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DELIVERABLE 5.1

LESSONS FROM MICROECONOMETRIC R&D SUBSIDY STUDIES TO MACRO-MODELING OF INNOVATION POLICY

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Lessons from microeconometric R&D subsidy studies to macro-modeling of innovation policy*

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Abstract

This paper summarizes the results from theoretical modeling of the R&D subsidy process as well as from microeconometric analysis on how firms apply for R&D subsidies, and how governments grant them, using data from 5 EU countries. The two key lessons for macro-modeling are: First, additionality is not a sufficient statistic on which one could build the micro-input into macro models. Second, an important feature of firm application and government subsidy rate decisions is heterogeneity. This heterogeneity manifests itself across firms/applications, across countries, and to some extent also across time. One source of heterogeneity are differences in institutions across countries and time.

JEL: D04, G38, H25, L59, O31, O38.

Keywords: R&D subsidies, applications, SME, subsidy rate.

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1 Introduction

Modern macro-models are increasingly seeking to build in parameters describing the R&D process that would be based on microeconometric results. Indeed, a key goal of SIMPATIC is to further the interaction between macromodelers and economists studying innovation using microeconometrics. This paper summarizes what the microeconometric and microeconomic research done under the auspices of SIMPATIC has so far yielded in this regard.

The approach taken in the microeconomic part of SIMPATIC is the following: 1) assemble as similar data as possible from the 5 EU Member States; 2) use a unified theoretical framework to guide construction of comparable econometric models; 3) estimate the models using data from all 5 countries; and 4) compare the results. At this stage of the research project, SIMPATIC micro-research has produced a series of discussion papers and theoretical work on the model to be adopted, and an e-book based on these. Thus, what can be achieved at this point is threefold. First, a discussion of the reasons to use parameters based on microeconometric evidence in macro models; second, a discussion of the lessons learned thus far from SIMPATIC microeconometric research, including possible parameter values; and theoretical lessons learned from SIMPATIC microeconomic theory-modeling. The objective of this discussion paper is to adopt this approach, which also gives the structure of the paper.

2 Why use micro-estimates of R&D parameters in macro models?

The idea behind using parameter values taken from solid microeconometric work into the R&D sections of large macro models is not unique: Indeed it follows the logic used in a long tradition of macro-modeling, where parameters characterizing e.g. the working of the labor market (wage elasticities at the extensive and intensive margins) have been used in macro-models for a long time.

There are good reasons to believe that the large cross-sectional variation utilized in microeconomic work allows a better identification of key parameters, though this is not universally so. To continue the above example, there is an ongoing debate as to why

these key labor market parameters vary across both microeconomic studies, as well as between micro and macroeconomic studies.

There is a special reason why to use microeconometric evidence as regards R&D parameters. This has to do with the fact, born out e.g. in all data sets used by SIMPATIC micro researchers, that there is a lot of persistence in R&D at the aggregate, and even at the firm level. Not using all possible sources of variation is thus an option of limited value when it comes to estimating R&D-related parameters.

There is however also a key challenge that has as its source the very variation that allows researchers using microdata to identify R&D-related parameters of interest: firm heterogeneity. It is well established in the literature that for many R&D related variables, observable firm characteristics have limited explanatory power. This, too, is borne out by the microeconometric research done in SIMPATIC. In addition, and again this holds for SIMPATIC-based research, even to the extent observables are able to capture the variation, results point to a very large amount of heterogeneity among firms. Numbers given in the next Section, taken from microeconometric research done in SIMPATIC, bear testimony to this. The challenge is therefore how to take this large and no doubt important heterogeneity at the macro level into account.

3 Insights from microeconomic theory work in SIMPATIC

The microeconomic part of SIMPATIC builds on a theoretical model of the so-called R&D subsidy process. A key part of that approach is to acknowledge that in addition to deciding on whether or not to invest in R&D, and if so, by how much, firms also need to make an active decision on whether or not to apply for public support: Data typically tell that only a small fraction of firms (even those performing R&D) apply for subsidies in a given year. For example, in Finland that percentage is round 20% for R&D performing firms. Somewhat surprisingly, data e.g. from Spain also suggests that the percentage of firms applying for R&D tax incentives is also surprisingly low; in the case of Spain, round 50%. Furthermore, in the case of R&D subsidies, it is not only the firm that needs to take an active decision – the government agency administering the R&D subsidy program also needs to decide whether or not it wants to subsidize the project the

firm is proposing. In most countries, and certainly the ones studied in SIMPATIC, this government decision is not only yes or no, but involves also a decision on what fraction of the firm's R&D expenses to cover. This percentage - called the subsidy rate - may vary a lot, and typically lies between zero (i.e., rejection) and up to 70%.

