Business R&D and the Role of Public Policies for Innovation Support: A Qualitative Approach

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Abstract

Policy makers are paying more attention to changing patterns of business R&D and the effectiveness of policy instruments for creating a supportive climate to encourage business innovation. This paper summarises the findings of qualitative research based on semi-structured interviews which were carried out with Austrian companies in 2002. The research concentrated both on the identification of factors which influence the formulation of internal R&D strategies as well as on the R&D managers' perception of innovation support policies. The interviews indicate that an explanation of growing R&D intensity on a micro-level has to consider both the (external) environment in which the companies operate and their (internal) strategic response. For example, industry trends such as outsourcing of product development within the framework of supplier networks and reduced product life cycles may contribute to higher R&D investments. At the same time, internal decisions (future product portfolio, diversification efforts, etc.) clearly matter when it comes to formulating the R&D strategy and devoting ressources to R&D departments. The perception and evaluation of single policy instruments – reducing R&D costs, reducing the risks of R&D and improving the domestic research infrastructure – indicate some of the companies' particular needs. While all instruments are designed to close particular gaps, no single policy measure is capable of meeting the wide range of needs.

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Introduction

Empirical evidence, which indicates that business strategies for research and development (R&D) have changed significantly in recent years, is increasingly entering the innovation policy debate[1]). If firms are forced to develop new strategic responses to challenges of their business environment, the question arises, which government policies should be employed in order to stimulate industrial innovation and to improve the capabilities of national innovation systems. At the same time, the technology policy agenda in many OECD countries – and particularly in the European Union – targets at enhancing overall R&D activities.

Against this background, the partners of the Austrian tip-Programme launched an initiative which contributes to the OECD project on "Changing Strategies for Business R&D and their Implications for Science and Technology Policy". In a first attempt, in February 2002, the tip group organised a workshop which concentrated on leverage effects of public support to private R&D and the determinants of the patterns of private R&D[2]). It was concluded, that further empirical research on the firm level could improve the understanding of changing patterns of business R&D and the ways of adapting government policy to the changing environment.

Instead of proceeding directly to the design of a structured study yielding representative and quantifiable results, the Austrian tip group decided to start with qualitative research in order to define problems more fully, to identify likely methodological problems and to formulate hypotheses to be tested in subsequent research. Using individual interviews for exploratory purposes seemed to be the most appropriate approach because data then have more depth and richness of context. A list of specific topics covering both innovative activities of firms and their judgement of R&D policies was developed from several group discussions.

The interviewed sample companies were chosen according to selection criteria the tip team discussed in the aftermath of the Vienna workshop:

- Companies should have their home base and headquarters in Austria, but not necessarily in Vienna. As a result, seven sample companies are located outside Vienna (one in Vienna) and only one further company – a foreign subsidiary with substantial R&D activities in Austria – was included in the list.
- Companies should differ significantly in size reflecting that industrial R&D is an activity not confined to the larger ones. Consequently, beside the large foreign subsidiary, four SMEs and four large companies were selected and interviewed.
- The domestic market should play a minor role. The rationale for this criterion was twofold: On one hand, it was based on the opinion that the exposure to

[1]) See e.g. *OECD* (2002a, 2002b).

[2]) See *Gretzmacher – Hutschenreiter – Polt* (2002).

international competition would force firms to develop innovation strategies compatible with “international trends in business R&D”. On the other hand, it was expected firms which depended heavily on foreign product markets would be most likely to have also internationalised their R&D activities and should be covered by the sample.

- Finally, companies should represent different industries and branches with high R&D intensity. With the exception of one, all interviewed companies find their technological basis in electrical and mechanical engineering. Although important in terms of R&D intensity, the pharmaceutical and biotech sector was omitted.

The sample is not fully random and because of the small size of the sample, the study may be considered a case study. Although based on the agreed criteria, the concrete selection of companies was rather arbitrary: Due to earlier projects, some knowledge about the activities of three sample companies was available; for contacting another ten companies, the personal views about the innovativeness of firms were relevant.

The final decision about selection depended on practical rather than methodological considerations: the availability of an appropriate interviewee by end of June. Finally, after having collected company information, face-to-face interviews with R&D managers were carried out in the period between May 14th and July 2nd 2002 (see Table I)[3]).

Table I: The interviewed companies

Large Companies	AT&S	FACC	FRONIUS	TRIDONIC
WWW	www.ats.net	www.facc.co.at	www.fronius.com	www.tridonic.com
Location	Leoben (Styria)	Ried.i.I. (Upper Austria)	Wels (Upper Austria)	Dornbirn (Vorarlberg)
Date of interview	5.06.2002	21.05.2002	7.06.2002	20.06.2002
Main interview partner	G. Leising (Sen. Vice Pres. Techn.)	W. Billinger R&D Manager	H. Hackl Head of R&D	R. Geller Product Development
Foundation and Ownership	Predecessor (1987); restructuring & MBO 1994; IPO in 1999 (listed: New Market Frankfurt)	Founded in 1989; owned by the founding parent company (Fischer) and a conglomerate (Salinen AG)	Founded in 1945; family-owned	Founded in 1991 as a subsidiary of the restructured and family-owned Zumtobel Group
SMEs	ADCON	FEMTOLASERS	TROTEC	WESTCAM
WWW	www.adcon.at	www.femtolasers.com	www.trotec.net	www.westcam.at
Location	Klosterneuburg (Lower Austria)	Vienna	Marchtrenk (Upper Austria)	Mils (Tyrol)
Date of Interview	14.06.2002	14.05.2002	29.05.2002	21.05.2002
Main interview partner	L. Paulian Chief Technical Officer	A. Stingl Managing Director	A. Penz Managing Director	N. Mühlburger Managing Director
Foundation and Ownership	Founded in 1992 by 3 partners; IPO July 1999 (listed: New Market Frankfurt)	University spinn-off founded in 1994; owned by founders	Founded in 1997; subsidiary of large, family-owned marking systems producer;	Founded in 1990; owned by founders

[3]) In addition to the 8 companies listed in Table I, one further interview, which focussed on selected topics, was conducted with the Head of R&D of BMW's diesel-engine competence centre in Steyr (Upper Austria).

