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Impact of government support on R&D and innovation

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Abstracts

This paper evaluates whether public support from innovation from the central government or the European Union spurs innovation in Austrian firms. The effect is estimated separately on R&D expenditures and the output side of innovation, measured by the share of total sales due to new or substantially modified products. A distinction is also made between products new to the firm and products new to the market. The analysis is based on the micro data from the third wave of Community Innovation Survey, CIS 3, covering the years 1998-2000. The effectiveness is estimated using a structural model explaining the determinants of various sources of government support and their effects on R&D and innovation output.

Receiving central government support increases the intensity of R&D by 2.3 percentage points. EU support is never significant once national support is taken into account. Central government support yields a 2.5 percentage point increase in the share of new to firm innovative sales. When new to market product innovations are considered, central government support leads to a total effect on the share of new to market innovative sales of 3.4 percentage points.

Keywords: government support, innovation surveys, Austria
JEL codes: H22, L52, O31

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Introduction.[1]

This paper tries to quantify the effect of public support for innovation on innovation inputs and outputs in Austria. The input side of innovation is measured by the intensity of R&D expenditures.[2] The output of innovation is measured by the share of total sales due to innovative products, i.e. new or substantially modified products. Moreover, the share in sales due to new products can relate to products new to the firm or new to the market. The former includes true innovations and imitations, the latter only true innovations. Both dimensions of novelty will be examined.

The goal is to evaluate how government intervention affects innovation, in other words to find out whether the firms that receive government support do better than those that do not get any public funding for innovation. The public support can be related to R&D expenditures as with the R&D tax credits, but they can also come to support other innovation activities like promoting new products and providing informational support for the introduction of new products. We cannot distinguish tax incentives from direct measures of government support. However, we can examine the relative effectiveness of national versus EU-originating public support.

The present analysis will be based on the microdata of the third wave of Community Innovation Surveys, CIS 3, covering the years 1998-2000. Micro data are much richer in informational content than macro data: they yield information on innovators and non-innovators and they are characterized by a substantial heterogeneity, not just across industries, but also across individual firms. Unfortunately, we have information on government support for innovation only for firms that declare in one way or another to be innovative according to the criteria defined in the Oslo Manual (OECD, 1992 and 1996). We do not correct for this potential selection bias, but instead

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[2] The Community Innovation Surveys contain information on a more wider definition of innovation inputs, namely the expenditures on innovation, which comprise intramural and extramural R&D, acquisition of machinery and equipment for the production of new goods, the costs of acquisition of patents, licenses, know-how, etc, of training for innovation, design, and market introduction of new products. Statisticians do not consider these responses very reliable and report many non-responses on this question. We therefore decided to only consider R&D expenditures as a measure of innovation inputs.

we condition the analysis on firms that are innovative. For those firms we want to know whether domestic or EU government support is more effective, for what type of innovation innovators, and in which way, directly or by stimulating R&D. In Austria tax incentives are only granted for eligible expenditures, i.e. those that are considered as valuable to the economy (see Hutschenreiter, 2002). Therefore we have to allow for the endogeneity of government support for innovation. We shall also allow for the endogeneity of R&D.

The rest of the paper is organized as follows. Section two presents the data and describes the relative importance of various funding sources for innovation in Austria. Section three introduces the econometric methods that we use to infer the impact of funding for innovation and the reasons for using these methods. Section four presents and discusses the results of the estimation and section five concludes.

2. Data

The analysis is based on the microdata of the third Community Innovation Survey (CIS3) in Austria, covering the years 1998-2000. The CIS survey collects information on innovation output and R&D and, at least for the firms that are innovative, it also asks respondents whether they received government support for innovation from local, regional, national and EU sources.

2.1 Frequency of innovation in Austria in 1998-2000

After a few identifying questions, respondents have to answer the following four central questions: (1) During the period 1998-2000, has your enterprise introduced on the market any new or substantially improved products? (2) During the period 1998-2000, has your enterprise introduced any new or substantially improved production process? (3) By the end of 2000, did your enterprise have any ongoing innovation activities? (4) During the period 1998-2000, did your enterprise have any innovation activities that were abandoned?

