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Subsidies, shadow of death and productivity

Heli Koski and Mika Pajarinen*

Abstract:
Our panel data from over 10,000 Finnish firms during the years 2003-2010 sheds light on the effect of different business subsidies on firm productivity performance and on the relationship between firms' lagged labor productivity and market exit. We find that not any of the subsidy types have statistically significant short-term or longer term impacts on the firms' productivity performance. It seems that particularly employment and investment subsidies tend to be allocated to the relatively less efficient companies. We further observe that a decline in the firm's lagged labor productivity levels are clearly more weakly related to the subsidized firms' exit than to the exit of firms that have not received any subsidies. Our empirical findings thus hint that the allocation of subsidies to the relatively inefficient firms increases their liquidity making their market exit less likely than it would be otherwise. In other words, our data indicate that subsidy allocation weakens the shadow of death phenomenon observed in the previous empirical studies and hinders the process of creative destruction in the economy.

JEL Classification: D24, J23, L10, L53, O25.
Keywords: productivity, business subsidies, firm exit, enterprise policy, technology policy.

Tiivistelmä:
Tutkimuksessa analysoidaan ensiksi erilaisten yritystukien vaikutuksia yritysten työn tuottavuuteen sekä toiseksi tuottavuuden ja yritysten markkinoilta poistumisen yhteyttä. Aineistona on yli 10 000 suomalaista vähintään 10 henkeä työllistävää yritystä vuosilta 2003–2010. Yritystuilla ei havaita selkeitä positiivisia tuottavuus-vaikutuksia lyhyellä (1 v.) eikä pidemmällä (3–5 v.) tarkastelujaksolla. Tulokset indikoivat, että etenkin työllisyys- ja investointitukia allokoidaan usein keskimääräistä heikomman tuottavuuden yrityksille. Havaitsemme lisäksi, että tuottavuuden heikkenemisen ja markkinoilta poistumisen välinen yhteys on merkittävästi heikompi yritystukia saaneilla yrityksillä verrattuna tukia saamattomiin yrityksiin. Tulokset viittaavat siihen, että tukien allokoiminen suhteellisesti keskimääräistä tehottomampiin yrityksiin parantaa niiden rahoitusasemaa ja siten alentaa niiden markkinoilta poistumisen todennäköisyyttä heikentäen luonnollista luovan tuhon ja uusiutumisen prosessia yrityskentässä.

JEL: D24, J23, L10, L53, O25.
Avainsanat: tuottavuus, yritystuet, luova tuho, elinkeinopolitiikka, teknologiapolitiikka.

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1. Introduction

This study contributes both to the literature focusing on the performance implications of government subsidies and to the stream of literature analyzing the exit of firms (see, e.g., Ebersberger, 2011). We are interested in two related effects of business subsidies: i) whether and how business subsidies affect firm productivity, and ii) whether business subsidies affect the relationship between a firm's lagged productivity and its probability to exit market, or the strength of so called shadow of death –phenomenon. We use data from over 10,000 Finnish companies from the years 2003-2010 to empirically explore not only firm-level performance implications of business subsidies but also use data to draw conclusions on the wider, dynamic market-level impacts of subsidies.

Previous empirical studies investigating the effectiveness of business subsidies have explored questions such as the impacts of subsidies on employment growth (see, e.g. Girma, et al. 2007; Koski and Pajarinen, 2012), a firm's own R&D spending (see, e.g., David, 2000; Gelabert et al., 2009) and productivity (see, e.g., Irwin and Klenow, 1996; Managi, 2010). There is relatively scarce and mixed empirical evidence on the productivity effects of subsidies. For instance, Irwin and Klenow (1996) detect no impact of government R&D subsidies for the U.S. high-tech companies' labor productivity, while Managi (2010) using more recent data from quite different industry finds a negative relationship between government subsidies and the total factor productivity of firms in Japan's forestry sector. Moreover, Oh et al. (2009) finds that credit guarantees have no effect on the total factor productivity growth of Korean firms. Instead, Baghana (2010) finds that the additional return of R&D subsidies among Canadian manufacturing firms is positive though lower than that of a firm's own R&D or R&D tax credits.

Our data provide two major advantages compared to those used in the prior studies investigating the relationship between business subsidies and productivity. First, unlike prior studies typically exploring the impact of a single subsidy type, we have information on all major subsidies allocated for firms in Finland that can be controlled simultaneously. Second, our database covers an exceptionally large set of companies: we have more than 10,000 companies and over 60,000 observations from the years 2003-2010 in our dataset.

