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Behavioural Additionality Effects of R&D-Subsidies

Empirical Evidence from Austria

Rahel Falk – Austrian Institute of Economic Research

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Abstract:

There is a broad empirical literature on directly measurable economic effects of public R&D-promotion schemes. While some papers focus on gross effects such as increased turnover, enhanced productivity, stronger competitiveness, improved market positions and the like (output additionality), others address the question in how far public R&D-assistance induces companies to spend more own additional resources on R&D than they would have spent anyway (input additionality). "Behavioural Additionality" in turn broadens the traditional additionality concepts by looking at permanent changes in the conduct of a company, possibly mirrored in a more formal institutionalization of innovation and R&D-activities. Based on firm-level data this paper is the first to empirically analyse such (behavioural) additionality aspects of companies that have received subsidies from the Austrian federal R&D-support scheme (FFF). The empirical results widely support the notion that assisted companies have been successful to enhance their innovation capabilities and competence building in general and to make use of new technologies and R&D-procedures elsewhere.

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1 Introduction

Rigby (2003) has proposed to require high output additionality as a necessary first-order condition for the provision of public money, while high input additionality is to be treated as a kind of second-order condition. In view of the scarcity of public funds, he (among others) argues that the second order test is to make sure that publicly funded R&D is not simply substituting for, or actually crowding-out private R&D-investment[1]) and that the latter additionality concept is "a measure of the leverage effect of public money on the private resources of the firm". Without questioning the ultimate need for efficient use of public resources, there is increasing awareness that R&D-promotion schemes must be judged on the basis of more than immediately materializable returns or directly measurable indicators. Instead, intangible social returns should also been taken into consideration, general competence building and networking included, since this may lead companies to spend more resources on innovation and R&D-projects in the future[2]). Accordingly, this chapter addresses long-term behavioural changes emerging from FFF-participation, so-called "behavioural additionality".

The concept of behavioural additionality as originally introduced by *Buisseret et al.* (1995) is an attempt to steer the notion of additionality away from a narrow focus on either immediate commercial effects, or various kinds of secondary, nevertheless materializable, effects. Instead, the traditional additionality concept is broadened by investigating whether participation in assisted projects influences the R&D-related *behaviour* of FFF-funded firms in a significant manner. Thus, attention is not so much drawn on the actual economical effects or the triggering of private economic funding of the projects themselves; the decisive point is rather if participation in FFF-funded projects has made the actors become more involved in R&D-activities, if there have been permanent changes in the conduct of a company and particularly on the institutionalization of innovation and R&D-activities (*Aslesen et al.,* 2001). In short, the focus is on the building of innovation capabilities and competence building in general and on the companies' ability to make use of new technologies and R&D-procedures elsewhere. If such was the case, this may strengthen the company's ability to absorb new knowledge (their 'absorptive capacity'). It should be noted that this form of competence building may also benefit other participants in the innovation system, including customers and collaboration partners, thus contributing to a permanent and sustainable increase in the level of Austrian R&D-investment.

This study explores various dimensions of behavioural additionality resulting from FFF-assistance, including project additionality, acceleration additionality, scope and scale additionalities[3]). In this context we present some descriptive evidence from a recent

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[1]) For a survey of the econometric evidence on this issue see *David et al.* (2000).

[2]) *Georghiou* (1997, 2000, 2002), *Luukkonen* (2000), *Papaconstantinou et al.* (1997), *Sakakibara* (1997).

[3]) For the motivation of these concepts see *Davenport et al.* (1998) and *Georghiou* (2002).

FFF-survey on, first, the behavioural consequences in case of rejection, second, on collaboration and networking when FFF-assisted projects are implemented, and, third, on the degree to which proposals are based on preceding projects and/or result in subsequent projects, respectively. Last, data from the FFF's linked firm-project database is exploited to estimate the effect of FFF-subsidies on the stock of scientific R&D-personnel.

2 Descriptive evidence from survey data

In 2003 the FFF's customers have been surveyed as regards their appraisal of the working of the Austrian Industrial research promotion Fund (FFF). Details on the survey and an overview description of the sample are presented in the relevant publications of the Austrian Institute of Economic Research (WIFO) and Joanneum Research (JR). One of this study one of the neat features of the survey is that questions in relation to behavioural changes in case of rejection do not take the subjunctive only, but that we can compare the results with answers from those respondents who have actually experienced rejection of their proposals. Ultimately, hypothetical questions are very likely to be answered in a strategic way and the (control) group of actually unsuccessful candidates allows us to uncover such strategic answering behaviour[4]).