This report summarises the main results of the interviews[4]). It is based on an earlier version, which was presented at an OECD-Workshop in November 2002 and another OECD Working Meeting hosted by IWT in February 2003[5]). The paper starts with a detailed description of the interviewed companies. In a next step, it concentrates on observations related to the sample companies' R&D efforts. This is followed by a chapter which explores the value of innovation support policies as perceived by people responsible for R&D in an industrial environment.

[4]) The author would like to thank both the interviewees for their willingness to provide him with the nescessary information to conduct this study as well as Jörg Borrmann, Niko Gretzmacher, Reinhold Hofer, Gernot Hutschenreiter, Leonhard Jörg and Andreas Schibany for their helpful comments. The usual disclaimer applies.

[5]) The November workshop – titled "Empirical Research on Business R&D Strategies and the Effectiveness of Government Policies" – allowed for a first discussion of approaches proposed by several countries which participate in the OECD project. It was suggested to refine the research agenda at the February working meeting ("Effectiveness of Government Policies for Influencing Business R&D Strategies") at IWT in Brussels.

The companies in the study

Although much of the research focussed on studying trends in business R&D and the role of public policies, we felt important, to have a closer look at the companies themselves as well as at their business environment. Against the background of the already existing innovation literature, it is obvious, that quite a few factors and parameters are likely to influence the conduct and performance of innovative activities in the firm. As a result, several specific circumstances deserve to be explored before interpreting the interviewees' evaluation of policies. The questionnaire concentrated in particular on the companies' fields of activity, their competitive environment, firm size and growth as well as strategic responses to globalisation.

Activities and competitive environment

All sample companies can be considered technology-based firms because of their intensive efforts in R&D. However, as Table 1a shows, in the sample, the focus of business in terms of industry and main products differs significantly. Differences also occur with respect to the type of main customers; this might play a role when it comes to deciding about outsourcing of R&D to other organisations or – the other way round – becoming an outsourcing partner for an industrial customer. Four firms, AT&S, FACC, TRIDONIC and (to some extent) ADCON, are basically component suppliers to other industrial customers, while the products of FRONIUS, FEMTOLASERS and TROTEC are directly used in other firms production processes. WESTCAM started as a CAD/CAM software vendor but has its focus now in the development of software solutions for production processes; the remaining organisation is the worldwide diesel-engine competence centre of German BMW Group.

All of the interviewed companies seem to be highly specialised. The global market share and the origin of main competitors can be used as a proxy for the specialisation of the firms. As Table 1a indicates, at least four companies – AT&S, FRONIUS, TRIDONIC and TROTEC – were able to quantify their global position in terms of market shares. ADCON and FEMTOLASERS are firms with a leading position in currently small niche markets, FACC is still on the move from standard technology to highly technologically advanced products and WESTCAM has recently proven its competence in a particular field by developing software solutions (used in medical equipment) which much larger competitors had failed to provide.

The source of main competitors is not only a useful indicator for the extent to which companies are exposed to international or global competition; it could be argued, that geographical distance to main competitors is in many cases also associated with a high degree of specialisation. As Table 1a shows, the interviewed companies do not face much competition from domestic competitors and even though Europe is the most important overseas market, for the vast majority of sample companies, the number of European competitors is limited to a few.

Table 1a: Fields of activities and competitive environment				
Company	AT&S	FACC	FRONIUS	TRIDONIC
Industry	Electronic components	Plastics	Machinery and equipment	Electronic components
Main products	Printed circuit boards with focus on telecom. & automotive applications	Fibre reinforced lightweight systems for the aviation industry	Welding technology and solar electronics	Magnetic and electronic lighting components such as ballasts, chokes, ignitors and transformers
Market share, specialisation	Global market share of about 10%; leading in Europe and No.3 worldwide	Highly specialised in several related fields	No. 5 globally (market share of about 3.5 %) and leading in Europe (about 12%)	Amongst the three leading European companies and No. 5 globally
Source of main competitors	Three main competitors which are based in Finland Taiwan and Japan	Global competition within the supplier networks of major aircraft manufacturers	Two European (Finland, Sweden), two Japanese and two American competitors	Two European Competitors (Germany, The Netherlands) and several in Asia and USA
Company	ADCON	FEMTOLASERS	TROTEC	WESTCAM
Industry	Communication hard- and software	Electronics	Machinery and equipment	IT services and software
Main products	Wireless telemetric and tele-monitoring applications (e.g. in agriculture)	Ultra-fast laser sources, amplifiers and measurement systems	Laser-based marking systems and laser engraving systems	IT-solutions for 3D-construction and process automation (applied e.g. in automotive and medical)
Market share, specialisation	Highly specialised	Highly specialised	Global market share of about 10-15%; highly specialised	Highly specialised
Source of main competitors	Main competitors in USA	Only a few competitors, all of them located in the USA	Two competitors in USA and one in Taiwan	Fragmented market with competitors in Europe and US

Size and growth

As the innovation literature suggests firm size is a relevant factor for the extent of industrial R&D activities. Both in terms of employment and with respect to turnover, the sample companies differ widely (see Table 1b). AT&S, FACC, FRONIUS and TRIDONIC are large firms, while the others – ADCON, FEMTOLASERS, TROTEC and WESTCAM – are SMEs[6]). Nevertheless, the number of production sites is small for all sample firms.