The second related stream of empirical literature considers the market exit of firms. Our exploration is particularly close to the reported empirical studies analyzing the pre-exit performance of firms (see, Griliches and Regev, 1995; Almus, 2004; Carreira and Teixeira, 2011).[1] Prior empirical studies suggest that there exist the "shadow of death" phenomenon: a firm's productivity level decreases notably, relative to those of survivals, various years before it exits the market. We contribute to this literature by arguing that the allocation of government subsidies may affect this market dynamics. The allocation of subsidies for firms of which productivity is relatively low or decreased are less likely to exit market than they would be without subsidies, and thus subsidies may weaken the relationship between firm productivity and exit and hinder the reallocation of market shares to more efficient firms.

The rest of the paper is organized as follows. Section 2 introduces the productivity framework applied in the empirical analysis. It further discusses the shadow of death phenomenon observed in the literature and links it to the business subsidy context. We also introduce here the variables used in the empirical analysis. Section 3 reports the

[1] Relatedly, various prior empirical studies conclude that there exist notable and persistent productivity differences among firms (see, e.g., Fox and Smeets, 2011).

estimation results and discusses the empirical findings. Section 4 summarizes our major results and discusses their implications.

2. Productivity and firm death

Productivity framework

We use the traditional productivity framework to investigate the effects of government allocation of subsidies on firm productivity. We apply the extended Cobb-Douglas production function for a firm i at time t to derive empirical model for the labor productivity:

$$Y_{it} = A_i K_{it}^{\beta_k} L_{it}^{\beta_L} S_{it}^{\beta_S} C^{\beta_C} e^{\varepsilon_i} \quad \text{(EQUATION 1)}$$

where Y is the value added of a firm capturing the firm's output, K is the capital measured by fixed assets, L is labor measured by the firm's man-years of labor (i.e. full-time equivalent), S is a vector for three different business subsidy types, C is a vector of control variables including, e.g., controls for heterogeneity of labor force, and e is a stochastic error term.

Equation 1 results in – after dividing both sides by L and taking a logarithm of them – empirically convenient equation for labor productivity:

$$\ln(Y_{it} / L_{it}) = \ln A_i + \beta_K \ln(K_{it} / L_{it}) + \beta_L \ln(L_{it}) + \beta_S \ln(S_{it}) + \beta_C \ln C_{it} + \varepsilon_{it} \quad \text{(EQUATION 2)}$$

Equation 2, with the dependent variable labor productivity, i.e. log value added per employee, provides basis for our empirical modeling. We have three separate continuous endogenous variables measuring different types of business subsidies: i) The order of magnitude of the employment subsidy allocated for a firm at a given year

divided by the firm's number of employees (the variable EMPL_SUBSIDY), ii) the order of magnitude of a firm's R&D subsidy at a given year divided by the firm's number of employees (the variable RD_SUBSIDY), and iii) all other business subsidies a firm has received in a given year divided by the firm's number of employees (the variable OTHER_SUBSIDY).[2]

We assume that the three government subsidy types may have different impact on firms' short- and long-term productivity. R&D subsidies are targeted to facilitate the development of new products and services. As R&D typically involves various resource- and time-taking stages from research to development and testing before a firm can reap the benefits from its innovation, it seems likely that in the short run, the initiation of new R&D projects financed by the government is likely to increase the firm's labor costs and not to produce notable value added. Another possibility supported by some empirical evidence (see, e.g., David et al., 2000) is that R&D subsidy crowds out a firm's own R&D investment meaning, in the context of our study, that R&D subsidy has no substantial effect on the firm's productivity. Thus, we expect that R&D subsidies are either negatively or not significantly related to the firm's short-run productivity performance. Instead, whether R&D financed by the governments does not replace a firm's own R&D and generates new, successful products or services, we should observe a longer term positive relationship between R&D subsidies and labor productivity.

[2] In the empirical analysis, we have excluded from the data R&D subsidies smaller than 30,000 Euros per year as, according to the Finnish Funding Agency for Technology and Innovation (Tekes), these are used merely for the planning and feasibility studies of R&D projects and do not represent actual R&D subsidies. Also, we use the threshold of 5000 Euros per year for employment subsidies that reflects the average minimum subsidy for employing one person per year and also to remove possibly erroneous recordings from the data (the smallest recorded annual employment subsidy was 19 Euros). Similarly, other subsidies are limited to those above 5000 Euros per year.

Employment subsidies are meant for the employment of unemployed and particularly for the employment of young people and persons whose productivity level has declined, e.g., due to their long-term unemployment. The employer may also be obligated to act to improve the professional skills of the hired person. It is, however, not certain whether the persons employed via government subsidies are actually (substantially) less productive than people employed without subsidies as it is difficult for the agency allocating employment subsidy to evaluate the productivity level of an unemployed person and as the firms naturally have an incentive to hire as skilled persons as possible. Therefore, it seems credible that the use of employment subsidies may lead into either negative or negligible labor productivity impacts.

