the technological results of an external source, like cooperative R&D (Cohen/Levinthal 1989, p.128; Colombo/Garrone 1994, p.7; Paasi 1994, p.10-12). The absorptive capacity of a firm is mainly generated by its own R&D investment (Cohen/Levinthal 1989, p.128).

Simultaneously, the expected demand for new technology determines the utilization and further development of the project results by a nation. The European economies face more or less similar demand conditions because of free trade, but the selection for further development can also be affected by other differences of the national economies, like national laws or economic policy.

5. R&D COOPERATION TO REDUCE TECHNOLOGICAL DISADVANTAGES

5.1. Savings of National Resources

The participation in R&D cooperation may be very beneficial for small economies because it gives access to research projects with high critical mass, and so removes the lack of scale economies in research. Additionally, the R&D cooperation saves national resources because the high development costs of an advanced technology can be shared and are subsidized.

International R&D cooperation, however, only induces an economic benefit if the new technology is used nationally, and if the national resources used are smaller than in the nation's own development of the corresponding technology. The national utilization of these project results is not possible without additional investment by the member states if the technological and scientific results are local technical change (Mowery 1994, p.21-22, see

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[7] The expected costs are not known, but there is certain information on the features of the underlying technology. The information is determined by the proximity of the industry to science, see Nelson/Winter 1982.

page 11 above). Such investment entails country-specific transfer costs, like for example, adaptive R&D investment by firms. The level of such necessary investment depends on the complexity of the technology and on the existence of an absorptive capacity in that technological regime (see above p.12). If the absorptive capacity in the underlying technology is lacking or insufficient, the national utilization of project results requires very high transfer costs. In this case, the R&D cooperation may not save national resources at all, because the high transfer costs must be added to the development costs in the project.

In many cases the participants of the EU projects are not firms, but rather research institutes and universities.[8)] In this case the national diffusion of project results requires that beneficial exchange of information between the research and industry is possible, as well as that the firms have a high capacity to absorb information.

Therefore, international R&D cooperation has the potential to save national resources only if the participation costs in an EU project and the transfer costs of the results are less than the expected costs of the national development of the same technology (Paasi 1994, p.11). At the given participation costs in a project the resource saving is the higher, the better the absorptive capacity is in the national economy and the better the interactions are between research and industry and within the industry.

Policy consequences for a small economy

The question of goverment support for adaptive R&D investment by firms and for the building up of the absorptive capacity, is a subject of controversy in the economic literature. According to the traditional opinion, the main focus of technology policy should lie on the early tests, and not on the direct support of the design or later phases of the innovation cycle (Nelson 1961, p.361-362). This basic principle is applied in the technology policy of the EU, which mainly supports cooperation in R&D during the pre-competitive phase of technical process.

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8) The Finnish and Austrian participants were mostly research institutes and universities (see p. 4 above).

The results of the project should, however, be utilized and developed by national firms and institutions. The national utilization of the so-called generic technologies, which arise in the process of R&D cooperation in the EU, are connected with strong positive technological spillovers in the member countries. Such economic benefits justify the policy support of the national diffusion of the project results, for example, by means of national technology programmes. The interactions between research institutions/universities and industry, or between the industries, can also be supported in such programmes. Public programmes can not only support the diffusion of information in a country, but can also help the small and medium-sized firms by building test and consultation centres (Mowery 1994, p.32).

A technology policy accompanying international R&D cooperation should, however, focus not only on the supply factors, because strong interaction exist between the production and the application of a new technology. Therefore, a supply-oriented technology policy (building up absorptive capacities, networking in the economy) should be accompanied by support for the demand for the new technology (Mowery 1994, p.30; Dodgson 1993, p.171-172). The support of the demand for the project results can be done with beneficial tax and depreciation rates (Mowery 1994, p.30).

5.2. Broadening of the Technology and Research Spectrum

Small advanced economies usually have a strong technological specialization, which entails some risks, as was mentioned above. Therefore, can the international R&D cooperation in the EU broaden the domestic technology and research spectrum of a small economy?

The R&D cooperation in the EU is organised so that the firms and the institutions compete to participate in the projects of the framework programme. This means, in practice, that only those firms and institutions of a country which already possess the knowledge in the underlying technology can succeed in the competition. Such guidelines are logical for a policy aimed at pushing the technological frontier of Europe forwards.

This competition to participate makes it impossible to diversify the technologies in a technologically strong, but specialised country. Therefore, a country with a low level of technological knowledge cannot participate in a project of producing new technologies, which implies the exclusion of learning possiblities for the technologically less developed members of the EU. Also, the costs of transferring the project results are very high when there is a lack of absorptive capacity of the technology. Consequently, there is no possiblity to enlarge the technological spectrum with the help of R&D cooperation in the EU.

Policy consequences for a small country

If national technology policy is to use the R&D cooperation for the development of a new technological capability, it must first build up the internal conditions for both the project competition and the national utilization of the project results. The current building up of appropriate knowledge and absorptive capacities (by means of R&D investment) determine future competitiveness in a technology. A technology policy aimed at supporting the generation of such technological capabilites should also consider the development of the future demand for such a technology.

The increasing importance of the European R&D cooperation in Finland and Austria would imply that not even the small economies should follow the strategy of a strong technological specialization. Otherwise, it is not possible to participate in a large number of projects.

6. CONSEQUENCES FOR THE TECHNOLOGY POLICY OF A SMALL ECONOMY

International R&D cooperation has only limited possibilities to reduce the technological disadvantages of small economies. Participation in the EU projects and the national diffusion of the project results are in fact only a potential means of using national resources more efficiently. The total savings of the national resources depend on the existence of absorptive capacities in specific technological regimes, and on the interaction between the industry and research. Also, the normally strong technological specialization in the small economies cannot be reduced with the help of R&D cooperation. On the contrary: the increasing participation of Finland and Austria in the R&D cooperation of the EU would require less technological specialisation and broader knowledge capital.

The technology policy of a small country faces a dilemma, because in the one hand success in the project competition requires strong knowledge and absorptive capacity in the corresponding technology, and on the other hand the broader participation in the R&D cooperation requires a broad spectrum of national technological and scientific capabilites. However, a broadening of the technological and scientific spectrum is not possible in practice in a small country with a strong resource constraint. The future technology policy in Finland and Austria must follow their traditional specialization strategy, and let the large, advanced countries like Germany and France develop the newest technologies. In such a division of labour, small advanced countries can take more advantage of new technologies by participating in the projects of the third activity of the fourth framework programme, which aims at faster diffusion of all kinds of advanced technologies in Europe.

Appendix 1

Areas of the First Activity in the Fourth Framwork Programme

	Million ECU
Information technologies	**1,932**
Telematics	**843**
Communications technologies	**630**
Industrial and material technologies	**1,707**
Measurement and testing	**288**
Environment and climate	**852**
Marine science and technology	**228**
Biotechnology	**552**
Biomedicin and health	**336**
Agriculture and fisheries	**684**
Non-nuclear energy	**1,002**
Nuclear safety	**414**
Controlled thermonuclear fusion	**840**
Transport	**240**
Socio-economic research	**138**

Source: European Commission 1994, Science, Research, Development. General Information: Community Research and Technological Development Policy. Report EU 15637 EN, p. 32

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