In addition to firm size at a specific moment, both the recent past and the medium-term growth prospects might be relevant for the discussion of a firms innovation efforts; experience of growth and growth prospects could influence the R&D strategy significantly. During the last 4-5 years, the sample companies showed remarkable growth in their annual turnover (see Table 1b). With the exception of TRIDONIC and ADCON, organic growth has been the dominant feature of interviewed firms. For the

[6]) Two remarks should be made now: First, one of the small companies, TROTEC, is a spin-off of a large Austrian firm, TRODAT. Second, we do not discuss figures for the Austrian BMW group as a whole, because we interviewed its diesel-engine competence centre which surprisingly has only weak links to the manufacturing parts of the Austrian group regarding innovation strategy.

majority of sample companies, at least within the next five years significant growth can be expected. This holds even for AT&S and FACC, two companies which currently face lower demand for their products.

Table 1b: Size and growth				
Company	AT&S	FACC	FRONIUS	TRIDONIC
Employment	~2 700	~650	~1 200	~1 940
Sales (in million €)	~320	~100	~117	~290
Number and location of production sites	Austria (3) India (1) China (1)	Austria (2)	Austria (3) Czechia (1) Ukraine (1)	Austria (3) Australia (2), South Africa (1) Switzerland (1), UK (1)
Growth in the recent past	Since 1996 sales almost tripled	Since 1999 sales doubled	Since 1997 sales doubled	Since 1995 (partly due to takeovers) sales more than tripled
Current growth situation	Consolidation	Consolidation	Continuous growth	Continuous Growth
Medium-term prospects	Annual growth of 10-20%	Growth from 2004 onwards	Annual growth of about 10%	Annual growth of about 5%
Company	ADCON	FEMTOLASERS	TROTEC	WESTCAM
Employment	~120	~20	~25	~40
Sales (in million €)	~16	~3	~8.5	~4.7
Number and location of production sites	Austria (1) France (1), Rumania (1) Netherlands (1), USA (1)	Austria (1)	Austria (1)	Austria (3)
Growth in the recent past	Since 1999 sales approximately doubled	Very strong; sales in 1997 only ~ 0.6m €	Very strong; sales in 1998 < 2m €	Since 1998 sales doubled
Current growth situation	Strong growth	Continuous growth	Continuous growth	Continuous growth
Medium-term prospects	Strong growth	Within 3 years doubling	Annual growth of 20-25%	Within 3-4 years doubling

Internationalisation

It is common to the sample companies that they are highly export-oriented (see Table 1c) as this has been one of the selection criteria. With the exception of WESTCAM, the export ratios vary from about 80 per cent to 100 per cent of sales. For all companies, the European Union is by far the most important overseas market and four companies – AT&S, FACC, ADCON and FEMTOLASERS – have significant North American and Asian-Pacific export markets.

Indicators such as source of main competitors (Table 1a) and importance of geographically distant markets (Table 1c) show, that a high degree of internationalisation is a common feature in the sample: All firms face global competition and most of them produce for global markets, while only for one firm the domestic

market plays an dominant role. However, internationalisation is limited with respect to production and R&D. The main share of production is still carried out in Austria (see Table 1b and Table 1c). Similarly, with the exceptions of TRIDONIC and ADCON, all companies have located their research facilities in Austria. Both TRIDONIC as well as ADCON have recently acquired several firms, which had already substantial overseas research facilities in place. Both companies have reorganised R&D in a decentralised manner according to the specialisation of sites. TRIDONIC, for example, is forming several R&D "Centres-of-Competence" outside Austria, which are linked up with specific production facilities.

Table 1c: Internationalisation of production and sales

Company	AT&S	FACC	FRONIUS	TRIDONIC
Production	Austria; increasingly Asia	Austria	Austria; some Eastern Europe	Austria, Australia, South Africa, Switzerland, UK
Markets	Austria negligible Europe (~80%) North America (~10%) Asia (~10%)	EU (~50%) North America (~50%)	Austria (~20%) EU (>65%)	Austria negligible Europe (>70%)
Company	**ADCON**	**FEMTOLASERS**	**TROTEC**	**WESTCAM**
Production	Focus on Europe	Austria	Austria	Austria
Markets	Austria negligible Western Europe (~ 40%) North America (< 40%) Lat. Am., AUS (~ 8% each)	Austria (< 10%) EU (~ 60%) North America (~15%) Asia (~15%)	Austria (<5%)	Austria (~ 50%) Germany (~ 35%) Italy and Switzerland

Obviousely, the strategic decision whether or not to set up R&D locations outside the home country depends on several factors. It seems that even in case of a substantial foreign customer base and the necessity of frequent interaction with major customers (e.g. FACC) a centralized approach still appears to be advantageous in many cases. This is particularly true for smaller firms which usually consider the concentration of internal R&D efforts in one location as the only viable or at least the most promising route. Furthermore, as mentioned above, it matters whether a firm tends to rely on organic growth or growth by acquisition; the latter requires a strategic decision about centralization or decentralization of R&D. Both observations deserve to be taken into account when it comes to formulate innovation policies: On the one hand, at least the smaller firms are heavily dependent on the quality of their domestic innovation system and seem to have "no international option"; on the other hand, the scope for affecting foreign firms' decisions on R&D locations is limited to larger ones.

The sample companies' R&D efforts

Although the sample companies differ in many ways, some structural commonalities remain. Most importantly, in the recent past, all companies have seen both high sales

growth rates as well as an increase of R&D expenditures. In order to explore the strategic reasoning behind increased research efforts on the firm level, the interviews addressed numerous issues, in particular the level and structure of R&D activities as well as the role of external knowledge sources and partnerships. From a theoretical point of view, it is clear that improving the availability of financial resources (via public support) is only one factor among others driving R&D investments.

Growing R&D intensity?

Recent empirical evidence suggests that – as part of a development towards a Knowledge-Based Economy or a New Economy – R&D intensity of products and services is accelerating[7]). As Table 2a indicates, most of the sample companies show relatively high levels of R&D activities if measures such as R&D to sales ratio or R&D personnel are employed. Moreover, internal R&D personnel – a common proxy of the R&D resources available to the firm –, shows significant growth over the recent past for most of the companies in the sample.