The other subsidies are mainly targeted for different investment or expansion purposes. Whether these subsidies are used for the new and more efficient production technology, the benefits may materialize fast and the firm's labor productivity increase already in a rather short term. However, benefits from certain investments - such as the construction of a new production unit or adoption of new technology that involves substantially changed working patterns and learning period - may not actualize in a short run but an increase in the firm's productivity can be observed with a lag.

The economic literature emphasizes potential endogeneity of subsidies that needs to be taken into account (David et al., 2000; Wallsten, 2000; Gelabart et al., 2009) and therefore we use the instrumental variable method with endogenous subsidy variables to capture both contemporary and longer term (i.e. 3- and 5-year average) relationship between subsidies and productivity performance. We further analyze the effect of

subsidies on firm productivity over time by using the conditional difference-in-differences (CDID) method[3].

We first estimate the two-stage least squares random effects model with the endogenous business subsidy variables[4]:

$$\ln(Y_{it}/L_{it}) = \alpha_0 + \beta_K \ln(K_{it}/L_{it}) + \beta_L \ln L_{it} + \beta_{S1} RD\_SUBSIDY_{it} + \beta_{S2} EMPL\_SUBSIDY_{it} + \beta_{S3} OTHER\_SUBSIDY_{it} + \sum_j \beta_j C_{it} + u_i + \varepsilon_{it}$$

(MODEL 1)

The subsidy variables are the fitted values of endogenous variables received from the first-stage of the estimation in which the subsidy variables are explained by the instrumental variables. The annual government budgets for each type of subsidy a firm has applied for provide good instrumental variables for the endogenous subsidy variables as these budgets bound and affect the order of magnitude of subsidies a firm may receive[5] (see, e.g., Wallsten, 2000). The instrumental variable EMPL_BUDGET captures the government's total employment subsidy budget for a given year. The instrumental variable RD_BUDGET covers the government's total budgets for those subsidies among three R&D subsidy sub-types (i.e. direct subsidies, loans and capital

[3] The major alternative for the CDID method would be the pair-wise matching approach that is rather commonly used for analyzing the causal effects of an industrial policy. The use of pair-wise matching method – as it pair-wise compares identical firms with respect to their characteristics – leads into the use of greatly limited number of control variables. Each additional control characteristic leads to the fewer number of identical pairs and thus, in practice, since firms are highly heterogenous, the major loss of data can only be avoided by controlling relatively few factors. As our database provides a rich set of control variables potentially affecting a firm's labor productivity, we rather use the conditional difference-in-differences method that enables controlling variation in multitude of relevant factors.

[5] We tested endogeneity of the three subsidy variables by first estimating a model that explains potentially endogenous variable with all exogenous variables and instruments. The saved residual from the estimated model was subsequently included as an additional explanatory variable in the model explaining productivity as a function of the set of exogenous and potential endogenous variables. The estimated coefficient for residual was statistically significant in the cases of all three subsidy types. In addition, endogeneity of all subsidy variables together was strongly supported by the Wooldridge's (1995) score test.

loans) that a firm has applied for added together. For instance, if a firm has applied for R&D loans and capital loans, the variable RD_BUDGET takes the value of the total government budget of R&D loans and capital loans for a given year. The instrumental variable OTHER_BUDGET covering the government's total annual budget for other subsidy types (i.e. direct subsidies, loans and guarantees) is calculated in a similar way. In addition, OTHER_BUDGET takes account of also three sources of possible funds: Finnvera (a specialized financing company offering loans and guarantees and owned by the State of Finland), the Ministry of Employment and the Economy, and the Ministry of Agriculture and Forestry. Allowing for the mix of sub-types and/or sources of business subsidies a firm may have applied for our instrumental variables have considerable variation also across firms and not only over time.

Second, we use the CDID model to capture the productivity performance of firms before-after subsidies compared to the performance of non-subsidized firms. The CDID model is estimated in two stages (see, e.g, Morgan and Harding, 2006; Imbens and Wooldridge, 2009; Baghana, 2010). First, we estimate the probit model for the firm's probability to receive a subsidy. Second, we use the propensity scores (i.e. the estimated probability that a firm receives subsidy) obtained from the probit model as weights to make the non-subsidized and subsidized firms similar with respect to observable characteristics. In other words, non-subsidized firms are reweighted such that they represent counterfactual outcome or the average labor productivity that the subsidized firms would have had without receiving subsidies. This method provides double-robustness as the use of propensity scores removes the sample selection bias and the difference-in-differences estimation further eliminates potential bias arising from the permanent (or non-time-varying) differences between the subsidized and non-subsidized

firms and aggregate factors that would affect productivity even in the absence of subsidies.