2.1 Project Additionality

One of the most compelling issues in the context of publicly funded projects is the question of implementation/non-implementation in the (hypothesized) situation of no public assistance. This dimension of additionality is occasionally referred to as "project additionality" (see *Davenport et al.,* 1998). Table 1 and Table 2 below present detailed evidence on this issue derived from the FFF-survey data. Analyses have been undertaken by sector-affiliation, as well as by firm-size and contrast hypothesized outcomes (first column) with actual outcomes (second column).

The first thing to note is that the readiness to carry out a revised version of the rejected proposal is broadly overestimated by around 10 percentage points (total sample). In fact, nearly every third respondent of the set of companies that have experienced rejection at least once reports full additionality, meaning that the project has been cancelled without FFF-support (as opposed to around 28 percent in the hypothetical scenario). Likewise 22 percent of the respondents say that the project has been implemented anyway, regardless of public assistance, while within the sample of actually supported firms only a fraction of 15 percent admit that ultimately no additional

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[4]) Since respondents have an interest in the continuation of public support, there is an incentive to over-emphasize the effects of public assistance measures. On the other hand one could argue that companies are reluctant to admit their dependency on public funds. In either case there is wide scope for speculation, i.e. we simply cannot tell the direction of distortion (*Sakakibara,* 1997).

R&D-activities are encouraged by means of FFF-sponsoring. Hence, the case of full additionality ("cancel project if FFF-funding is denied") is systematically underestimated, as is the ultimate willingness or ability to realize the project even if no support was granted. Firms' wrong assessment with regard to their actual readiness to carry out a revised version of the project is particularly severe in case of the traditional industries and for companies with more than 10 but below 100 employees[5]), while the micro-sector firms are generally characterized by more realistic self-assessments.

Table 1: Implementation/non-implementation if application was/is rejected: analysis by sector-affiliation

	Hypothetical Scenario[a)]	Actual Consequences[b)]
Carry out project without changes (total)	*15.13*	*21.85*
Traditional industries	19.77	34.02
R&D-intensive industries	16.32	23.61
Traditional services	16.36	18.75
Knowledge-intensive service	8.93	12.12
Carry out a revised version of the project (total)	*57.16*	*46.79*
Traditional industries	60.47	46.39
R&D-intensive industries	59.64	47.92
Traditional services	49.09	41.67
Knowledge-intensive service	54.29	47.73
Cancel project (total)	*27.72*	*31.35*
Traditional industries	19.77	19.59
R&D-intensive industries	24.04	28.47
Traditional services	34.55	39.58
Knowledge-intensive service	36.79	40.15
Number of sample firms	985	421

[a)] Sample comprises companies that never have been rejected by the FFF and answered the relevant question 41;
[b)] Sample comprises companies that have experienced rejection by the FFF and answered the relevant question 56.

Public R&D-assistance proves to be most crucial for servicing companies, while – quite by surprise – manufacturing industries are more likely to execute the projects unaltered when FFF-funding is denied, i.e. with the same scale and timetable. Conversely, the share of respondents who claim that the project would have been/has been dropped entirely without FFF-funding is lowest within this subgroup (see Table 1). Presumably these findings are "by construction". Recall that the questionnaire has only been sent to firms that have ever applied for FFF-support. It is very likely that R&D-intensive firms, or servicing firms, respectively, apply for FFF-support on regular grounds, while

[5]) Here, discrepancies between hypothesized and actual outcomes range between 14-16 percent (see Table 1 and Table 2).

traditional manufacturing firms only do so if the project is deemed to be successful and without risk. This would explain our finding that traditional industries are least dependent on FFF-funding. More sophisticated methods are in order to deduce unambiguous evidence on the additionality aspect of public R&D-support[6]).

Table 2: Implementation/non-implementation if application was/is rejected: analysis by firm-size

	Hypothetical Scenario[a)]	Actual Consequences[b)]
Carry out project without changes (total)	*15.10*	*21.93*
less than 10 employees	8.15	14.08
10 – 99 employees	14.07	19.15
100 – 249 employees	21.64	42.31
250 and more employees	25.44	26.97
Carry out a revised version of the project (total)	*56.47*	*46.70*
less than 10 employees	49.22	47.18
10 and more employees	59.55	43.97
100 and more employees	56.72	44.23
250 and more employees	62.72	51.69
Cancel project (total)	*28.43*	*31.37*
less than 10 employees	42.63	38.73
10 and more employees	26.38	36.88
100 and more employees	21.64	13.46
250 and more employees	11.83	21.35
Number of sample firms	1020	424

[a)] Sample comprises companies that never have been rejected by the FFF and answered the relevant question 41;
[b)] Sample comprises companies that have experienced rejection by the FFF and answered the relevant question 56.