Takalo, Tanayama and Toivanen (2013a,b,c TTT henceforth) model this R&D subsidy process theoretically. Figure 1 displays the game tree of the TTT model (without private financier). First, the firm gets an idea about a potential R&D project. It then decides whether or not to apply for a subsidy. If it does, the government needs to decide on the level of support. Finally, TTT assume that the firm chooses the actual level of R&D after the government has decided on the level of support. TTTb,c add private funding with and without financial market imperfections to the model. They assume that the firm contracts with private financiers after it knows the decision of the government agency.

Figure 1. The TTT game tree without private financiers.

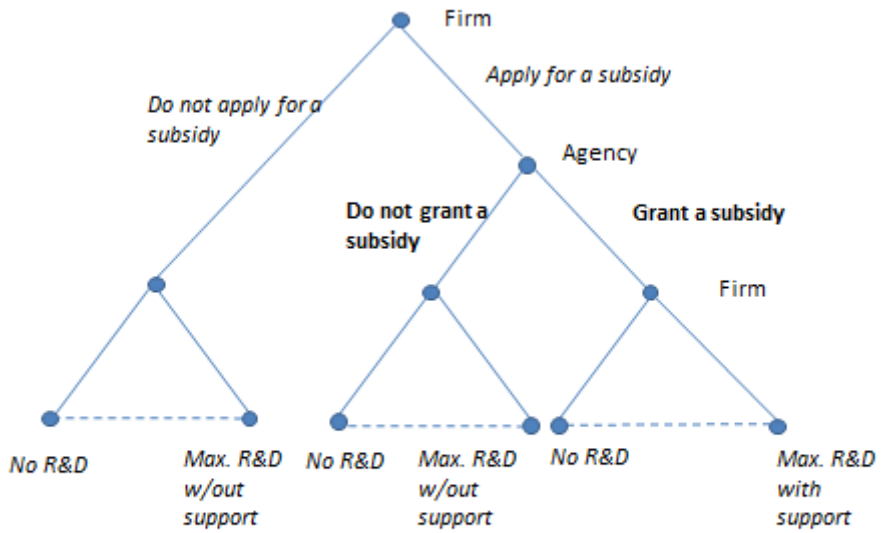


Figure 1. Game Tree of the TTT model

The assumption that the firm chooses the level of R&D after having been informed of the government agency's decision on the level of subsidies has one important implication in the simplest version of the model where there are no capital market imperfections nor fixed costs of R&D: It means that from a welfare perspective, the social planner can rely on the firm maximizing profits, conditional on the level of subsidies. There-

fore, if the agency acts as a (benevolent) social planner, it need not take firm profits into account in choosing the subsidies, but can concentrate on the spillovers, i.e., all those effects of R&D that are not captured by the firm.

TTTb and TTTc show that this clear-cut picture gets somewhat more complicated when financial market imperfections and fixed costs of R&D are introduced as then both of these bear on the level of socially optimal R&D subsidies. What remains however is that the government decision is largely dictated by the spillovers the project is likely to generate, not the profits. The key impact of profits is that the firm needs to implement the project: the agency is therefore interested in making sure that a project with large positive spillovers satisfies the firm's participation constraint, i.e., that the firm wants to implement the project given the level of government support.

The TTT model highlights that firm and R&D project characteristics (the "quality" of the R&D idea, and the spillovers the project is likely to generate) have a large impact on both firm and government decisions. What this means is that one should expect (optimal) subsidy rates to vary considerably across firms and projects. This feature of the model also allows it to explain why a surprisingly small fraction of firms applies for what seems to be "free" money.