A first way to characterize innovators is to consider as innovators those that have responded “yes” to one of those four questions. This is in the spirit of the CIS survey, where those who have responded “no” to all four questions are considered as non-innovators and do not have to respond to most of the other questions in the survey. We have therefore only scant information about non-innovators, and therefore we restrict ourselves to innovators only. We can also be more precise and consider different types of innovators; are product innovators those who have responded affirmatively to the first question, process innovators those who have responded affirmatively to the second question, and potential innovators those who had either ongoing but unfinished innovation activities or those who were not successful in their innovation activities in the three year time-span. Moreover, among the product innovators, we can distinguish innovators with products new to the firm but not to the market, who can be assimilated to imitators, and those with products new to the market, who can be regarded as true innovators.

After some basic cleaning of the dataset,[3] we end up with 1287 observations, 42 percent of which declare themselves as innovators. Those will constitute our working sample. Among those, 77 percent are product innovators offering products new to the firm, and a lower fraction, 35 percent, have come up with products new to the market and 63 percent with new processes, 75 percent were unsuccessful or not yet successful innovators, and 12 percent had to abandon some innovation projects (see table 1). Of course, a firm may belong to various groups of innovators. Almost half of the Austrian innovators are both product and process innovators, and many successful innovators during the 1998-2000 period had ongoing innovation activities and may come up with new products or processes in the future. The focus in the remainder of the analysis will be on product innovators because only for those the CIS 3 dataset contains quantitative data on innovation.

[3] The original dataset has been cleaned by eliminating 18 firms, 3 of which report zero turnover or employment, 11 of which belong to the primary sector and to the industries with NACE codes 37 and 73 with an insufficient number of firms per industry, and 4 of which have an R&D over sales ratio greater then 48%, which are suspected to be firms specializing in R&D. Missing values for R&D and all explanatory variables such as sources of information or sources of government funding are set equal to zero.

Table 1. Distribution of innovator types in Austria, 1998-2000

	Number of observations	Percentages with respect to all firms	Percentages with respect to innovating firms
Total	1287	100%	
Innovators	546	42%	100%
New to firm product innovators	418	32%	77%
New to market product innovators	190	15%	35%
Process innovators	346	27%	63%
Ongoing innovation activities	409	32%	75%
Abandoned innovation activities	63	5%	12%

2.2 Distribution of various sources of government support for innovation

In the CIS 3 dataset, firms are asked about four sources of public support for innovation: from the local and regional government, from the central government, from the EU, and in particular from the EU 4th and 5th Framework Programmes for research and technological development (RTD). The central government, including agencies working for the central government, is the most often cited source of public support for innovation, followed by the local government, the EU and the Framework Programmes for RTD, be it for innovators, R&D performers, new to firm or new to market product innovators. Again a firm may receive various kinds of public support.

Table 2 Distribution of government support among innovators, Austria, 1998-2000

	All Innovators		**R&D Performers**		**New to Firm Product Innovators**		**New to Market Product Innovators**	
	Nb	Percent	Nb	Percent	Nb	Percent	Nb	Percent
Local Government funding	113	20.7	78	25.8	89	21.3	56	29.5
Central Gov't funding	172	31.5	150	49.7	145	34.7	91	47.9
EU funding	64	11.7	51	16.9	51	12.2	32	16.8
4th or 5th RTD Framework	46	8.4	40	13.2	39	9.3	22	11.6

A comparison of the sources of funding among all innovators, R&D performers and the two types of product innovators reveals that the R&D performers are more likely to get support for innovation than all innovators together (see table 2). Support for innovation is thus more concentrated on the input side than on the output side of innovation. It is also noticeable that new to market product innovators are more likely to receive public support of some kind than new to firm product innovators.

3. Methodology

The question is whether government support for innovation from its various sources affects innovation activity. Are firms that receive government support more innovative than those that receive no government support? Is government support more effective for certain types of innovation? In particular, does government intervention affect the input and/or the output side of innovation? Is there a noticeable difference in the effectiveness of national versus EU support for innovation? Those are the questions we shall address.

3.1 Econometric model

It is not sufficient to compare the means of the respective variables for supported and non-supported firms. We must control for other variables that may have varied and affected the innovation activity variables. Moreover, the support variables themselves can be endogenous, that is, there might be a systematic attribution of government funding for innovation related to such things as firm size, past success and promise of future success as revealed by the patent portfolio.