A second, likewise unexpected result is that it is *not* the largest firms which prove to be the least reliant on FFF-funding (see Table 2). It is true that within this size-category the share of respondents who claim that they would carry out the project irrespective of funding opportunities is highest and, conversely, the share of companies reporting that projects would be cancelled in case of FFF-rejection is lowest. However, when we leave the hypothetical scenario and take a look at the actual consequences, we find additionality to be lowest in case of companies with above 100 and below 250 employees. Irrespective of this irregularity, it remains true that micro-sector firms are naturally the most vulnerable if FFF-support is/was withdrawn, or – to put it the other way round – the role of FFF-assistance is quite decisive in encouraging additional R&D-activities within very small firms.

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[6]) For a survey of the econometric evidence over the past 35 years see *David et al.* (2000).

2.2 Behavioural changes in case of rejection

Hypothetically asked, 61 percent of the set of companies which never failed to qualify for FFF-support state they would seek for alternative public assistance to further promote the rejected project proposals, while not even every third respondent within this subset states the contrary[7],[8]. In this respect differences between various branches turn out statistically insignificant. Repeated analysis by firm-size reveals that the largest size-category is characterized by the highest share of respondents stating that they would indeed send in rejected proposals to other R&D-promotion schemes in case their FFF-application was turned down. But in fact only every fourth company of the total sample actually did seek for alternative support funds, suggesting that dependency on public R&D-assistance is broadly overestimated[9]. However, evidence on that issue is not that conclusive since for the latter finding the relevant sample is reduced to only about 300 firms as compared to 1131 firms in case of the hypothetically asked question[10].

Table 3: Behavioural Additionality: adaptations if application was/is rejected

At issue		Hypothetical Scenario[a]	Actual Consequences[b]
Starting date of the project	postponed	32.03	43.35
	remains unchanged	61.02	48.77
Duration of the project	longer	50.68	61.08
	remains unchanged	30.34	23.15
Scale of the project	smaller	74.07	60.10
	remains unchanged	21.53	32.51
Technical demands	less sophisticated	48.81	39.90
	remain unchanged	46.78	51.72
Accessibility of project results	Later	62.71	63.55
	at no later point in time	31.02	27.59

[a] Refers to Question 42; N = 590; very few firms report an *earlier* starting date, *shorter* duration of the project, *greater* scale of the project or *higher* technical demand. The share of missing answers ranges between 3-4 percent; [b] Refers to Question 57; N=203; very few firms report an *earlier* starting date, *shorter* duration of the project, *greater* scale of the project or *higher* technical demand. The share of missing answers ranges between 4-7 percent.

Table 3 below displays conceived, as well as actual consequences, respectively, in case FFF-application turned out unsuccessful. Note that the sample is reduced to the set of respondents who claim that the project would be/has been implemented in a

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[7]) Refers to question 50 of the questionnaire (unreported results). Share of missing answers: 8 percent,

[8]) untabled results.

[9]) Refers to question 60 of the questionnaire (unreported results). Share of missing answers below 1 percent.

[10]) In the actual scenario, companies that dropped their proposal after FFF-rejection are deleted from the relevant sample.

revised form[11]). First, we observe great unanimity when it comes to the accessibility of project results, i.e. in this respect conceived and actual consequences do not really differ from each other. Two out of three respondents agree that project results could only be exploited at some later date than originally aimed at, supporting the notion that so-called "acceleration additionality"[12]) really matters[13]). We find acceleration additionalities to originate as an immediate consequence of postponed starting dates and prolonged implementation phases in case of no public sponsoring. In fact, delays generally turn out much more severe than expected. More than 60 percent of the unsuccessful candidates admit prolonged project duration.

Most interestingly, it is again the firm-size category of above 100 and below 250 employees which deviates from the norm[14]). Not even one in three respondents report extended implementation phases and one in five even claims that the project has even been finished earlier than originally aimed at. Furthermore, when asked hypothetically, more than three in four respondents of this size-category claim they would still stick to the original time schedule and only one in five companies conceive that the starting point would have to be postponed. Quite similar results on (hypothesized) starting date and project duration, respectively, are obtained for traditional servicing companies. In summary, there seems to be some evidence that large (but not the largest) firms, as well as traditional servicing firms, do not really *change their behaviour* when experiencing FFF-rejection, but rather make concessions to the time horizon of the project. This notion is supported by results from a previous customer content analysis based on the same survey data. Here, firms of the size-category 100-250 employees were found to invest the least time-input when seeking for FFF-support. They might thus simply be unable to respond in another than a rather pragmatic way.