The difference-in-differences estimation, on conditional the propensity scores, is undertaken as follows. The (log) labor productivity of firms that received a certain type of subsidy in 2004 is compared to the (log) level of productivity of firms that did not receive the subsidy in 2004. We restrict the sample to the firms that did not receive any subsidies in the first observation year (2003) to investigate properly the effectiveness of subsidies. We estimate the model separately using 1, 3 and 5 years' periods to investigate the presence of possible lagged effects of these subsidies to the firms' labor productivity.

We estimate the following equation for two cross-sections, before and after the subsidy year (in which the firm-specific i-indicators are dropped for simplicity and propensity-score weights are used in the estimation):

$$\ln(Y/L) = \alpha_0 + \beta_K \ln(K/L) + \beta_L \ln L + \alpha_1 S_1 + \alpha_2 S_2 + \alpha_3 S_3 + \delta_0 dT + \delta_1 dTS_1 + \delta_2 dT2S_2 + \delta_3 dTS_3 + \sum_j \beta_j C_j + u \qquad \text{(MODEL 2)}$$

where S_i (i=1,...,3) denotes the dummy variable that takes value 1 if a firm has received subsidy i. The estimated coefficients α_1, α_2 and α_3 reveal whether there are differences in labor productivity between the subsidized and the other firms *prior* to the reception of a subsidy type. The after-subsidy time dummy dT captures changes in time-related aggregate factors (such as business cycle) that may affect firms' productivity irrespective of subsidies. Coefficients δ_1, δ_2 and δ_3 capture the effects of three subsidies at after-subsidy year d2.

The shadow of death

The second part of our empirical analyses tackles explicitly the impact of business subsidies on the length of shadow of death and firm exit from the market. The previous studies (see, e.g., Carreira and Teixeira, 2011) find that exiting firms tend to have a falling productivity levels over various years prior to their exit. It seems possible that also the allocation of subsidies among firms affects the firm exit probabilities. Various subsidies (such as the EU structural funds) are targeted for firms located in the areas of which geographical situation slows down their development. Consequently, it is argued (see, e.g., Ottaviano et al., 2009) that subsidies allocated for relatively inefficient firms may enhance their survival probability or to prevent their "natural exit" (at the cost of industry-level performance) and consequently hinder re-allocation of resources to the more efficient firms.

Whether business subsidies hinder structural change in such a way, we should observe that decrease in labor productivity has a relatively smaller impact on the probability of exit of subsidized firms than that of non-subsidized firms. Furthermore, subsidies may weaken the relationship between the probability of death and lagged productivity performance making the estimates of the lagged labor productivity variable among subsidized firms less accurate than among non-subsidized firms.

Hypothesis 1:

The relationship between a firm's probability of death and its lagged productivity performance is weaker for subsidized than non-subsidized firms and the shadow of death is shorter among subsidized firms than it is among non-subsidized firms.

To test this hypothesis, we estimate the following random effects probit model:

$$EXIT_{it} = \alpha_0 + \beta_1 S_{it} * LP_{it-k} + \beta_2 NO\_SUBS_{it} * \beta_I LP_{it-k} + \beta_I INDUSTRY_t + \beta_Y YEAR_t + u_i + \varepsilon_{it}$$

(MODEL 3)

where the dependent variable EXIT gets value 1 if a firms exits the market at year t, and 0 otherwise. The lagged observations for labor productivity are measured for k=1…5. We multiplied the explanatory labor productivity variable by the subsidy dummy variables taking value 1 if a firm had obtained subsidy in question, and the dummy variable NO_SUBS that takes value 1 if a firm had not obtained any subsidies. In other words, we divided the sample to the subsidized and non-subsidized firms and estimated separate coefficients for the labor productivity variables for each group of firms.

C**ontrol variables**

Our modeling framework (above) introduces the dependent variables and the major explanatory variables of the estimated equations. In addition, we have controlled for various factors that may affect labor productivity (see Table 1 for the brief explanations and descriptive statistics of used variables). Our econometric models regarding productivity account for heterogeneity of labor force by two set of variables: quality of human capital and age structure. The quality of human capital is captured by the share of college educated and academically educated employees of a firm's total number of employees (the variables COLLEGE and ACADEMIC, respectively) and the age structure of the firm's employees is measured by the shares of employees in five different age groups in relation to a firm's total number of employees (i.e. the variables AGE_EMP18-24 (control group), AGE_EMP25-34, AGE_EMP35-44, AGE_EMP45-54, and AGE_EMP55-70).

Other controls include dummy variables for firm age (the variables AGE_0-5, AGE_6-15 (control group) and AGE_over 15, respectively, for the firms up to the five years old, 6-15 years old and over 15 years old), and the dummy variables for foreign ownership, government ownership and the domestically owned companies (the variables FOREIGN_OWNED, GOV_OWNED and DOMESTIC).