Table 2a: Level of R&D activities

Company	AT&S	FACC	FRONIUS	TRIDONIC
Current R&D to sales ratio	~ 2-3%	~ 8%	~ 7%	~ 10%
Internal R&D personnel	20	55	~ 100	~ 120
Stability of R&D expenses	Further increase of R&D efforts despite of currently declining sales expected	Increase expected with R&D to sales ratio target of 8-12%	R&D to sales ratio only 3.5% by end of 80s; stable at about 7%	Increase in the past and stability at current level expected
Company	ADCON	FEMTOLASERS	TROTEC	WESTCAM
Current R&D to sales ratio	~ 22%	~15%	~ 12%	~ 14%
Internal R&D personnel	42	4	5	5
Stability of R&D expenses	Remaining at high level	R&D expenses should still grow in line with sales	Continuous growth of R&D in the past and some further increase expected	Stable R&D expenses but R&D-personnel increasing

In two of the larger companies, FACC and FRONIUS, the number of developers has seen substantial growth. FRONIUS, for example, increased its R&D staff from 3 in 1981 to about 100 in 2002. The interesting question then is, what factors might be responsible for levels, which are seemingly higher than industry average.

On the level of the individual firm several hardly distinguishable factors might explain the recent increases of R&D efforts. Janssens – Suetens (2001) distinguish in a

[7]) See e.g. *OECD* (1996, 2000, 2002a) and *Knoll* (2001).

qualitative study between company, market and government related parameters as candidates for determining decisions on R&D investment within a firm. Our sample companies indicate that some parameters might be important under very particular circumstances. However, it can become rather difficult to evaluate the importance of internal parameters (e.g. strategy) and external parameters (e.g. environment) as examples indicate:

- A vision-led strategy. As a result of the reorganisation of Fischer in 1989, FACC started as a relatively autonomous subsidiary with about 70 employees, which had already some experience in the manufacture of aircraft interiors. The company was a typical build-to-print supplier with a low technological profile. A stimulating environment in combination with an ambitious strategy has brought the company forward. Build-to-print is increasingly being replaced by FACC-designed products and the goal to develop and integrate key components in complete systems is within reach. Co-operation with several firms, which participate in the Upper Austrian Plastics Cluster, enabled a technological breakthrough which allows replacing a classic metal centre fitting for mounting aircraft spoilers with a composite component.
- Trends in a specific industry. Electronic component suppliers, such as printed circuit board manufacturer AT&S, might benefit from an outsourcing trend within their industry. Original electronic manufacturers, increasingly transfer responsibilities for the design of new products to their suppliers. The development of innovative components such as circuit boards which integrate additional functionalities offers opportunities to improve the company's position along the value chain. Similarly, ADCON increasingly benefits from the development of customized components / products such as radio units, which are integrated into products of original equipment manufacturers or value added resellers. Both companies have responded to an outsourcing trend in their industry by increasing their own innovation efforts.
- Diversification into new fields. Innovative diversification efforts targeting at fields – not only new to the company but also to the market – require a substantial extension of a company's technological capabilities. Both TROTEC and FRONIUS are good examples. The main difference concerns organisational boundaries (TROTEC being a subsidiary of a diversifying parent company, while FRONIUS opened a solar electronics division inside the organisation). The increase of internal problem-solving capacities is – in the case of FRONIUS's diversification effort – directly reflected in the research personnel: A solar project was started in 1992 a separate unit with 3 developers was created in 1997 and 30 employees – 14 of them R&D staff – form a division now. There are good reasons to generalize the diversification issue to a shift of a firms organizational boundaries including vertical integration. If firms perform the activities of former suppliers (integrating vertically backward) or those previously performed by customers (integrating vertically forward) specific R&D capabilities are required.

Nevertheless, several explanations for an increase of firm-internal development efforts might hold in a specific case. Some of them are interlinked. For example, the firms' strategic decisions can hardly be separated or isolated from their external environment; any strategic response makes only sense in the context of the firms' environment. Against the general background of interviewed companies one might also get the impression, that waiting to see what the leaders in the industry do and then copying them is no feasible strategic option for most of the interviewed companies but might be for others.

The questionnaire itself includes additional information, which might be useful in the context of clarifying the determinants of increased R&D intensity within the firms. Several candidates of factors which on occasion may be directly linked to the level of internal development efforts have been mentioned during the interviews. Some of them are of technical nature and product-related (e.g. miniaturization), others point at the relationship with customers and suppliers. FACC and AT&S, for example, are suppliers to very demanding, international industrial customers (aviation industry, telecommunications equipment suppliers).

Responses to the question of how R&D expenses developed in the past and how they will develop in the future indicate continuous growth of R&D to sales ratios up to a provisional target, which is laid down in the firms' R&D strategy. The perceived stage of a firm's own development – its perspectives for picking up the fruits and making commercial use of its research – clearly matters. Most of the interviewees were rather convinced, that the future of their company can only be secured if high levels of R&D were maintained. External factors, such as a downturn of the business cycle and temporarily lower demand for their products would despite of potential cost-cutting exercises not necessarily reduce the level of R&D investments. It is perhaps a bias towards technology-intensive companies in the sample which manifests in this opinion.