The TTT model further illuminates (see TTTb in particular) that additionality is not informative of social benefits.[1] The key reason for this is that additionality or the lack of it derives from how firm profits react to an increase in R&D that follows from a given reduction in marginal cost of R&D, achieved through an increase in the subsidy rate. The level of spillovers is a function of the level of R&D (TTT assume a linear relationship), and the amount of spillovers per euro of R&D. The latter parameter may or may not be correlated with the private profits per euro of R&D which drive the firm's decision to expand R&D in response to a subsidy. TTTb show that additionality may or may not be a sufficient (or necessary) condition for a given subsidy decision to be welfare improving within the TTT model. It is also important to note what "spillovers" mean in the TTT model: the term captures all those effects of R&D that the social planner cares about which are not captured by the firm. This may include such diverse things as con-

[1] Additionality has been defined (see Takalo, Tanayama and Toivanen 2013c for a precise definition) as the increase in privately funded R&D as a response to public funding of private R&D. Rephrasing, there is additionality if, in response to a one euro input of public money towards a firm's R&D project, the total R&D of the firm increases by more than one euro.

sumer surplus, information spillovers (both positive – to other domestic firms, and negative – to foreign competitors of domestic firms) and rents captured by workers.

The theoretical work in SIMPATIC has thus far produces a couple of key messages for macro modeling of R&D. First, unlike what has been thought throughout, additionality is most likely not a sufficient statistic to be used in modeling the macro effects of R&D subsidies. A better understanding of the spillover effects of R&D is needed. Second, a key characteristic of both R&D and the effects of government support to private R&D is heterogeneity, especially in the cross-section, but also over time (within a firm). When transferring micro-based estimates of the effects of government R&D support to macro models, these features need to be kept in mind.

4 Evidence from SIMPATIC microeconometric research

The current empirical literature on the effects of government support to private R&D (see recent surveys by Zúñica-Vicente et al. 2012, Cerulli 2010 and Mohnen and Lokshin 2010) concentrates on estimating the so-called additionality effect of such support. As the previous section demonstrates, things are unfortunately not that straightforward, and additionality alone is not an interesting parameter to be used, whether in policy analysis or macro modeling. The SIMPATIC approach in microeconometrics is therefore to explore in more depth the "R&D-subsidy process". The purpose of this section is to summarize the empirical evidence provided by SIMPATIC. This evidence thus far is reduced form: SIMPATIC researchers have studied two key decisions of the R&D subsidy process – that of the firms of whether or not to apply for a subsidy, and that of the government agency of whether or not to give a subsidy, and how large the subsidy rate should be.

4.1 Subsidy schemes

Something to keep in mind is that subsidy schemes are uniform neither across countries nor across time. Simplifying, one can categorize R&D subsidies into targeted (e.g., subsidies) and untargeted (e.g. R&D tax incentives) and/or national and local. Targeted aid can either be available to all firms, or e.g. specific industries can be chosen / empha-

sized. As an example, The Netherlands had targeted subsidy schemes, where specific industries were targeted (see Pacher and Mohnen 2013a). Spain (Huergo 2013a) has both targeted (subsidies) and untargeted (tax incentives) support. Spanish subsidies that are mostly available to all firms, but both national and regional funding is important. Finland on the other hand (see Takalo and Toivanen 2013a) had mostly targeted funding, but within that form of aid, the share of funding channeled to specific industries and/or technologies has increased over time. Germany is similar to Finland in this respect (see Beyer, Czarnitzki and Toivanen 2013a). This heterogeneity in the institutional setting, both across countries and across time, naturally partly explains the observed heterogeneity in both how firms behave and in how the agencies make decisions.