Since in the CIS 3 questionnaire only innovators are asked about sources of government funding, we can only compare the means of innovation among innovators of a certain type. This leaves us with too few observations to proceed to a matching estimator where each firm receiving support is matched to a similar firm receiving no support, where similarity is defined by variables like size, network or industry affiliation (for examples of this approach in a similar context, see Aerts and Czarnitzki, 2004, Czarnitzki, Hanel and Rosa (2004), Czarnitzki and Licht, 2006, and Bérubé and Mohnen, 2009). We therefore turn to a structural modeling of the endogeneity of innovation and of public support for it.

A model is set up where government support, R&D and innovative sales are all three endogenous. More precisely, the model is composed of four equations. The first two explain the determinants of government support for innovation. Two sources of support are considered: those emanating from the central government and those emanating from the European Union. The results were rather similar when we aggregated central and local government support and when we included support from the 4th and 5th Framework Programmes in the EU support.[4] As modeled in González, Jaumandreu and Pazó (2005), firms form expectations about government funding for innovation from domestic and EU sources. These expectations (through latent variables) then enter the R&D and innovation output equations. The third equation relates to the determinants of (intramural and extramural) R&D. Since not all firms are R&D performers, we could have a selection bias if we only considered firms that perform R&D. In fact, we have a concentration of data with zero R&D. To correct for selectivity, we use a tobit model which explains simultaneously the R&D intensity for R&D-performing firms and the fact that there are some non-R&D performing enterprises for which the latent variable falls below a critical threshold. The fourth equation pertains to innovation output. The focus is on product innovations for which the dataset provides both qualitative and quantitative information, as opposed to process innovation for which there is no quantitative measure in the dataset. Since we have both (product) innovators and non-(product) innovators, we have again a tobit model with a latent variable that is equal to the observed intensity of innovation for innovators and which falls below the innovation threshold for non-innovators. We have two models, one in which the innovation output is composed of products new to the firm (corresponding to imitators and true innovators) and one in which it is composed of products new to the market (characterizing true innovators). The latent variable for R&D enters the latent variable for innovation. The more firms spend on R&D, the higher their chance of coming up with a new product. Government support for innovation can thus affect innovation output directly, or indirectly by stimulating R&D.

[4] The CIS 3 dataset for Austria is too small for analyzing separately the four sources of government support contained in the CIS 3 questionnaire.

Formally, the model is a follows:

$$g_{dom} = 1 \quad \text{if} \quad g^{*}_{dom} = \alpha_1 z_1 + \varepsilon_1 > 0 \qquad (1)$$
$$= 0 \quad \text{otherwise}$$

$$g_{EU} = 1 \quad \text{if} \quad g^{*}_{EU} = \alpha_2 z_2 + \varepsilon_2 > 0 \qquad (2)$$
$$= 0 \text{ otherwise}$$

$$R\&D = 0 \quad \text{if} \quad R\&D^{*} = \beta_{r1} z_3 + \beta_{r2} g^{*}_{dom} + \beta_{r3} g^{*}_{EU} + \varepsilon_r \leq 0 \qquad (3)$$
$$= R\&D^{*} \text{ if } R\&D^{*} > 0$$

$$inno = 0 \quad \text{if} \quad inno^{*} = \beta_{i1} z_4 + \beta_{i2} g^{*}_{dom} + \beta_{i3} g^{*}_{EU} + (\beta_{i4} R\&D^{*}) + \varepsilon_i \leq 0 \qquad (4)$$
$$= inno^{*} \quad \text{if } inno^{*} > 0$$

where

ε_1, ε_2, ε_r, ε_i are normally distributed error terms with zero means and resp.
1, 1, σ_r and σ_i standard deviations,
z_1, z_2, z_3, and z_4 are control variables,
g_{dom} and g_{EU} are dummies for the presence of resp. domestic and EU government support for innovation,
$R\&D$ = R&D/sales ratio,
$inno$ = share in sales due to new products.