- TABLE 1 HERE –

Furthermore, we control for a firm's industry by 32 dummy variables, location by 16 regional dummy variables, and include dummy variable for each year of observation. As many firms had obtained different subsidies not only once but at various years, we further control the effect of multiple or cumulative subsidies by POST_RD_SUBSIDY, POST_EMPL_SUBSIDY and POST_OTHER_SUBSIDY variables that were calculated in the instrumental variable model using panel data as the order of magnitude of a firm's cumulative subsidies at each time period. In the difference-in-differences model - in which the subsidy variables are also categorical variables – we controlled for the count of each subsidy type that a firm has received after the "treatment year" (or the year it received subsidy).

3. Empirical findings

A descriptive look into the productivity performance of sample firms shows that during the years 2003-2010 the average labor productivity of firms that haven't obtained any subsidies has developed in parallel with the productivity of those firms that have received different types of subsidies (see Figure 1). The average labor productivity of non-subsidized firms has been somewhat higher than that of firms that have obtained

employment subsidies or other subsidies. The average labor productivity levels of the receivers of R&D subsidies are strikingly higher, on average, than those of other companies. A closer inspection of data indicates that this descriptive finding is, by and large, explained by the higher than average labor productivity of those firms that are active in R&D. In other words, we find similarly higher average labor productivity levels among firms that are active in R&D but have not received any R&D subsidies.

- FIGURE 1 HERE -

The estimation results of the instrumental variables model suggests that R&D subsidies are not statistically significantly related to labor productivity, while employment subsidies and other subsidies are negatively related to labor productivity in all models.[6] In other words, it seems that the short-term productivity performance of firms is lower in the firms that have received more employment or other subsidies.

- TABLE 2 HERE –

The conditional difference-in-differences estimates further shed light on the causality between subsidies and firms' labor productivity. We find that none of the subsidy types is statistically significantly related to labor productivity. The same result applies for the

[6] We also estimated the IV models for different sub-groups of firms such as different geographical locations (i.e. for different provinces, and for firms located in cities, urban areas and country side) and different industries, and found similarly either not statistically significant or negative effects between subsidies and labor productivity.

estimation results concerning one, three and five years (after subsidy) productivity effects.[7] Instead, we find that those firms that have received employment and/or other subsidies have been less productive than firms on average *prior* the reception of employment and/or other subsidies. In other words, it seems that employment and other subsidies tend to be targeted for less (than average) productive firms. Furthermore, this empirical finding may also explain the observed negative relationship between labor and other subsidies and labor productivity of the instrumental variable estimations. It seems credible that employment and other subsidies do not decrease firms' labor productivity but, instead, the relationship is negative as these government subsidies tend to be allocated for less productive firms.

- TABLE 3 HERE -

These empirical findings rouse the question of the market impacts of the allocation of public funding. Our empirical analysis concerning the impacts of subsidies on the relationship between labor productivity (at time periods t-1…t-5) and market exit (at time t) aims at answering this question. We find, similar to prior studies, that a firm's fallen productivity level statistically significantly predicts its market exit from one to five years prior to the exit (see, e.g., Carreira and Teixeira, 2011), expect for the R&D subsidized firms for which only the one-year lagged value of labor productivity statistically significantly explains exit.

- TABLE 4 HERE -

The estimation results support our hypothesis on the impact of subsidies on the relationship between productivity and exit (see Table 4). The orders of magnitudes of estimated coefficients for the labor productivity variable are, according to the Wald test, statistically significantly smaller for the firms that have received subsidies than for the non-subsidized firms. It seems that one percent decline in a firm's labor productivity relates to substantially (i.e. 10-70 times) smaller probability of exit during the next one to five years if a firm has received government subsidies.[8] Also, we observe that the order of magnitude of the estimated coefficients for labor productivity variable decline with the number of lags taken. This empirical finding reasonably suggests that that the further we go to the past the weaker is the firm's productivity's prediction power of exit.

- FIGURE 2 HERE -

We further estimated the model in which a firm's labor productivity was used as the major explanatory variable of firm exit separately among non-subsidized firms and among the receivers of each subsidy type. The idea here was to further explore whether the accuracy of estimated coefficients for the labor productivity variable differs among different sub-samples. The estimation results are reported here using a figure showing

[8] As a robustness test, we also estimated the model for each subsidy type separately (i.e. in each estimated equation, multiplied the lagged labor productivity variable by the reception and non-reception of one subsidy type only). These estimation results led to the similar conclusions concerning the difference between the orders of magnitudes of coefficients of lagged labor productivity variable for subsidized and non-subsidized firms.

the mean estimated values and 95 percent confidence values for the labor productivity variable in each sample. Figure 2 shows that there is more dispersion around the estimated mean values for the firms' lagged labor productivity among the different groups of subsidized firms than among non-subsidized firms. Particularly, 95 percent confidence interval for the estimated coefficient of the lagged labor productivity is clearly larger among the firms that have received R&D subsidies than among firms in other sub-samples. These findings are in line with our hypothesis that when a firm receives subsidies, it becomes more difficult to use the firm's productivity level as the predictor of its future market exit.