A final good news from Table 3 is that the least concession are made when it comes to the technical demands. In fact actual consequences turn out less severe than hypothetically conceived and the same is true for the "scale"–issue. Still, 60 percent of the rejected firms state to have carried out the project on a smaller scale when FFF-assistance had been denied, hence so-called "scale additionalities" are also prevailing to a considerable degree.

2.3 Collaboration and networking

Collaboration and networking must be considered as key aspects of project participation. They involve both, individual and organisational learning, generate

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[11]) For the hypothetically asked question N=590, while 203 respondents report what actually happened when a revised version of the rejected proposal had been carried out.

[12]) Acceleration Additionality: when R&D-assistance is speeding up the course of the project (*Georghiou,* 2002).

[13]) Within the traditional servicing companies the respective fraction amounts to only 42 percent when asked hypothetically, however, actual consequences do not differ in a statistically significant way.

[14]) Detailed results are not tabled.

network externalities and thereby influence the competences of the actors, as well as their future behaviour (*Aslesen et al.,* 2001, *Georghiou,* 1997). Furthermore, working closely with R&D-institutions enhances the companies' absorptive capacity as regards scientific knowledge. At least every other respondent claims that collaboration has taken place in one or the other way (see Table 4). Collaboration may take the form of joint project proposals (true for 52 percent of the FFF-funded firms), cooperation with research institutes or with other companies (true for 51 percent and 55 percent, respectively). It is, however, not that conclusive whether *additional* partnerships have been established, or if existing partnerships have simply been continued. A previous empirical study undertaken in New Zealand, for example, revealed that only around 10 percent of the respondents claimed that the government-assisted project resulted in a new partnership (*Davenport et al.,* 1998).

Table 4: Behavioural Additionality: collaboration and networking (Question 38)

	yes	No	Missing
Joint project proposal with customers/suppliers/research partners	52.43	37.75	9.81
Cooperation with research institutes	50.84	38.11	10.96
Cooperation with other companies	55.35	33.69	10.88
Building of research networks	31.39	56.23	12.38

A detailed analysis verifies that it is especially the more traditional companies, both within the manufacturing sector as well as within the servicing sector, which aim to make good own deficiencies and make use of the particular knowledge of research institutions by respective collaboration. Most surprisingly, however, this hypothesis (i.e. levelling own comparative disadvantages by means of collaboration with the scientific community) does not prove true for the microsector, but rather the contrary is the case. Instead, these obviously highly specialized small firms are particular prone to the building of own research networks, i.e. collaboration is rather complementary than substitutive in nature. Generally spoken, servicing firms are more involved into research networks and are more responsive to teamwork with other companies. In other words, supporting servicing firms are more likely to generate so-called "scope additionaties"[15]) as the benefits of public R&D-assistance spill over to collaboration partners as well, while the diffusion effects are moderate in case of the manufacturing firms.

[15]) Scope additionalities refer to the outcome that "the coverage of an activity is expanded to a wider range of applications or markets than would have been possible without government assistance (including the case of creating a collaboration in place of a single-company effort)" (*Georghiou,* 2002).

2.4 Preceding and subsequent projects

If FFF-participation actually enhanced a company's efforts as regards own R&D-activities, such increased commitment should ultimately result in subsequent projects. In total 485 firms, accounting for 43 percent of the relevant sample, report that participation in the FFF-funding scheme has resulted in successive projects which are directly based on preceding, FFF-sponsored research projects (see Table 5)[16]). Likewise, roughly the same fraction states that the FFF-sponsored project just happens to be the later project, i.e. the proposal had been based on some project that had been carried out before. Chain effects (in both directions) are the most likely to occur within R&D-intensive industries, or knowledge-intensive services, respectively, where at least every other firm bases FFF-proposals on former projects, or vice versa. Furthermore, three out of four firms within the R&D-intensive industries, or knowledge-intensive services, respectively, appreciate the value of FFF-support in as far as R&D-activities could be extended to new areas. Such extensions imply changes at the strategic level (i.e. to move into a new area of activity) as well as changes at the level of competences to be acquired in the future. More traditional firms, on the other hand, show a significantly lower readiness to enter unknown research territory (hence the term "traditional") so that in total "only" about two in three companies extend their research scope. Still, the triggering effect of FFF-participation must be regarded as a definite success.