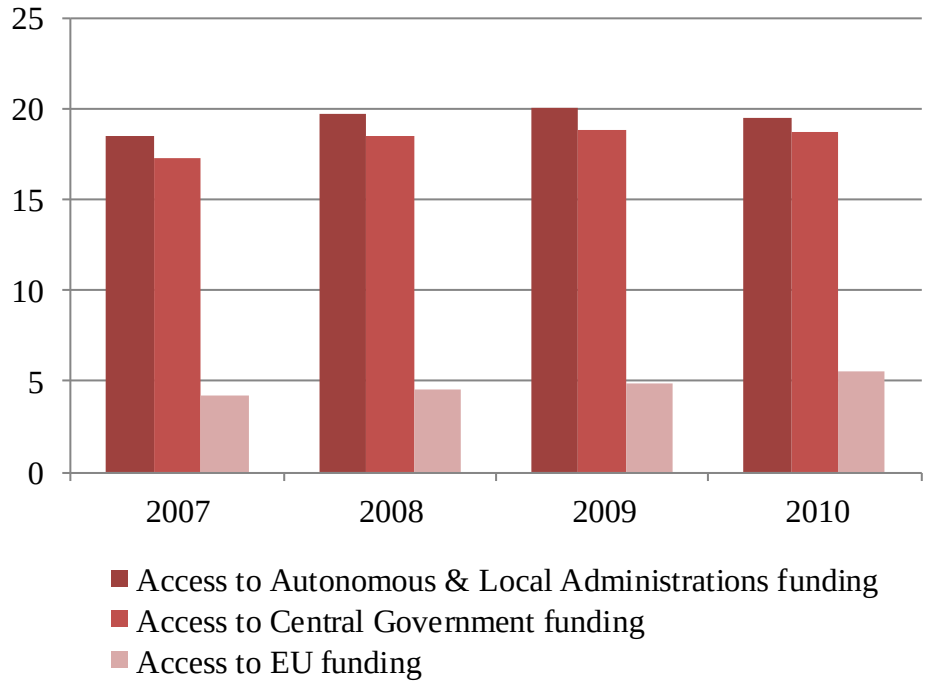
Support schemes also vary in what type of funding instruments they have available, and how they use them. Besides subsidies, government agencies can often grant soft loans, R&D tax incentives or grants for collaborative research, for example.

Subsidy schemes may also differ in how they treat different types of firms. Typically, because of EU regulations, SMEs may be granted higher maximum subsidy rates than large firms; also regional aid/ structural funds may lead to an increase in the maximum allowed subsidy rates.

4.2 Evidence on firm application behavior

The first stylized fact to keep in mind in terms of using micro evidence in macro models is that a surprisingly small fraction of firms apply for and are granted subsidies. Huergo (2013a) reports – see Figure 2 below – that less than 20% of R&D performing firms received R&D subsidies in 2007-2010 in Spain.

Figure 2. Access to public subsidies to finance R&D projects in Spain between 2007 and 2010 (% of innovative firms) [2]



Similarly, Beyer, Czarnitzki and Toivanen (2013a) report that less than 5% of German firms receive subsidies in a given year between 1994 and 2011; the average percentage is higher (7.8%) for large firms than for SMEs (3.3%). The difference in the Spanish and German numbers is largely explained by the fact that the Spanish numbers are reported as a percentage of innovative firms. Only roughly a third of Spanish firms invest in R&D. If investing in R&D is roughly as frequent as being innovative, then the Spanish percentage of firms receiving subsidies is round 5-6%, i.e., very close to the German numbers reported by Beyer, Czarnitzki and Toivanen. The lesson to be taken to macro models is that any firm level measure of the effects of R&D subsidies needs to be weighted by the fraction of firms receiving support, and this fraction is surprisingly low.

The second lesson to be taken arises from the SIMPATIC reduced form regressions. These show that firms are very heterogenous in terms of their probability of applying for R&D. Beyer, Czarnitzki and Toivanen (2013a), Czarnitzki and Toivanen (2013a), Huergo (2013a), Pacher and Mohnen (2013a), and Takalo and Toivanen (2013a) show for Germany, Spain, The Netherlands and Finland respectively, that firm characteristics have quite similar effects on the probability of applying for an R&D subsidy (see Table

[2] The categories are not mutually exclusive. The firms can have access to more than one type of aid.

1). Flemish (Belgian) firms are however somewhat different from those in the other EU countries.[3] Thus not only are firms heterogenous in terms of which firms are more (or less) likely to apply for subsidies in a given country, but the relationship between firm characteristics and the probability of applying for subsidies also varies across countries.

Table 1. Comparison of some application probability coefficients

Variable	Finland	Flanders	Germany	The Netherlands	Spain
Age	-	+	-	-	-
SME	0	+	-	-	-
sales/emp	-	+	-	+	-

NOTES: - = negative, statistically significant coefficient ;
+ = a positive, statistically significant coefficient
0 = an insignificant coefficient
In case of a quadratic specification, the sign refers to the overall effect at the mean.

4.3 Evidence on government decision-making

Just like with the firms' application behavior, the first lesson for macro-modeling comes from descriptive statistics of government decision making regarding R&D subsidies: There is a great deal of heterogeneity. This is displayed through three figures: Figure 3 (from Takalo and Toivanen 2013b) shows the probability of getting a subsidy, conditional on applying for one, using data from Finland. The Figures shows clearly how the probability is between 65 and 85%, and higher for SMEs. There is also some fluctuation over time.