- FIGURE 3 HERE –

The results of Table 4 concerning firms that have received R&D subsidies hints that the relationship between 2-5 years lagged labor productivity and firm exit cannot be estimated accurately. Further exploration of data shows that a larger variation around the estimated mean values for the lagged labor productivity levels among the sample of R&D subsidized firms is rather specific to the firms that are active in R&D than to those firms that have received R&D subsidies. Figure 3 compares the shadow of death –effect among firms active in R&D and among firms that have not reported to have R&D activities. It shows clearly that the relationship between lagged labor productivity and firm exit can be more accurately estimated among the firms that are not active in R&D than among R&D active firms.

The explanation for the different dynamics of the relationship between the lagged labor productivity and firms' market exit among R&D active firms is not obvious. One

possibility is that the firms investing in R&D witness more fluctuations in their labor productivity[9] that relates to various time-taking labor-intensive innovation stages dropping a firm's labor productivity in the short term but neither means a longer term decline in the firm's performance nor the approaching exit. After a temporary drop in labor productivity during the intense research phase, a successful innovators' labor productivity is likely to increase again. This dynamics may at least partly explain why the shadow of death effect is vaguer in the case of R&D firms than among the firms not active in R&D.

4. Conclusions

Our panel data from over 10,000 Finnish firms during the years 2003-2010 sheds light on the effect of different business subsidies on firm productivity performance and on the relationship between firms' lagged labor productivity and market exit. We find that not any of the subsidy types (i.e. R&D, employment and other (investment) subsidies) have statistically significant short-term or longer term impacts on the firms' productivity performance. Our data suggest that particularly employment subsidies and other subsidies tend to be allocated to the relatively less efficient companies causing negative short-term relationship between the subsidy variables and labor productivity in the instrumental variable estimations.

We further observe that a decline in the firm's lagged labor productivity levels are clearly more weakly related to the subsidized firms' exit than to the exit of firms that haven't received any subsidies. Our empirical findings thus hint that the allocation of subsidies to the relatively inefficient firms increases their liquidity making their market

[9] Our data, indeed, show that there is a greater variance in labor productivity among firms that are active in R&D than among those that are not.

exit less likely than it would be otherwise. In other words, our data indicate that subsidy allocation weakens the shadow of death phenomenon observed in the previous empirical studies and hinders the process of creative destruction in the economy.

Our study finds no grounds for the allocation of business subsidies from the perspective of productivity growth and the structural renewal of the economy. As direct subsidies for firms seem to hinder the exit of the relatively less efficient firms and thus also delay the re-allocation of resources into their more efficient or productive use, better economic policy means from the point of view of economic growth would rather be those ensuring the conditions for fair competition. Also, government should focus on taking care that the most important source of productivity growth, the accumulation of human capital and knowledge, remains secured in the case of temporary turbulences of structural changes in the economy.

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Table 1. Descriptive statistics

Variable	Description	Mean	S.D.	Obs.
PROD	ln(value added/labor input)	3.787	0.528	60943
CAP_TO_LAB	ln(fixed asset/labor input)	2.636	1.850	60943
LABOR	ln(number of employees)	3.379	0.966	60943
RD_SUBSIDY	ln(r&d subsidy/labor input)	-9.953	1.623	60943
EMPL_SUBSIDY	ln(employment subsidy/labor input)	-9.640	2.031	60943
OTHER_SUBSIDY	ln(other subsidy/labor input)	-8.993	3.264	60943
AGE_0_to_5	Firms up to 5 years old (dummy)	0.054	0.225	60943
AGE_6_to_15	Firms 6-15 years old (dummy, control group)	0.365	0.482	60943
AGE_over_15	Firms over 15 years old (dummy)	0.581	0.493	60943
FOREIGN_OWNED	Foreign-owned firm (dummy)	0.097	0.296	60943
GOV_OWNED	State-owned firm (dummy)	0.020	0.141	60943
DOMESTIC	Domestic-owned group (dummy)	0.234	0.423	60943
ACADEMIC	Share of academic-level educated employees	0.056	0.116	60943
COLLEGE	Share of college-level educated employees	0.732	0.151	60943
OTHER_EDU	Share of low-level employees (control group)	0.212	0.153	60943
AGE_EMP16_24	Share of 16-24 years old employees (control group)	0.126	0.134	60943
AGE_EMP25_34	Share of 25-34 years old employees	0.242	0.140	60943
AGE_EMP35_44	Share of 35-44 years old employees	0.252	0.117	60943
AGE_EMP45_54	Share of 45-54 years old employees	0.239	0.128	60943
AGE_EMP55_70	Share of 55-70 years old employees	0.142	0.114	60943