We are in the presence of a system of simultaneous equations with limited dependent variables as in Crépon, Duguet and Mairesse (1998). The government funding variables are dichotomous variables, and the R&D and innovation intensities are censored variables. The econometric model is estimated by using the method of asymptotic least squares (also known as the minimum distance estimator). In a first stage, the reduced form equations of the model are estimated consistently by running a probit on the two sources of government funding, and a simple tobit model for the R&D and innovation output equations. In the second stage (if there are overidentifying restrictions) the parameters of the structural form are estimated by minimizing the distances between the estimated reduced form parameters and those predicted by the model from the identifying constraints, weighted by the estimated variance-covariance matrix of the reduced form parameters (see Gouriéroux, Montfort, Trognon, 1985). Identification is generally assured by way of exclusion restrictions. Asymptotic least squares yield convergent and asymptotically normal estimates. Endogeneity and selectivity are explicitly taken into account in the estimation of the model. As opposed to Heckman's selection models, we do not allow for correlations between the error terms of the selection and outcome equations, but we estimate a probability of receiving government support for every firm in the working sample (for examples of sample selection models in this context, see Busom, 2000, and Hussinger, 2008). We do not, unlike Hussinger (2008), have data on the actual amount of subsidies. A analysis similar to ours in a somewhat different context is given by Arvanitis, Hollenstein and Lenz (2002).

Firms that have not introduced a product, or a process, and that have no unfinished or abandoned innovation activities are asked to respond to only a few identifying questions. Relevant information for trying to explain what makes a firm a candidate for government support, what makes it reach the threshold level for R&D or for innovation, and what determines the intensities of R&D and innovation, is only available for the 546 firms in the sample that are innovative in some way. We therefore run the analysis only on this subsample of innovating firms.

3.2 Control variables

In each equation, we control for a number of other determinants than the policy and innovation variables. The choice of the control variables in each equation is not a trivial one. To identify the parameters of the model we have to impose exclusion restrictions, i.e. exclude some explanatory variables in some of the equations in order to identify the other ones. The choice of exclusion restrictions is partly motivated on theoretical grounds (sources of information are more likely to determine innovation directly than through government support), and partly based on the significance of estimated coefficients. Non-significant coefficients might characterize bad instruments to identify other key parameters of the model.

The main variables and their role in the model are in order:

Industry Dummies:

The idea of using dummy variables is to account for some industry specific effects in each equation. Government might be more willing to foster certain industries, like biotechnology, because it is promising to invest in new technologies. There are not enough observations per NACE two-digit industry codes to control for each of the corresponding industries. We classify the industries into three industry clusters: the high-tech cluster (vehicles, chemicals, machinery, electrical products, plastics, telecommunication, computer services, engineering services, support auxiliary transport activities, and not elsewhere classified industries), the low-tech cluster (food, textiles, wood, non-metallic mineral products, basic metals, supplies, finance and transportation), and the wholesale industry, which is strongly represented in the sample.

Domestic Group:

Government might be less willing to intervene if firms belong to a group because it is expected that these firms benefit from group support.

Foreign Group:

According to the country where the head office is located we can distinguish domestic and foreign groups. Government might be even less willing to finance projects of subsidiaries of foreign companies because taxpayers' money is supposed to help fostering domestic firms. The group variables are dichotomous variables that appear only as determinants of financial support.

Size:

Bigger firms might innovate more and do more R&D. Government support may be more targeted to small and medium size enterprises but it might also be concentrated in big firms if government is too risk averse to finance R&D in small firms. Size is measured by the logarithm of the number of employees and enters as an explanatory variable in each equation.

Competition:

The more competition a firm faces, the more a helping hand might be considered to be a good policy. Competition is prevalent if the international market is perceived to be the predominant market. It may also be argued, however, that government considers the firms that operate on the international market not to be in need of additional government support.

Cooperation:

Government normally likes firms to collaborate at the research stage, especially with universities and research institutes, when it foots part of the research or innovation bill. Cooperation is a dichotomous variable directly borrowed from CIS 3. Competition and cooperation affect R&D and innovation only through government support.

Human Capital:

The higher the qualification of workers, the higher the capacity of the firm to be successful in the innovation process. Human capital is constructed as the ratio of the number of workers with higher education divided by the total number of workers in the firm. It enters as a determinant of R&D intensity.

Appropriability problems:

The capacity to appropriate the output of research, be it by patenting, by secrecy or other means, is regarded as a significant determinant of R&D (see Cohen and Levin (1989)). The presence of appropriability problems is proxied by the perceived importance of economic risk as an obstacle to innovation.

Financial difficulties:

Because of the market failure typical for information goods, innovators might have difficulties to find appropriate financing for their innovation. Financial difficulties are measured by the perceived difficulty of access to finance as an obstacle to innovation.