Table 2b: Product development time and product life time

Company	AT&S	FACC	FRONIUS	TRIDONIC
Average product development time	1-2 years	2-3 years	~ 2 years	1.5-2.5 years
Average product life time	~ 3 years	Up to about 10 years	4 to 8 years	3-4 years
Company	ADCON	FEMTOLASERS	TROTEC	WESTCAM
Average product development time	1-3 years	1-2 years	~ 2 years	1-1.5 years
Average product life time	~ 8 years	~ 3 years	3-4 years	~ 5 years

Product life time and time-to-market is another issue which deserves to be mentioned in the context of growing research-intensity. Both the literature as well as some of the interviewees' remarks point at shorter periods available for developing new products and shorter product life cycles. However, quantification is difficult and the indication

given by the interviewees can only provide a rough guideline. Both within as well as across firms the indicators vary widely, because of variety as well as type of products on offer (see Table 2b). While it is clear from a theoretical point of view that changes of these parameters influence the firms' research efforts and reverse, it seems difficult to develop accurate and practicable means of measurement (which could be used in a questionnaire). However, during the interviews, it became clear that companies actively seek for practices which keep development efforts at practicable levels despite of shorter product life times. Co-operation is probably the most important one.

Generally, characteristics of products and markets have great influence on the formulation of R&D strategies. R&D strategy is – for the vast majority of interviewees – tied very closely to overall goals of the company, in particular to the future product portfolio. Especially the larger firms have developed strategic plans based on product road maps, which are often long range (up to 10 or even 12 years) and under constant review. The R&D agenda is then divided into two types of projects: Product platforms (or product families) relevant for longer periods and variants to be developed in the short term.

Interviewees considered the timing of introducing new products one of the driving forces of their company's R&D strategy. Consequently, they were also asked about the distribution of R&D efforts with respect to the time horizon for commercial exploitation. As Table 2c indicates, the sample companies show a considerable variation. Average product life time in an industry sets an absolute time limit to much of the development efforts. Nevertheless, strategic choices do exist and some companies report recent efforts to organise R&D projects in a more efficient way. Beside the criteria and mechanisms of project selection, average project length is one of the critical parameters of success. However, in particular for smaller companies, there are limits to a reduction of project length, because this would usually require, that more resources – both human and financial – are devoted to the project teams. Only one company, FACC, reported a significant shift in the structure of R&D activities in the recent past and for the immediate future. The change is a result of moving from the developing end of R&D to research.

While most interviewees reported that long-term research is confined to a smaller share of activities (e.g. developing future product platforms, occasional entry into completely new fields), only two companies have a share of long-term research clearly above 5-10 per cent: In the case of ADCON, specific characteristics of product development are responsible for this and FEMTOLASERS is a typical science-based firm which still devotes a high share of its R&D expenses into more fundamental research. Basic or fundamental research is usually not carried out by the smaller firms themselves but outsourced or conducted in co-operation with external partners. The larger firms in the sample feel a need to become more involved in basic research. However, for them, instead of extending internal capacities significantly, partnerships with research organisations and universities seem to be the most promising route.

Table 2c: Time horizon for commercial exploitation of R&D efforts (actual share)				
Company	AT&S	FACC	FRONIUS	TRIDONIC
Within 1 year	~60 %	< 30 %	~20 %	~25 %
2-3 years	~30 %	~ 66 %	~70 %	60-70%
Long-term	~10 %	< 5 %	~10 %	5-10%
Structural changes of time horizon	Stable	In the past short term used to dominate but is increasingly replaced by medium-term	Stable	Stable
Company	ADCON	FEMTOLASERS	TROTEC	WESTCAM
Within 1 year	< 10%	~10 %	> 10 %	~50 %
2-3 years	~ 60 %	~70 %	~80 %	~50 %
Long-term	~ 30 %	~20 %	< 10 %	
Structural changes of time horizon	Stable	Stable	Stable	Stable

Co-operation and external knowledge

Quite frequently, internal development and the internally available knowledge base have to be supplemented by knowledge from external sources. Recent literature on so-called “knowledge-based economies” has argued that access to knowledge generated outside an innovating organisation seems to be of growing importance[8]). Although building R&D capabilities internally, is still of utmost importance, the interviewed companies increasingly explore alternatives to internal development, where there is a need of instant access to knowledge or innovative capabilities needed are so different that the firm would have to develop them scratch.

For large firms, to acquire another firm has become a common tool in order to enter a new market, to increase production capacities (e.g. in low-cost countries), to improve their global position or to expand their technological capabilities. Unless the acquired firm is without any doubt technology-based, it is hard to evaluate and explain the reasoning which led to the final decision. Two of the large firms in the sample, AT&S and TRIDONIC, use acquisitions – at least to a limited extent – as a means of technological advancement in new areas. Over the years, TRIDONIC, for example, has acquired several companies and the number of researchers in its overseas subsidiaries already exceeds its R&D personnel employed in Austria. Furthermore, the company is founding partner of a development & production joint-venture, which significantly extends its existing technological capabilities in the field of LEDs.

Usually, due to financial constraints, the acquisition of another firm, that already has the desired capabilities, is a viable option for large firms only. ADCON is an example of a medium-sized company, which chose acquisition for widening its technological base:

[8]) See e.g. *Knoll* (2001).

In 1999, the acquisition of a French company paved the way for new applications of its data technology in products such as credit card terminals, wireless barcode reader systems as well as in building and household automation; last year, ADCON acquired a Dutch company in order to expand its technological reach in a new field. Listed companies, such as ADCON, can, though being smaller, overcome financial constraints, which SMEs with different ownership structure – in particular family ownership – have to face. Furthermore, it seems, that – even in large firms – family-ownership tends to favour strategies based on organic growth and internal development instead of acquisition.

While companies may rule out an extension of technological capabilities via acquisition for several reasons, it is common for all interviewed firms to enter co-operative ventures and partnerships in R&D in order to gain access to external sources of technological knowledge. In many cases co-operation is directly supported by project grants offered on different levels (EU Framework Programmes, national schemes and regional schemes). During the last five years or so, Austrian government initiatives increasingly address the creation of research networks, which goes beyond the usual support of ad hoc collaboration on the basis of single projects.