[3] One has to keep in mind that the specifications in the different studies vary somewhat, and in particular, that for some of the listed variables, some authors used a quadratic (in logs) specification while others did not. In future work, these differences in specification will be addressed.

Figure 3. The mean probability of getting a subsidy in Finland over time.

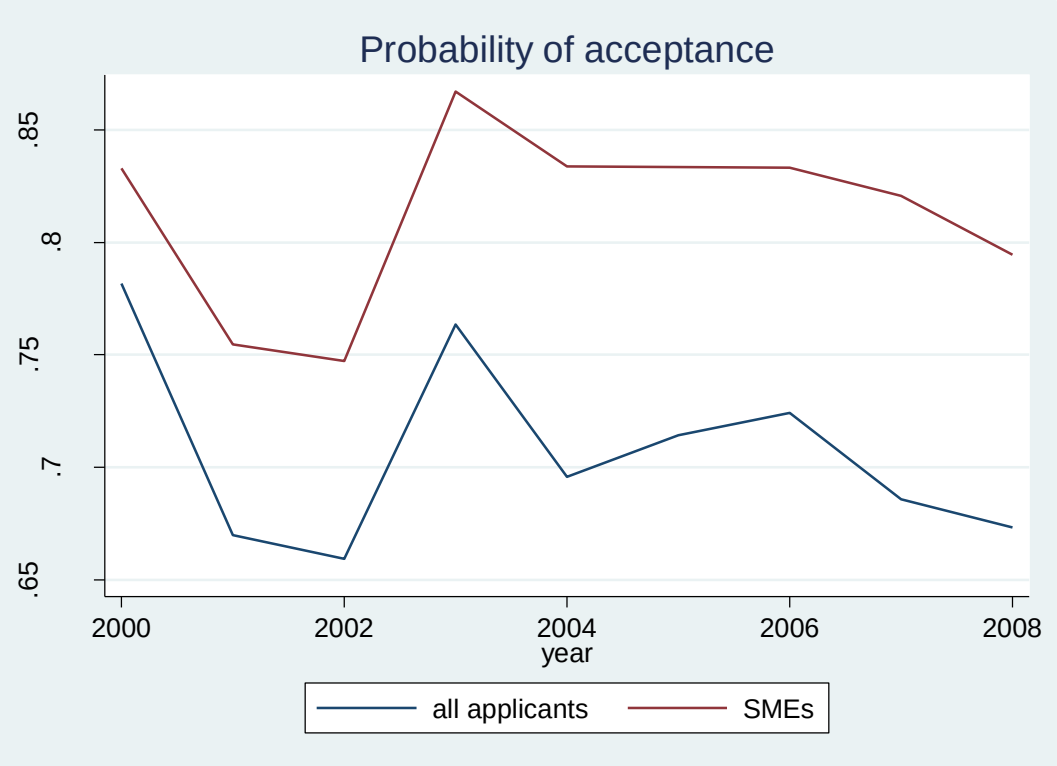


Figure 4 (from Beyer, Czarnitzki and Toivanen 2013b) shows that even conditional on having the application accepted, a great deal of heterogeneity remains. Based on German data, it shows that while the modal subsidy rate is 50% in Germany, the government grants subsidies covering between 20 and 80% of R&D costs. Clearly, the impact of a 20% subsidy rate is very different from a 50%, let alone an 80% subsidy rate. This heterogeneity is important to take into account.

Figure 4. The distribution of subsidy rates in Germany 1994 – 2011.