Table 2. The estimation results of the two-stage least squares random effects model for labor productivity

	PROD_1Y	PROD_3Y	PROD_5Y
	Coef./S.E	Coef./S.E	Coef./S.E
RD_SUBSIDY	-0.002	-0.003	-0.001
	(0.002)	(0.002)	(0.003)
EMPL_SUBSIDY	-0.011***	-0.013***	-0.024***
	(0.004)	(0.002)	(0.003)
OTHER_SUBSIDY	-0.002**	-0.003***	-0.006***
	(0.001)	(0.001)	(0.001)
LABOR	-0.038***	-0.033***	-0.026***
	(0.005)	(0.004)	(0.005)
CAP_TO_LAB	0.056***	0.064***	0.075***
	(0.001)	(0.002)	(0.002)
AGE_0-5	0.010	0.013**	0.016***
	(0.007)	(0.005)	(0.006)
AGE_OVER_15	-0.005	-0.005	-0.011**
	(0.005)	(0.004)	(0.004)
FOREIGN_OWNED	0.160***	0.112***	0.106***
	(0.010)	(0.009)	(0.009)
GOV_OWNED	0.025	0.038**	0.109***
	(0.020)	(0.018)	(0.018)
DOMESTIC	0.067***	0.042***	0.033***
	(0.007)	(0.006)	(0.007)
ACADEMIC	0.763***	0.912***	1.079***
	(0.033)	(0.036)	(0.044)
COLLEGE	0.247***	0.311***	0.371***
	(0.019)	(0.022)	(0.029)
AGE_EMP25_34	0.165***	0.249***	0.416***
	(0.022)	(0.026)	(0.040)
AGE_EMP35_44	0.250***	0.334***	0.526***
	(0.022)	(0.025)	(0.037)
AGE_EMP45_54	0.197***	0.270***	0.351***
	(0.021)	(0.028)	(0.040)
AGE_EMP55_70	0.197***	0.270***	0.351***
	(0.024)	(0.028)	(0.040)
POST_RD_SUBSIDY	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)
POST_EMPL_SUBSIDY	-0.002	-0.001	-0.000
	(0.002)	(0.132)	(0.001)
POST_OTHER_SUBSIDY	-0.003***	-0.002***	-0.001**
	(0.001)	(0.001)	(0.001)
Constant	3.153***	3.014***	2.706***
	(0.040)	(0.043)	(0.053)
Industries	Yes	Yes	Yes
Regions	Yes	Yes	Yes
Years	Yes	Yes	Yes
Observatios	60943	35941	16031
Firms	12660	10450	8506
Wald(Model)	7623.437***	6758.542***	6027.180***
R2	0.306	0.399	0.440

The robust firm cluster-specific standard errors are reported in the parentheses. Significance levels are reported on superscripts, where *** denotes significance level of 1%, and ** significance level of 5%.

Table 3. The estimation results of the conditional difference-in-differences model for labor productivity

	PROD_1Y	PROD_3Y	PROD_5Y
	Coef./S.E	Coef./S.E	Coef./S.E
dT	0.032***	0.048***	0.042***
	(0.006)	(0.007)	(0.008)
d_RD_SUBSIDY	0.024	0.028	0.034
	(0.041)	(0.047)	(0.052)
d_EMPL_SUBSIDY	-0.064***	-0.060**	-0.058**
	(0.022)	(0.023)	(0.026)
d_OTHER_SUBSIDY	-0.045***	-0.053***	-0.054***
	(0.016)	(0.017)	(0.019)
dTxRD_SUBSIDY	-0.026	0.032	0.012
	(0.041)	(0.040)	(0.046)
dTxEMPL_SUBSIDY	-0.008	-0.011	0.028
	(0.022)	(0.024)	(0.026)
dTxOTHER_SUBSIDY	0.001	0.011	0.024
	(0.016)	(0.018)	(0.020)
Observations	17300	14592	11966
Firms	8650	7296	5983
Wald(Model)	34.723***	34.075***	32.115***
Adj. R2	0.344	0.381	0.401

Control variables: Constant, LABOR, CAP_TO_LAB, AGE_0-5, AGE_OVER_15, FOREIGN_OWNED, GOV_OWNED, DOMESTIC, ACADEMIC, COLLEGE, AGE_EMP25_34, AGE_EMP35_44, AGE_EMP45_54, AGE_EMP55_70, AGE_0-5, AGE_OVER_15, FOREIGN_OWNED, GOV_OWNED, DOMESTIC, POST_RD_SUBSIDY, POST_EMPL_SUBSIDY, POST_OTHER_SUBSIDY and industry and regional dummies. The robust firm cluster-specific standard errors are reported in the parentheses. Significance levels are reported on superscripts, where *** denotes significance level of 1%, ** significance level of 5%.