In addition to longer lasting close relationships to important suppliers and customers, seven out of nine interviewed organisations participate in government initiatives which were established in order to strengthen industry-science linkages. AT&S, FACC, FRONIUS, TRIDONIC, TROTEC and BMW are actively involved in one of the 'Centre-of-Competence Programmes' (K+, K-IND) and AT&S and FEMTOLASERS are co-founders of two 'CD-Labs'. Both CoCs as well as CD-Labs are intended as partnerships which are co-financed by industry and the government for a period of at least five years. Basically, the programmes differ with respect to scale and focus: CD-Labs are formed between a few partners (at least one university department + at least one industrial partner) while CoCs tend to have 20 or more participants; as opposed to CD-Labs, which concentrate on basic research and a scientific programme, the CoCs may devote the bulk of resources to industrial projects.

Public policies to support private R&D

It was a central task of this investigation to explore the value of innovation support policies as perceived by people responsible for R&D in an industrial environment. In a first step, interviewees were asked to evaluate policies aimed at assisting innovation by reducing the risk involved with R&D activities. We felt important to distinguish between two types of policies: Instruments, which reduce financial risks by lowering R&D costs, were separated from others, which do not necessarily affect the level of resources available to a firm and still reduce risk associated with failing projects. We chose instruments investigated in Fölzer (1992), modified them slightly and divided them into two groups.

The four instruments in the first group of policies provide an immediate financial contribution to researching firms and thereby permanently increase the resources available to the companies. As a result, they primarily lower the cost of corporate R&D activities and thereby reduce the associated financial risk. The selected schemes addressing R&D costs are:

- Tax incentive. In the recent past, several countries – including Austria – have introduced schemes by which R&D expenses lower the amount of corporate tax.
- Personnel subsidy. Some countries, such as Germany and the Netherlands, have tried with subsidies for the employment of R&D staff. In Austria, schemes developed so far have only subsidised the transfer of academic researchers to industry.
- Project grants. This is the most common instrument internationally and all interviewed firms have – at least once – successfully applied for this type of R&D supporting scheme.
- Project loans. As with project grants, R&D is supported with this type of schemes on the basis of projects. However, instead of a grant, the financial support is being reaped through below market interest rates for a loan.

The schemes were not specified in detail in advance. However, it was assumed for all four instruments that the financial support for carrying out a R&D project could be the same. Nevertheless, the level of support is very much dependent on the design of an instrument. As a result, most of the interviewees pointed at several design parameters which have the potential to substantially change their overall evaluation.

The four measures in the second group do not fully provide for a permanent increase of financial resources available to the companies. However, they are characterized by one commonality, the reduction of risk (schemes addressing R&D risks); their overall objective is risk sharing and not financial support in any case. By nature, these measures are most important when R&D work fails to come up with commercially useful results (reducing cost of failure), whereas in case of success the eventually granted support is refunded to the supporting investor in one form or the other. Instruments to be ranked by interviewees were as follows:

- Conditional loan. Companies receive loans for specific research activities, and only in the case of failure, a substantial proportion of the project costs does not have to be paid back.
- Loan guarantee. Again it is assumed, that an R&D project is not financed internally. The public support is granted by guaranteeing for a loan, just in case the researching company goes bust.
- Royalty grant. Substantial financial support is provided until R&D work is finished and the resulting product can be used within the company or launched on the

market. Over a longer period, the original support is refunded to the investor as a license fee.

- Stock option grant. This scheme differs from the royalty grant with respect to the mechanism of refunding and emulates venture capital. For a certain period, the investor has an option to become owner of the firm or of a joint venture to the extent of his financial contribution to the R&D project.

For the ranking process it was assumed, that it is the only purpose of the last four schemes to reduce risk, whereby the risk sharing organisation is not compensated for taking the risk by any fees. All four instruments resemble existing modes of financing R&D investments seen in the private sector. For example, a large private company might support its researching subsidiary by way of conditional loan or loan guarantee; similarly, an R&D performing company might have an agreement with a financial investor using one of the remaining modes. As with cost reducing schemes, comparability of risk reducing instruments is incomplete and, as a consequence, discussions with interviewees evolved.

The ranking started with a brief explanation of the proposed instruments, interviewees were asked to present their personal views about them and to rank their effectiveness in two different ways. One ranking used grades, with 1 being the best and 4 the worst grade (Likert scale). The other ranking was achieved by asking interviewees which of the instruments would be their first, second, third and forth choice. The second ranking proved useful, because some interviewees at first avoided differentiating between instruments in terms of grades. The two groups of instruments – cost reducing and risk reducing – were ranked separately. The resulting overall ranking is summarised in Table 3a and Table 3b.

Given the small size of the sample, the results of the ranking cannot be considered representative for any group of firms. However, the individual data can be interpreted against the background of the individual companies and the remarks made by interviewees during the ranking process.

Reducing R&D costs

Within the group of cost reducing measures, there is hardly any difference in opinion about the usefulness of tax incentives, personnel subsidies and project grants (see Table 3a). Each of these three instruments has its merits and as mentioned earlier, a detailed specification of schemes is likely to change the picture. Individual remarks covered several issues:

- Tax incentives: During the interviews, it was assumed that relevant schemes use corporate taxation and the level of support depends on the beneficiary's profitability. As a result, permanently – or at least currently – highly profitable firms would prefer these measures, while others considered the same fact a disadvantage. Several firms agreed that a lower level of taxation would strengthen the resources available to a firm and therefore also induce higher

R&D budgets, whereas one interviewee categorized this kind of support as 'nice-to-have but not necessarily stimulating'. Moreover, another interviewee considered taxation the easiest way to increase public support for industrial R&D and as opposed to project grants a much higher number of firms would benefit from this scheme.

- Personnel subsidy: Subsidies for the employment of R&D staff were unanimously welcomed by all interview partners. On the one hand, this type of measures is directly linked to the overall internal research capacity of a firm and is therefore considered very effective by most interviewees. On the other hand, the vast majority of interviewed firms can be classified as research-intensive and some of the companies intend to even increase the number of researchers in the near future; consequently, most of the interviewed firms would benefit from an extension of this instrument.