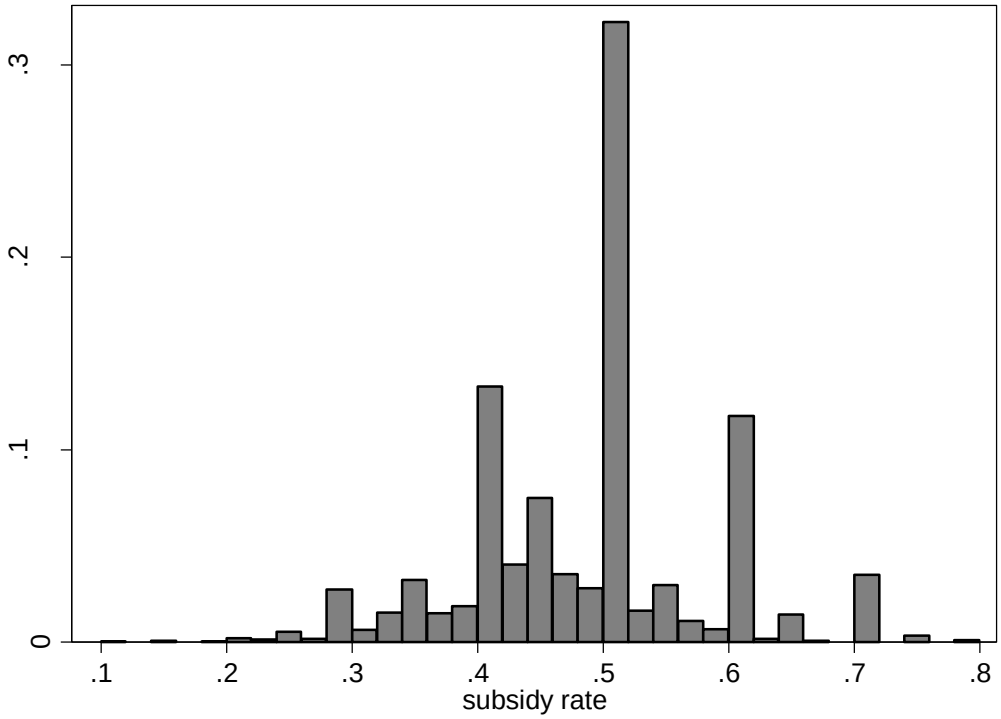


Figure 5 (from Takalo and Toivanen 2013b) displays the (kernel-estimated) distribution of subsidies for Finland in 2003 (2004- 2008 distributions are very similar). The distribution is clearly different from the in Germany: There is a concentration of mass at zero subsidies (as some 15-35% of applications are rejected), a few others at the middle both sides of the 40% subsidy rate, and a final couple of mass points at the upper end of the distribution (60 and 70%).

Figure 5. The distribution of subsidy rates in Finland in 2003.

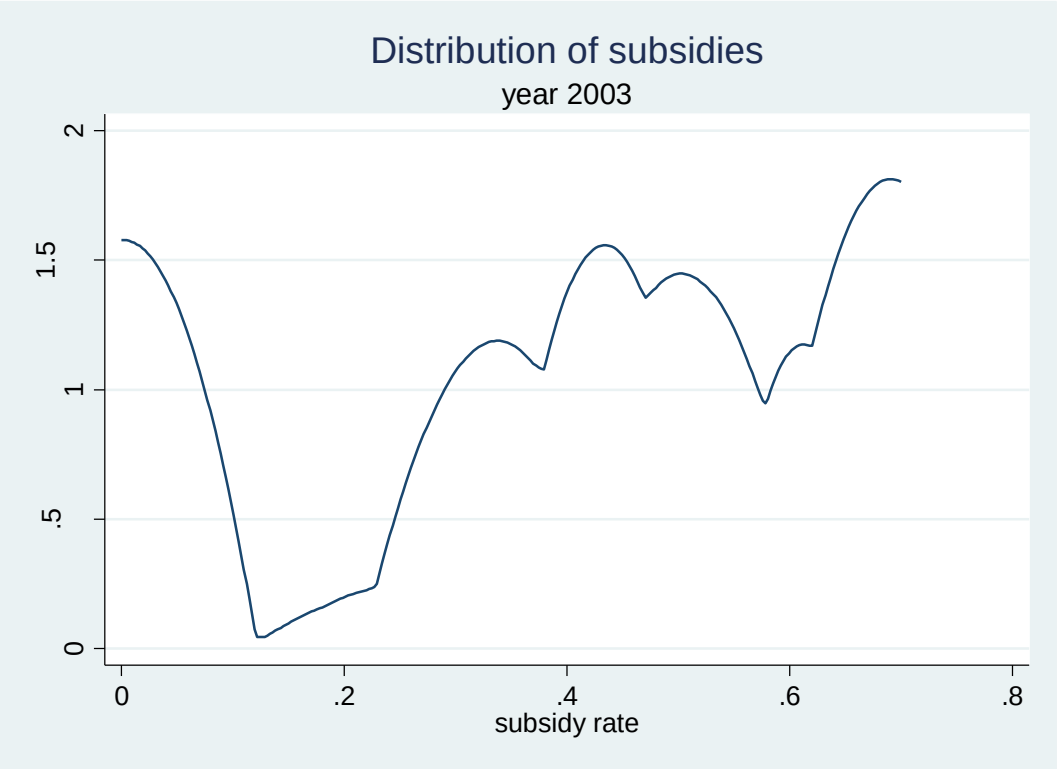
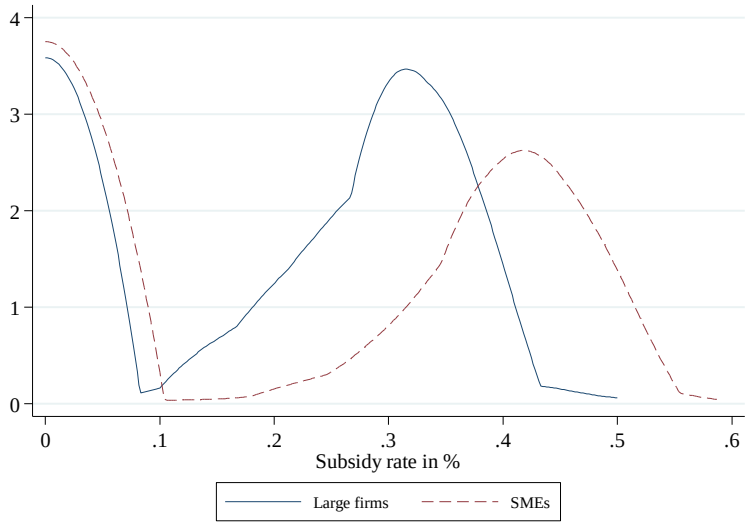