Demand pull:

Clients are often recognized as an important source of information to convey the demand needs in the market (see von Hippel (1988)). Since we concentrate on product innovations, it seems reasonable to expect information from clients to influence product innovations.

Science push:

The other possible source of information that we would like to control for derives from basic research at universities and public research institutions. Appropriability, access to finance, demand pull and science push are transformed from categorical to binary variables by associating a one to any positive response, and a zero to zero or missing responses. Human capital, appropriability problems, financial difficulties, and science push are considered to influence R&D intensity but not directly the share of sales due to new products, whereas demand pull is modeled as affecting the success of introducing new products on the market but not the R&D intensity.

Table 3 Descriptive statistics, Austria, 1998-2000, CIS 3, 546 innovators

Variable name	Mean	Std Dev
Hich-tech industries	0.291	0.455
Low-tech industries	0.504	0.500
Wholesale industry	0.205	0.404
Domestic group	0.447	0.498
Foreign group	0.198	0.399
Size (log nb of employees)	4.462	1.590
Competition	0.429	0.495
Human capital	0.052	0.085
Cooperation	0.236	0.425
Appropriability problems	0.756	0.430
Financial difficulties	0.643	0.480
Demand pull	0.788	0.409
Science push	0.463	0.499
Central government support	0.315	0.465
EU innovation support	0.117	0.322
National innovation support	0.375	0.485
Overall EU innovation support	0.137	0.345
Doing R&D	0.553	0.498
R&D over sales for R&D performers	0.028	0.060
Share in sales of new to firm products	0.258	0.252
Share in sales of new to market products	0.165	0.203

Table 3 presents some descriptive statistics. From the 546 innovative enterprises in our sample, 29.1 percent belong to the high-tech industry cluster, 50.4 percent belong to the low-tech industry cluster, and 20.5 percent to the wholesale trade sector. Almost half of the enterprises in our sample belong to an Austrian group and almost 20 percent to a foreign group; 42.9 percent consider the international market as their most important market, and are thus likely to face stiff competition; on average 5.2 percent of the employees have a vocational school or university degree; 23.6 percent declare that they cooperate to innovate; a large fraction declare to have difficulties with appropriability (75.6 percent) or with access to finance (46.3 percent). If we aggregate local and central government support, on the one hand, and EU and RTD support, on the other hand, we get percentages of supported firms not far away from the percentages that receive central government and EU support. Among the innovators 55.3 percent do some R&D with an average R&D intensity with respect to total sales of 2.8 percent. The product innovators with new to firm innovations have on average 25.8 percent of their total turnover accounted for by new products, and those among them with products new to the market 16.5 percent.

4. Results.

Table 4 contains the magnitude and the direction of the marginal effects of the explanatory variables on the probability to receive government support for innovation. When a firm shifts from a low-tech industry to a high-tech industry it increases its probability of getting government support. The chance of getting support from the central government is 11.1 percentage points higher in the high-tech than in the low-tech industries, only 3 percentage points higher for EU support. In Austria the wholesale trade sector is more likely to get support, be it from the national government or from the EU, than the low-tech sectors. Firms that belong to a group are less likely to get innovation support, probably because they are supposed to have access to resources emanating from the group. The central government is even more reticent to finance firms belonging to foreign groups, probably because taxpayers' money is deemed to help domestic and not foreign-owned firms. The national government prefers funding firms that are independent, that have a certain size, that operate mostly in foreign markets, that cooperate and that experience difficulties in financing their innovation. Firms that face international competition have a 15 percentage points higher probability to be funded by the central government. Enterprises which cooperate in innovation are more likely to get help from both national and EU sources. A one percent increase in size increases by 7.7 percentage points the probability of receiving central government support and by 4.6 percentage points the probability of receiving EU support for innovation. Support is more responsive to national than to EU sources. The last two columns show that there is not a great difference in the factors determining local and central government support or EU and RTD Framework Program support for innovation, but that there is some difference between national and EU support in general.