- Project grant and project loan: All the interviewed firms successfully participated in schemes based on project grants or loans. Their overall experience seems to be very good and at least those who consider their ideas technologically advanced prefer this support mechanism to any other. For the vast majority of interviewees administrative hurdles were no issue. While one interviewee reported that efforts to get a project proposal through can be demanding and – as opposed to tax incentives or personnel subsidies – there is always a risk to miss the support, others did not observe any difficulties for themselves. Nevertheless, some interviewees agreed that other firms without much experience in project management could fail during the application procedures, which in turn reduces the overall number of firms to be supported by this type of measures. Only one interviewee observed that a grant might increase the chance of getting a project through the company's hierarchy.

Table 3a: Schemes addressing R&D costs				
Ranking by grades [no. of companies]				
	(1) + +	(2) +	(3) -	(4) - -
Tax incentive	3	4	1	1
Personnel subsidy	4	5	0	0
Project grant	6	3	0	0
Project loan	1	5	3	0
Ranking directly [no. of companies]				
	1st	2nd	3rd	4th
Tax incentive	3	3	2	1
Personnel subsidy	2	5	1	1
Project grant	4	1	4	0
Project loan	0	0	2	7

In the ranking process, problems occurred, because of the complexity of design parameters and the incomplete specification of instruments. It seems that responses are sensitive to several assumptions made by the interviewer or the interviewee:

- During the interviews it proofed hard, to ascertain interviewees that each proposed instrument would have the same potential in terms of financial benefit; doubts about the potential extent of support might be the main reason, why project loans have not been regarded as useful as the three other instruments.
- Individual experiences with already existing measures might bias the ranking. For example, all interviewed firms have participated in project grant programmes, and most of them rather successfully. What about firms which failed?
- For existing instruments such as tax incentives and project grants, many interviewees might have an order of magnitude of support in mind when speaking about the value of an instrument (e.g., tax saving of 5-10% of overall R&D expenses versus grants covering 15-25% of individual project cost).
- The ranking might become a difficult task, because the base of support differs across instruments; e.g., tax saving might be based on overall R&D expenses covering all activities, while the project grant is only given for a particular effort. Consequently, the response then depends on the extent to which R&D can be packed into projects eligible for public support. If respondents have the feeling, that the bulk of their R&D work does not meet the criteria of project selection (for example, technologically advanced projects only) both the tax incentive and the personnel subsidy offer higher returns.

For interpreting the exceptional high number of interviewees favouring personnel subsidy, at least two aspects have to be accounted for. First, the proposed scheme avoids surprises and eventualities which could occur with other measures; it is clear, that neither a company's profitability nor the decisions of potentially supporting organisations will influence the level of support. Second, the measure is directly linked with a firm's internal research capacity. If – and this is seemingly one of the most important goals for the interviewed companies – innovative capabilities should be improved by building up new research teams and extending their number of researchers, this kind of instruments could prove valuable. At the same time, R&D subsidies might help to stabilize and secure already existing human resources in the R&D department, even though the profitability of a firm is endangered by external factors (e.g. a downturn of the business cycle). Besides all that, the instrument could impact positively research mangers' or research directors' span of control.

Reducing the risks of R&D

As opposed to the evaluation of cost reducing R&D support, the ranking of risk reducing instruments indicates a clearer picture in terms of winners and losers (see Table 3b); furthermore, most interviewees showed a much higher willingness to grade disliked measures down. Several reasons can be thought of, why for all instruments –

with the exception of conditional loans – popularity was rather low (e.g., insecure benefit, unwillingness to accept a change in the ownership structure, interviewees not familiar with these instruments).

Table 3b: Schemes addressing R&D risks				
Ranking by grades [no. of companies]				
	(1) +	(2) +	(3) -	(4) - -
Conditional loan	4	4	1	0
Loan guarantee	0	1	4	4
Royalty grant	1	4	2	2
Stock option grant	1	0	2	6
Schemes addressing R&D risks [no. of companies]				
	1st	2nd	3rd	4th
Conditional loan	7	2	0	0
Loan guarantee	0	3	5	1
Royalty grant	2	3	4	0
Stock option grant	0	1	0	8

For the vast majority of interviewees, the conditional loan is the absolute favourite within this group of policies and has been considered the best measure to reduce the risks of researching companies. It allows to – as one interviewee put it – "test the limits" and might be useful for "very large projects" which could then even be carried out by smaller firms. As opposed to this, most interviewees did not consider loan guarantees a practicable risk-reducing option for their own company, although some respondents conceded, that in particular smaller firms as, e.g. start-ups, might benefit from this measure; this seemed to be the only reason, why only one respondent considered loan guarantees attractive.

In the ranking, the royalty grant is placed second amongst the risk reducing measures. Five companies considered it to be an effective instrument. The major question for interviewees was a rather technical one: Is the license fee (to be paid after the project has proven successful) limited to the level of original investment and how can it be determined? Other interviewees considered the instrument to function as a substitute for conditional loans or existing license agreements between firms.

Amongst the four schemes addressing R&D risks, stock option grants had the by far worst performance. During the interviews, the reasoning became rather clear: The vast majority of interviewees were convinced that the envisaged change of ownership structure would not be compatible with their company's goals. While for most of the respondents, the royalty scheme would still be feasible, a change of ownership would be an absolutely inappropriate measure from their company's point of view. However, due to its functional similarity with venture capital the scheme has been considered potentially useful for other firms – in particular start-ups.