Table 5: Behavioural Additionality: chain effects of public funding

	Yes	No	missing
FFF-project is based on former R&D-projects of our company (Question 38)	44.39	44.47	11.14
FFF-Project has resulted in subsequent projects (Question 47)	42.88	49.96	7.16
Project allowed us to extend R&D-activities to new areas (Question 38)	62.86	26.44	10.70

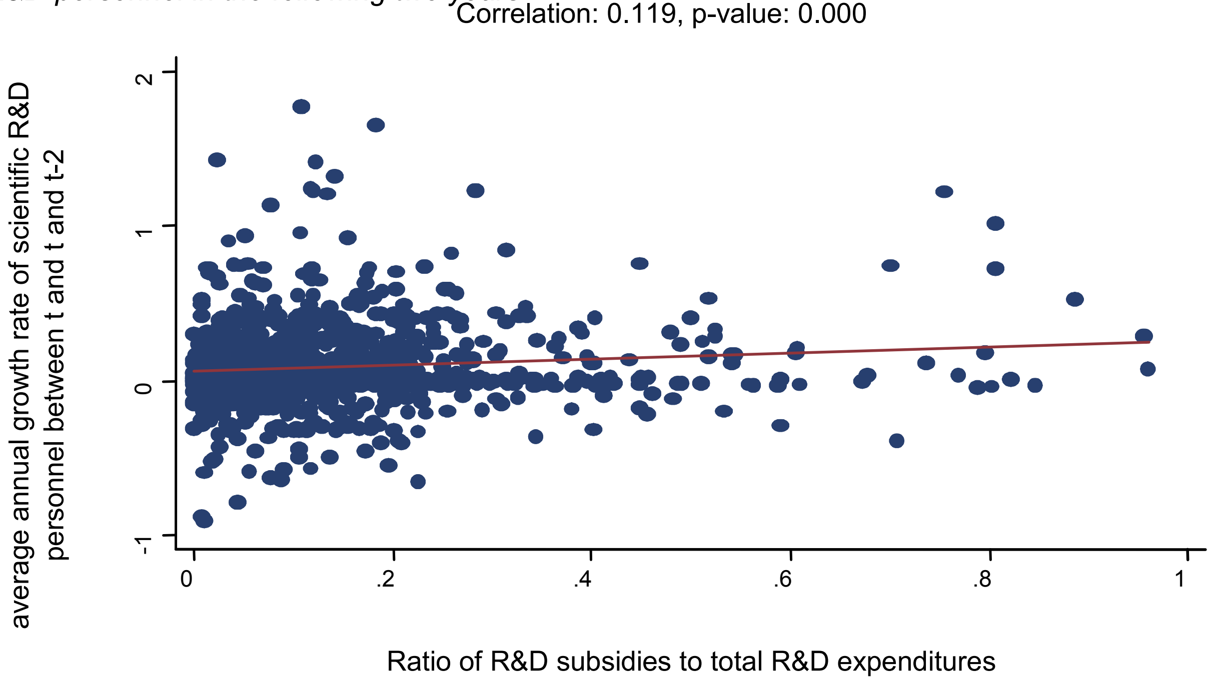
3 Econometric evidence from the FFF-panel data set

The standard econometric approach to input additionality is to regress measures of private R&D-resources (expenditure or scientific labour input) on public assistance correcting for selectivity. Behavioural Additionality deals with "the difference in firm behaviour resulting from the intervention" (*Georghiou,* 2003). As straightforward as appealing this definition may appear, it is not that easy to make operational for econometric purposes. After all, B.A. aims to capture *intangible* benefits, such as training of researchers, increased awareness of R&D opportunities in general and

[16]) A fraction of 38 percent (i.e. 182 firms) has been successful to get public support for the following project as well (no significant difference across sector-affiliation or firm-size). Out of these 79 percent have again managed to attract FFF-subsidies, 44 percent have received financial assistance from other Austrian R&D-promotion schemes and 12 percent have been funded by the European Union. Note that some companies must have been assisted by more than one institution.

establishment of informational networks (*Sakakibara,* 1997). In search for a suitable left hand-side variable we scanned the linked firm-project FFF-database[17]) and eventually came up with log(R&D-personnel). True, this specification once again sheds some more light on the issue of input additionality in an orthodox sense. But additional R&D-personnel will certainly facilitate "increased awareness of R&D opportunities", the "establishment of informational networks" and the like and will hence improve the firm's absorptive capacity with respect to new knowledge. Ultimately, the differences between input additionality and behavioural additionality are hard to tell and even harder to quantify.

Graph 1: Correlation between the initial R&D subsidy ratio in t-2 and the growth rate of R&D-personnel in the following two years[a)]



[a)] number of observations (firms) is 1405.

Figure 1 presents some preliminary bivariate evidence on the relationship between the initial R&D-subsidy ratio (i.e. FFF-subsidies as a share in total R&D-expenditure) and the average annual growth rate of R&D-personnel. Though the correlation turns out statistically significant and positive, as expected, the coefficient of correlation is very small in magnitude.

[17]) For a description of the dataset, see *M. Falk* (2004).