Table 4 Marginal effects of determinants of various domestic and EU support for innovation, Austria, 1998-2000, CIS 3, probit estimation

Explanatory variables	Support from central Government	Support from the European Union	Support from national sources (local or central Government)	Support from European Union and 4th or 5th RTD Framework Programmes
High-tech sectors	-0.513***	-0.389***	-0.470***	-0.408***
Low-tech sectors	-0.624***	-0.419***	-0.586***	-0.435***
Wholesale trade	-0.598***	-0.363***	-0.530***	-0.379***
Domestic group	-0.141***	-0.084***	-0.197***	-0.085***
Foreign group	-0.126***	-0.121***	-0.216***	-0.122***
Size	0.077***	0.046***	0.083***	0.048***
Competition	0.152***	-	0.180***	-
Cooperation	0.129***	0.113***	0.121***	0.111***
Financial difficulties	0.105***	-	0.117***	-

* significant at 10%, **significant at 5%, ***significant at 1%

Table 5 Marginal effects of determinants of new to firm product innovations, Austria, 1998-2000, CIS 3, ALS estimation

	Exogenous support		Endogenous support			
	R&D intensity	Share of Innovative sales	R&D intensity	Share of Innovative sales	R&D intensity	Share of Innovative sales
Central government support	0.010***		0.023***		0.023***	-0.004
EU support	0.004		0.000		-0.001	0.016
R&D		1.106***		1.097***		1.087**
High-tech industries	-0.008**	0.143***	0.022	0.150***	0.021*	0.187**
Low-tech industries	-0.017***	0.115***	0.015	0.123***	0.013	0.156**
Wholesale trade	-0.018***	0.080***	0.010	0.085***	0.009	0.113
Size	0.000	-0.010	-0.005***	-0.010	-0.005***	-0.013
Human capital	0.064***		0.130***		0.128***	
Appropriability problems	0.001		0.005		0.005	
Financial difficulties	0.003		-0.004		-0.004	
Science push	0.005***		0.011***		0.011***	
Demand pull		0.052***		0.050**		0.053**

* significant at 10%, **significant at 5%, ***significant at 1%

Table 6 Marginal effects of determinants of new to market product innovations, Austria, 1998-2000, CIS 3, ALS estimation

	Exogenous support		Endogenous support			
	R&D intensity	Share of Innovative sales	R&D intensity	Share of Innovative sales	R&D intensity	Share of Innovative sales
Central government support	0.010***		0.026***		0.023***	0.027**
EU support	0.003		-0.004		-0.001	-0.016
R&D		0.376***		0.530***		0.303*
High-tech industries	-0.008**	-0.080***	0.021*	-0.085***	0.021*	-0.076**
Low-tech industries	-0.017***	-0.091***	0.015	-0.090***	0.014	-0.075**
Wholesale trade	-0.018***	-0.093***	0.011	-0.093***	0.009	-0.078***
Size	0.000	0.008***	-0.005***	0.008**	-0.005***	0.004
Human capital	0.059***		0.115***		0.123***	
Appropriability problems	0.002		0.005		0.006	
Financial difficulties	0.003		-0.005		-0.005	
Science push	0.005***		0.012***		0.012***	
Demand pull		0.028**		0.027**		0.025**

* significant at 10%, **significant at 5%, ***significant at 1%

We have estimated the model with two measures of product innovation. Table 5 reports the estimation results obtained with the broad measure of innovation in products new to the firm, i.e. mixing true product innovators and imitators. Table 6 reports those with the more narrow measure of innovation in products new to the market, corresponding to true product innovators. As we would expect, the major difference between the two models is in the innovation equation. Since the model for true innovators selects a more homogeneous set of firms, the estimates of model 2 are slightly more precise. In both cases, the Sargan test of overidentifying restrictions does not reject the null hypothesis that the overidentifying restrictions hold. In this sense the data do not reject the model specification.

As the comparison of columns 1 and 3 of table 5 reveals, when government support is treated as endogenous, as it should be, the effect of central government support, human capital and science push externalities doubles, whereas the marginal effect of size becomes insignificant. Central government support appears to be one of the most important determinants of R&D. Receiving central government support increases by 2.3 percentage points the intensity of R&D, which is a high figure if we recall that the mean R&D intensity is 2.8 percent. A doubling in the number of employees decreases R&D intensity by half a percentage point. A one percentage point increase in human capital, which is big given the mean value of human capital of 5.2 percentage points, is connected to only one tenth of a percentage point increase in R&D intensity. The only other significant effect comes from the science push: firms that benefit from information emanating from universities or government labs have a 1.1 percentage point higher R&D intensity ceteris paribus.