Improving the research infrastructure

Public policies to support industrial R&D traditionally rely both on direct support via the funding of business-performed R&D (e.g. through grants, procurement and fiscal incentives) as well as on indirect support via a country's research infrastructure (in particular public laboratories and universities). This publicly provided infrastructure supports private research activities basically in two ways:

- On the one hand, the (public) researching organisations complement internal efforts of the enterprises by providing access to specialised knowledge, which may be generated and transferred ad hoc or in a longer lasting partnerships.
- On the other hand, it is the training of scientists and engineers in universities and other institutions of the education sector (e.g. polytechnics, technical high schools) which improves the human capital industrial R&D facilities require.

One question directly addressed the research infrastructure and its importance for researching firms: "How important is financial support when compared to a country's research infrastructure (including competent research institutes, trained research staff, human resources in general, etc.)?"

The responses to this question indicated, that public funding for R&D, though considered important, can only be an element of policies supporting industrial innovation. With the exception of one, all interviewees highlighted the importance of having good access to educated and trained researchers and developers. Differences in opinion occurred with respect to the most relevant qualification segment (technical upper-secondary, polytechnics, universities); some firms are more concerned with the medium-segment of developers and researchers while others feel a particular need for highly specialised scientists; e.g. three interviewees indicated, that Austria should step further building up a "research elite" consisting of internationally renowned scientists. The structure of the interviewed firms' current R&D personnel does not necessarily reflect their needs for the future, while – at least for some of the larger firms – developments over the past suggests tremendous improvements of human capital in terms of both quantity as well as quality.

Though not considered as important as qualification, the existence of domestic – and in two cases even local – public research facilities (specialised university institutes, public research centres) has been highlighted. Despite of some companies' international orientation and subsequent needs for (highly-specialised) international research partners, the majority of interviewees considered the availability of national partners a particular advantage for their own research activities. In this point, two interviewees would disagree nevertheless acknowledge that national public research facilities in Austria take a pivotal role at least in basic research, which is neglected by many private firms.

When finally asked, which measures should be taken in order to increase the level of R&D activities in Austria substantially, the majority of interviewees pointed out that one

or two of their most favoured measures (tax incentives, personnel subsidy, project grants) would be key: Tax incentives were considered the best way to increase the number of researching firms and funding organisations such as FFF and FWF should extend their activities because they offer substantial support for risky “key projects”; personnel subsidies might be a new measure addressing the needs of research-intensive firms without any delay (caused e.g. in the decision making). However, several remarks made clear that a policy mix would be necessary because each of the instruments would serve particular needs of companies.

In addition to these answers – which would hardly cause surprise – two interviewees mentioned the importance of awareness for innovation both in the business community and in the general public. Another interviewee pointed out that the financial burden of international patenting is substantial and further improvement of public support could be valuable for smaller firms. However, as opposed to cost reducing measures, risk reducing schemes were not mentioned by any of the interviewees. Additional public support for the own company as well as for other researching firms was considered a – at least important – stimulus for improving the Austrian research landscape.

Concluding remarks

Interviewing a sample of nine Austrian manufacturing firms, this paper sought to explore two central issues: changing patterns of business R&D, on the one hand, and the companies' perception of innovation support policies, on the other. Based on previously collected company information semi-structured face-to-face interviews were carried out in the period between May 14th and July 2nd 2002. While small size of the sample and the selection of companies prevent from generalisation, the study may be considered a case study, delivering qualitative findings, which might be useful for further investigations into the subject.

The interviews enabled us to have a closer look at the companies themselves as well as at their business environment. All sample companies can be considered highly specialised technology-based firms which face competition mostly from international competitors. During the last 4-5 years, the sample companies showed remarkable growth and for the majority of them, at least within the next five years significant growth can be expected. Even for the larger firms, the number of production sites is small and although all firms are highly export-oriented the main share of production is still carried out in Austria. Internationalisation is high in terms of relevance of overseas markets, but with two exceptions, all companies have located their research facilities in Austria pursuing a centralized approach. Consequently, it is a first lesson learned, that at least smaller firms are heavily dependent on the quality of their domestic innovation system and seem to have no international alternative.

When it comes to explaining a trend of growing R&D intensity, difficulties arise. The interviews indicate that some factors might be important under very particular circumstances and that it becomes hard to disentangle the web of external and internal parameters. For example, in some industries specialised suppliers respond to an outsourcing trend by increasing their own innovation efforts. Strategic response might also include the diversification into new fields, which in many cases requires a substantial increase of internal problem-solving capacities. Some factors are of technical nature and product-related (e.g. miniaturization, reduced product life cycles). For the vast majority of sample companies R&D strategies are tied very closely to overall goals of the company, in particular to the future product portfolio and the timing of introducing new products becomes a driving force of R&D investments irrespective of external factors such as a downturn of the business cycle and temporarily lower demand.

In the sample, the composition of R&D activities in terms of time horizon for commercial exploitation of R&D efforts is diverse but most interviewees reported low commitment to long-term research. The larger firms feel a need to become more involved in basic research and in general basic or fundamental research is outsourced or conducted in co-operation with external partners. The interviewees were well aware of a permanent need to gain access to external knowledge. For two of the large and one medium-sized firm the acquisition of another firm has become a common tool of technological advancement in new areas. However, in particular for smaller firms the

acquisition of another firm is – due to financial constraints – usually no viable option. Seven out of nine interviewed firms participate in government initiatives which were established to strengthen science-industry linkages.

In order to evaluate the appropriateness of innovation support policies the interviewees were asked to rank instruments which reduce costs (by lowering R&D costs) or risks (by reducing risk or risk sharing). In the ranking process, problems occurred, because of the complexity of the design parameters and an incomplete specification of instruments. The interviewees clearly preferred cost reducing schemes – in particular tax incentives, project grants and R&D personnel subsidies – to risk reducing measures such as conditional loans, loan guarantees, royalty grants and stock option grants. For the rejection of some of the latter, the current ownership structure was the most used argument. In a final general assessment, interviewees made clear that improving a country's research infrastructure (including research organisations and education) should play a crucial role when it comes to formulating public policies to support industrial R&D.

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