Figure 6 displays a similarly calculated subsidy rate distribution for the Netherlands, separately for SMEs and large firms. The distribution is clearly different from that in Finland, and seems to lie "between" the Finnish and German distributions.

Figure 6. The distribution of subsidy rates in the Netherlands.



Notes: Only tender/R&D projects included

Taken together, Figures 3-6 show that there is a great deal of heterogeneity across firms (applications). They also suggest that countries are different – the German and Finnish distributions are remarkably dissimilar.

To further illuminate this heterogeneity let us turn to a summary of the regression results. SIMPATIC researchers (Beyer, Czarnitzki and Toivanen (2013b), Czarnitzki and Toivanen (2013b), Huergo (2013b), Pacher and Mohnen (2013b), and Takalo and Toivanen (2013b) show for Germany, Flanders, Spain, The Netherlands and Finland respectively) find that firm characteristics are usually not strongly correlated with the government's subsidy decisions. A case in point is Flanders, where the only firm characteristic that is correlated with the subsidy rate decision in a statistically significant way is membership in a group (it has a negative impact on the subsidy rate), but the general lesson carries over to the other countries. In those countries where the government agency grades the applications (and SIMPATIC researchers had access to the data on grades), grades have a strong impact on the subsidy rate. To take an example, if Tekes' (the Finnish government agency responsible for R&D subsidies) engineers evaluate an application one grade point higher in terms of technical challenge on a 5-point Likert scale, the project gets an R&D subsidy that is eight percentage points higher. This is an economically very significant change.

Table 2. Comparison of some agency decision rule coefficients

Variable	Finland	Flanders	Germany	The Netherlands	Spain
risk/ranking	-	.	.	-	-
technical challenge	+	.	.	.	+
Age	-	0	0	0	0
employment	0	0	0	0	-
SME	+	0	+	+	0
sales/emp	0	0	0	0	-

NOTES: - = negative, statistically significant coefficient ;
+ = a positive, statistically significant coefficient
0 = an insignificant coefficient
. = variable not used in the analysis of the country in question
In case of a quadratic specification, the sign refers to the overall effect at the mean.

5 Summary

The current consensus view is that parameters fed into macro models should be based on solid microeconometric evidence where possible. The objective of SIMPATIC is to further our understanding of such parameters at the micro-level, and to feed them into macro models for purposes of policy analysis. SIMPATIC research has already in the first year and a half uncovered some novel results. First, additionality is not a sufficient statistic on which one could build the micro-input into macro models. Second, an important feature of firm application and government subsidy rate decisions is heterogeneity. This heterogeneity manifests itself across firms/applications, across countries, and to some extent also across time. Further SIMPATIC research will look deeper into the effects of R&D support policies, and into how to incorporate the new results from microeconomic research into macro models in a credible and useful way.

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