For the multivariate analysis we fit a fixed effects model with time-invariant variables as introduced by *Hausman and Taylor* (1981), results are displayed in Table 6.

Table 6: Panel estimates of the determinants of log(scientific R&D-personnel)

	coeff.	t-value	p-value
Year dummy 1996 (ref. 1995)	0.02	0.66	0.51
Year dummy 1997	0.06	2.08	0.04
Year dummy 1998	0.08	2.91	0.00
Year dummy 1999	0.13	4.23	0.00
Year dummy 2000	0.17	5.46	0.00
Year dummy 2001	0.23	7.21	0.00
Year dummy 2002	0.28	7.37	0.00
Founded in the last five years	0.00	-0.07	0.95
log R&D subsidies (net present value)	0.04	4.31	0.00
log total sales	0.19	10.89	0.00
Food & bev., textiles and clothing	-0.17	-1.05	0.30
Wood, paper, publishing	-0.60	-3.23	0.00
Chemicals, rubber	0.26	1.85	0.06
Non-metallic mineral products	0.06	0.29	0.77
Metals, fabricated metal products	-0.41	-2.68	0.01
Electrical machinery, instruments	0.83	6.88	0.00
Transport equipment	0.61	3.36	0.00
Other manufacturing	0.08	0.22	0.83
Computer services	1.06	7.26	0.00
Other industries	-0.15	-0.66	0.51
Company with limited liability (GMBH)	0.36	0.90	0.37
10-24 employees	0.46	3.89	0.00
25-49 employees	0.73	5.19	0.00
50-99 employees	0.67	4.54	0.00
100-249 employees	0.81	5.62	0.00
250-499 employees	1.29	8.02	0.00
> 500 employees	2.38	13.39	0.00
Log project duration in months	1.23	1.53	0.13
Constant	-5.13	-2.44	0.02
number of observations (firms)	3031(1064)		

Notes: Dependent variable is log scientific R&D personnel. Estimates are based on the Hausman-Taylor estimator (Fixed effects with time-invariant variables). The references for industry and size dummies are machinery and 0 -9 employees, respectively.

Coefficients on the year dummies indicate that the number of scientific R&D-staff hat increased by some (exp(0.28)–1)=32 percent[18]) between 1995 (the left-out reference year) and 2002. Results on the other control variables are likewise plausible: companies undertaking R&D in computer-related services, or in high-tech electrical machinery, respectively, employ significantly more R&D-workers as compared to the reference group and apparently the number of scientific R&D-personnel is increasing in firm size (a tautological relationship). With respect to the actual variable of interest, viz. log(R&D-subsidies), a highly significant coefficient of only very small magnitude confirms the first impression from the bivariate analysis displayed in figure 1: a one-percent increase in the amount of R&D-subsidies granted will induce firms to increase its scientific R&D-staff by 0.04 percent. To illustrate, suppose the company in concern employs 40 R&D-workers[19]). One additional worker would increase the stock of R&D-personnel by 2.5 percent. Hence, in order to achieve this 2.5& increase – or to hire exactly one more R&D-worker, respectively – the net present value of FFF-subsidies would have to increase by 62.5 percent. We conclude that the demand for high-skilled R&D-personnel is only marginally affected by additional FFF-assistance. Instead, it is rather driven by fundamental performance indicators such as total annual sales, or by the NACE-classification of the supported project. In qualitative terms, the above findings are confirmed if the same regression is run on various firm-size samples (less than 25 employees, 25-99 employees and 100 and more employees – see Table 7). Comparing the crucial coefficients across size-categories we find that the demand for scientific R&D-labour is the more elastic with respect to FFF-sponsoring the smaller firms. In particular, a statistically insignificant coefficient on log(subsidies) points at the fact that the largest firms hire additional R&D-labour irrespective of additional FFF-funding.

Last, some evidence on a dynamic specification resulting from a partial adjustment model is presented in Table 8[20]). Here, coefficients on year dummies turn out insignificant and the trend effect (persistence) is captured by the lagged endogenous variable instead. We find that contemporaneous, as well as lagged subsidies have a positive short-run effect on the number of scientific R&D-workers of 0.02 percent. The long-run effect of 0.06 percent is calculated as the sum of contemporaneous and (one-period) lagged effects divided by the partial-adjustment coefficient[21]). These effects match the results of the static approach (Table 6) remarkably well and once again support the finding that increased FFF-sponsoring impacts only marginally on the additional demand for high-skilled R&D-labour.

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[18]) See *Halvorsen et al.* (1980) on the correct interpretation of dummy variables in semilogarithmic equations.

[19]) This is the average number of scientific R&D-personnel in the linked firm-project database.