Treating government support as endogenous, as opposed to exogenous, has little bearing on the estimates of the innovation equation (compare columns 2 and 4 of table 5). Demand pull increases the innovation intensity by 5 percentage points. The higher intensity of innovation in high-tech as compared to low-tech and in low-tech as compared to wholesale trade justifies our ad-hoc industrial classification. R&D has a significant effect on innovation. The rate of return on R&D in terms of innovative sales is of the order of 110% (1 Euro of R&D yields a net 1.1 Euro increase in innovative sales).[5] Multiplying this number by the 2.3 percentage point effect of central government support on R&D intensity yields a total effect of central government support on the share in sales of new products of 2.5 percentage points. The last two columns of table 5 report the results of the specification that allows government support measures to affect innovation directly in addition to their indirect effect going through R&D. The direct effects are not significant.

It is noticeable that the EU support always turns out to be non-significant. A large fraction of firms that receive central government support also get EU support. So it may be that the effects of the latter are confounded with those of the former. It may even be that some EU money is handed out by national ministries and has the appearance of being nationally funded. Financial difficulties and appropriability problems do not significantly affect R&D, and size does not influence the intensity of product innovation.

In table 6 are reported the marginal effects of the explanatory variables for the new-to-market product innovations. When the public support measures are treated as endogenous we observe again an increase in the marginal effects of the explanatory variables on R&D and this time also an increase in the marginal effect of R&D on innovation. The marginal effects of the explanatory variables on new to market product innovations are similar to those on new to firm product innovations, except for the rate of return on R&D: in terms of new to the market products one Euro of extra R&D yields only 53 Eurocents of extra turnover in innovative products. It is possible that it takes more time for R&D to show up in true innovative sales. The major difference between true innovators and innovators cum imitators is in the specification of the last two columns in table 6, namely when direct effects of government support on innovation are allowed for. Central government support leads to a direct increase of 2.7 percentage points in the share of innovative sales in addition to the 0.7 (0.023 x 0.303) percentage point increase due to the indirect effect passing through R&D. Central government support increases in total the new to market share of innovative sales by 3.4 percentage points, which is 0.8 percentage points more than its effect on the new to firm share of innovative sales. Again EU support has no significant effect on R&D or innovation output.

[5] Since both the share in sales due to new products and R&D intensity are normalized by total sales, we can interpret the coefficient of R&D intensity as a rate of return in terms of sales of new products.

How do our results for Austria compare with other estimates reported in the literature? Busom (2000) on Spanish firms found that in the aggregate subsidies increased R&D expenditures by 20%, but that for 30 % of the firms complete crowding out could not be excluded. González, Jaumandreu, Pazó (2005) also found a stimulating effect of R&D subsidies in Spain both in the intensity and in the propensity of doing R&D. Czarnitzki, Hanel and Rosa (2004) and Bérubé and Mohnen (2009) found that respectively R&D tax incentives and R&D subsidies increased the proportion of innovators and especially world first innovators among Canadian firms. Few studies have quantified the effect of government support on the share of innovative sales. Czarnitzki and Licht (2006) found that public R&D grants increased the share of sales due to new products by 4 percentage point in West German firms and 1.5 percentage points in East German firms. Their results are comparable to ours.

5. Conclusion

This paper has examined the extent and the effects of government support for innovation in Austria in the period 1998-2000. The central government, including agencies working for the central government, is the most often cited source of public support for innovation, followed by the local government, the EU and the 5th and 6th Framework Programmes for RTD. It is also noticeable that a higher percentage of new to market product innovators receive public support of some sort than new to firm product innovators.

In order to account for the endogeneity of government support for innovation and of R&D and product innovation, a system of simultaneous equations was estimated where government support affects R&D that itself explains innovative sales. Two definitions of innovative sales were distinguished: products new to the firm and products new to the market. The central government prefers funding firms that are independent, that have a certain size, that operate mostly in foreign markets, that cooperate and that experience difficulties in financing their innovation. Competition and financial difficulties turn out to be insignificant in explaining EU support for innovation.

Receiving central government support increases by 2.3 percentage points the intensity of R&D. There is no great difference in the factors determining local and central government support or EU and RTD support for innovation, but there is some difference between national and EU support in general. EU support is never significant once national support is taken into account. Central government support thus yields a 2.5 percentage point increase in the share of new to firm innovative sales. When new to market product innovations are considered, central government support leads to a total effect on the share of new to market innovative sales of 3.4 percentage points.

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