[20]) This specification has been suggested by *Lach* (2000).

[21]) Partial adjustment coefficient = (1 – coefficient on the lagged endogenous variable).

Table 7: Panel estimates of the determinants of the logarithm of scientific R&D personnel: Detailed results by firm-size

	100 and more employees			25-99 employees			Less than 25 employees		
	coeff.	t-value	p-value	coeff.	t-value	p-value	coeff.	t-value	p-value
Year dummy 1996 (ref. 2002)	0.03	0.71	0.48	-0.03	-0.39	0.70	0.05	0.76	0.45
Year dummy 1997	0.06	1.71	0.09	0.04	0.53	0.59	0.08	1.16	0.25
Year dummy 1998	0.08	2.05	0.04	0.09	1.21	0.23	0.07	1.05	0.29
Year dummy 1999	0.10	2.78	0.01	0.05	0.62	0.54	0.21	2.88	0.00
Year dummy 2000	0.16	3.98	0.00	0.07	0.77	0.44	0.22	3.01	0.00
Year dummy 2001	0.23	5.56	0.00	0.14	1.55	0.12	0.27	3.47	0.00
Year dummy 2002	0.26	5.56	0.00	0.16	1.58	0.11	0.34	3.83	0.00
Founded in the last five years	-0.08	-1.45	0.15	0.01	0.09	0.93	0.08	1.45	0.15
log subsidies (net present value)	0.02	1.52	0.13	0.05	2.22	0.03	0.07	3.83	0.00
log total sales	0.24	7.70	0.00	0.26	6.04	0.00	0.14	5.05	0.00
Food & bev., textiles and clothing	-0.51	-1.95	0.05	0.25	0.80	0.43	0.19	0.75	0.45
Wood, paper, publishing	-1.12	-3.80	0.00	-0.10	-0.25	0.81	-0.12	-0.48	0.63
Chemicals, rubber	0.09	0.35	0.73	0.57	1.87	0.06	0.07	0.42	0.68
Non-metallic mineral products	-0.05	-0.13	0.90	-0.14	-0.32	0.75	0.29	0.78	0.43
Metals, fabricated metal products	-0.65	-2.68	0.01	-0.12	-0.40	0.69	-0.28	-1.17	0.24
Electrical machinery, instruments	0.95	3.94	0.00	1.12	4.83	0.00	0.46	3.26	0.00
Transport equipment	0.69	2.44	0.02	0.24	0.60	0.55	0.12	0.44	0.66
Other manufacturing	-0.25	-0.50	0.62	0.38	0.34	0.73	0.42	0.95	0.34
Computer services	0.69	1.55	0.12	1.36	4.94	0.00	0.69	5.27	0.00
Other industries	-0.74	-1.58	0.11	-0.01	-0.02	0.98	0.18	0.74	0.46
limited liability comp. (GMBH)	6.35	3.37	0.00	-0.53	-0.98	0.33	0.00	0.01	1.00
10-24 employees							0.43	4.92	0.00
25-49 employees									
50-99 employees				-0.07	-0.44	0.66			
100-249 employees									
250-499 employees	0.45	2.60	0.01						
> 500 employees	1.46	7.69	0.00						
Log project duration in months	0.79	0.41	0.68	1.08	1.13	0.26	-0.07	-0.12	0.91
Constant	-9.32	-1.67	0.09	-4.06	-1.60	0.11	-1.20	-0.83	0.41
number of observations (firms)	1501 (390)			638 (237)			892 (437)		

Notes: Dependent variable is log scientific R&D personnel. Estimates are based on the Hausman-Taylor estimator (Fixed effects with time-invariant variables). The references for industry and size dummies are machinery and 0-9 employees (specification1), 50-99 (specification 2) and >500 (specification 3), respectively.

Table 8: Impact of subsidies on scientific R&D personnel: Dynamic panel estimates[a)]

	(1)			(2)		
	coeff	t-value	p-value	coeff	t-value	p-value
Δlog R&D personnel (t-1)	0.22	1.76	0.08	0.24	1.98	0.05
Δ log R&D subsidies (t)	0.02	1.65	0.10	0.02	1.68	0.09
Δ log R&D subsidies (t-1)	0.02	2.12	0.04	0.02	2.12	0.03
Δlog sales (t)	0.06	2.42	0.02	0.06	2.18	0.03
Δlog sales (t-1)	0.05	2.03	0.04			
newly founded	0.00	0.04	0.97	0.01	0.44	0.66
year dummy 1997 (ref 2001)	-0.01	-0.44	0.66	-0.02	-0.64	0.52
year dummy 1998	-0.02	-1.10	0.27	-0.02	-1.16	0.25
year dummy 1999	0.02	0.85	0.40	0.02	0.71	0.48
year dummy 2000	0.02	1.01	0.31	0.02	0.92	0.36
Constant	0.02	1.16	0.25	0.02	1.51	0.13
number of observations (firms)	1186 (422)			1186 (422)		
Implied long run subsidy effect	0.06			0.06		

[a]) One-step estimates based on heteroscedasticity robust standard errors. Data consist of all firm-year observations with non-missing and non-zero values of subsidies and sales.

Given the overall disappointing and fairly robust results of the econometric exercise, is FFF-funding at least a useful instrument to boost R&D-employment within small firms? The answer is "yes, in relative terms" and clearly "no in absolute terms". To illustrate, take the extreme case of a one-person firm. One additional R&D-employee translates into a doubling of the existing stock of scientific labour (+100 percent). A one-percent increase would induce the labour stock to rise by 0.07 percent. To let it rise by 100 percent FFF-subsidies would have to grow by (100/0.07)=1,428.6 percent. Table 9 below illustrates this argument.

How to reconcile the unambiguous evidence of high behavioural additionality from the FFF-survey data with the moderate effects from the econometric approach? The first problem deals with the near impossibility to capture what *Papaconstantiou and Polt* (1997) call the "soft side of innovation" (networking, learning effects, cooperation, innovative behaviour… etc.). Except for the growth of R&D-personnel there is no such variable in the FFF-project database which could be regarded as a proxy for firms' improved abilities to absorb new knowledge and accordingly we just estimated what is estimable. A second, arguably more technical problem, is introduced by the fact that the FFF requires companies to reveal certain performance indicators and firm characteristics only when they apply for funds. At this stage information from the three preceding accounting years are mandatory. But ex post figures are only implicitly available, and that only for supported firms repeatedly turning in new research proposals. For our purposes therefore the relevant sample set is highly selective and biased in favour of more or less continuous R&D-performers. Even if further behavioural changes for these were not subject to the law of diminishing returns, the need for an ever greater R&D-staff certainly is.

Table 9: Increase in FFF-subsidies necessary to employ one additional R&D-worker

Refers to…	Size-classes	Coefficient on log(subsidies)	Number of scientific R&D-personnel (various scenarios)	Increase in FFF-subsidies necessary to hire one more R&D-worker[a)]
Table 6	all	0.04	40	62.5
Table 7, colums 8-10	smaller	0.07	1	1428.6
Table 7, colums 8-10	firms	0.07	12	119.0
Table 7, colums 8-10	only	0.07	24	59.5
Table 7, colums 5-7	medium-	0.05	25	80.0
Table 7, colums 5-7	sized	0.05	62	32.3
Table 7, colums 5-7	firms	0.05	99	20.2
Table 7, colums 2-4	larger	0.02	100	50.0
Table 7, colums 2-4	firms	0.02	300	16.7
Table 7, colums 2-4	only	0.02	500	10.0
Table 8, short-run effect	all	0.02	40	125.0
Table 8, long-run effect	all	0.06	40	41.7

[a)] The following formula applies: ((((X+1)*100)/X) −100)/c, where X denotes the existing stock of scientific R&D-personnel and c gives the estimated coefficient on log(subsidies).

4 Summing up

This paper has addressed long-term behavioural changes emerging from FFF-participation, so-called "behavioural additionality". Descriptive evidence from the survey data revealed that FFF-funding is indeed generating various dimensions of behavioural additionality:

- Around 80-85 percent of the sample firms experience some degree of project additionality.
- Acceleration additionalities arise for two in three firms.
- The share of companies appreciating scale additionalities ranges between 60-74 percent.
- At least every other firm reports scope additionalities to have arisen from collaboration and a fraction of over 62 percent benefits from scope additionalities in as far as new research areas could be entered with the financial help of the FFF-scheme.

Results from some subsequent econometric exercises based in the linked company-project FFF-database turned out not that conclusive, however. In this context the first problem refers to the unavailability of appropriate measures for the mostly intangible merits of behavioural additionality. A second problem is introduced by the general unavailability of ex-post information which makes it hard to systematically evaluate additionality effects of FFF-funding. Conceivably, the greatest effects of FFF-funding on firms' demand for high-skilled R&D-labour should be observable for firms that do not undertake R&D-activities on regular grounds. Unfortunately, however, it is exactly this type of firm which is hardest to assess, instead the relevant data set consists of "routine" R&D-performers only. Even if further behavioural changes for these were not subject to the law of diminishing returns, the need for an ever greater R&D-staff certainly is. The FFF is therefore recommended to condition the provision with public assistance on the obligation to give ex post information.

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