Table 4. Random-effects probit estimation results for the shadow of death effect

	Lag k = 1	k = 2	k = 3	k = 4	k = 5
RD_SUBSxPROD(t-k)	-0.001***	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
EMPL_SUBSxPROD(t-k)	-0.002***	-0.002***	-0.002***	-0.002***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
OTHER_SUBSxPROD(t-k)	-0.004***	-0.003***	-0.003***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
NO_SUBSxPROD(t-k)	-0.071***	-0.047***	-0.029***	-0.022***	-0.014***
	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
Wald tests for each subsidy variable versus NO_SUBSxPROD(t-k):					
RD_SUBSxPROD(t-k)	312.39***	98.74***	34.96***	21.52***	7.06***
EMPL_SUBSxPROD(t-k)	303.33***	93.01***	32.16***	19.42***	6.10**
OTHER_SUBSxPROD(t-k)	290.05***	86.69***	29.59***	18.22***	5.39**
Observations	84512	69848	56628	44100	32258
Firms	14126	13424	12765	12109	11504
Wald(Model)	665.60***	323.40***	228.88***	164.19***	124.01***
Log likelihood	-18537.23	-15356.95	-12625.48	-9849.24	-7293.88

Reported coefficients are marginal effects, standard errors are in the parentheses. Industry and year dummies are included in all estimations. Significance levels are reported on superscripts, where *** denotes significance level of 1%, and ** significance level of 5%.

Figure 1. Productivity performance: no subsidy vs different subsidy types

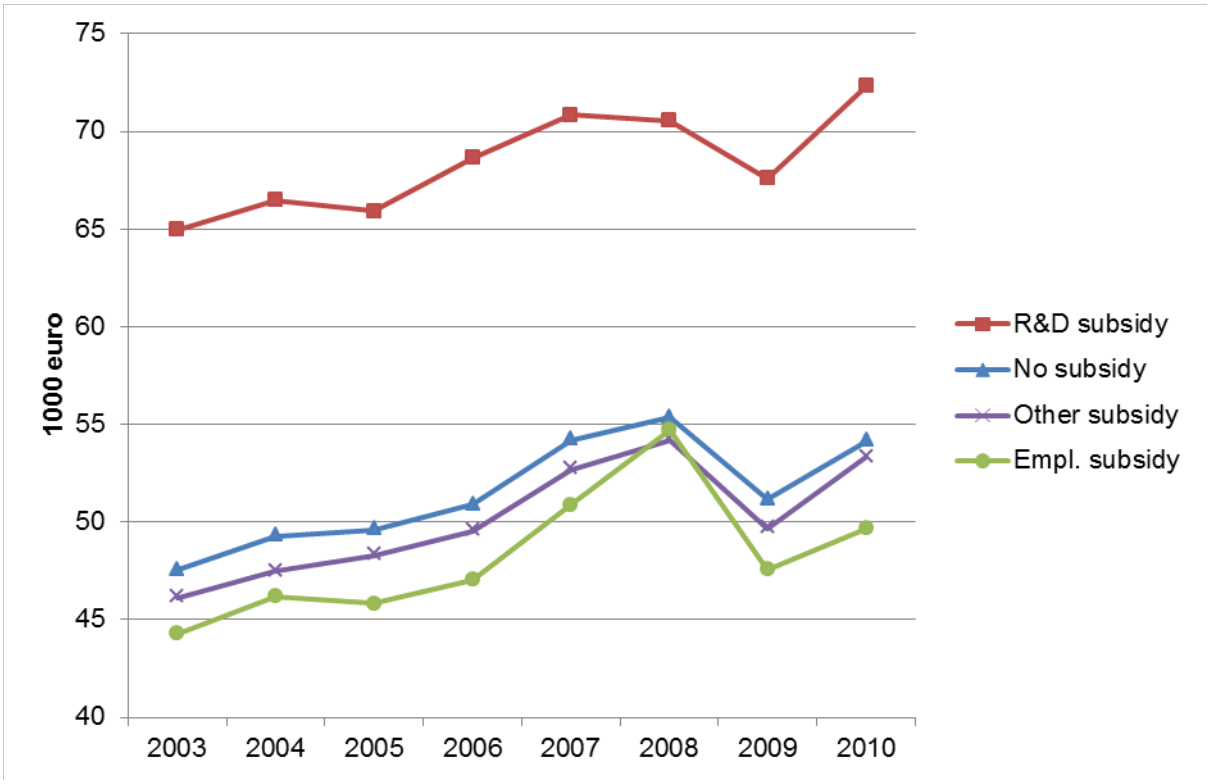


Figure 2. Shadow of death and productivity: No subsidy vs. different subsidy types

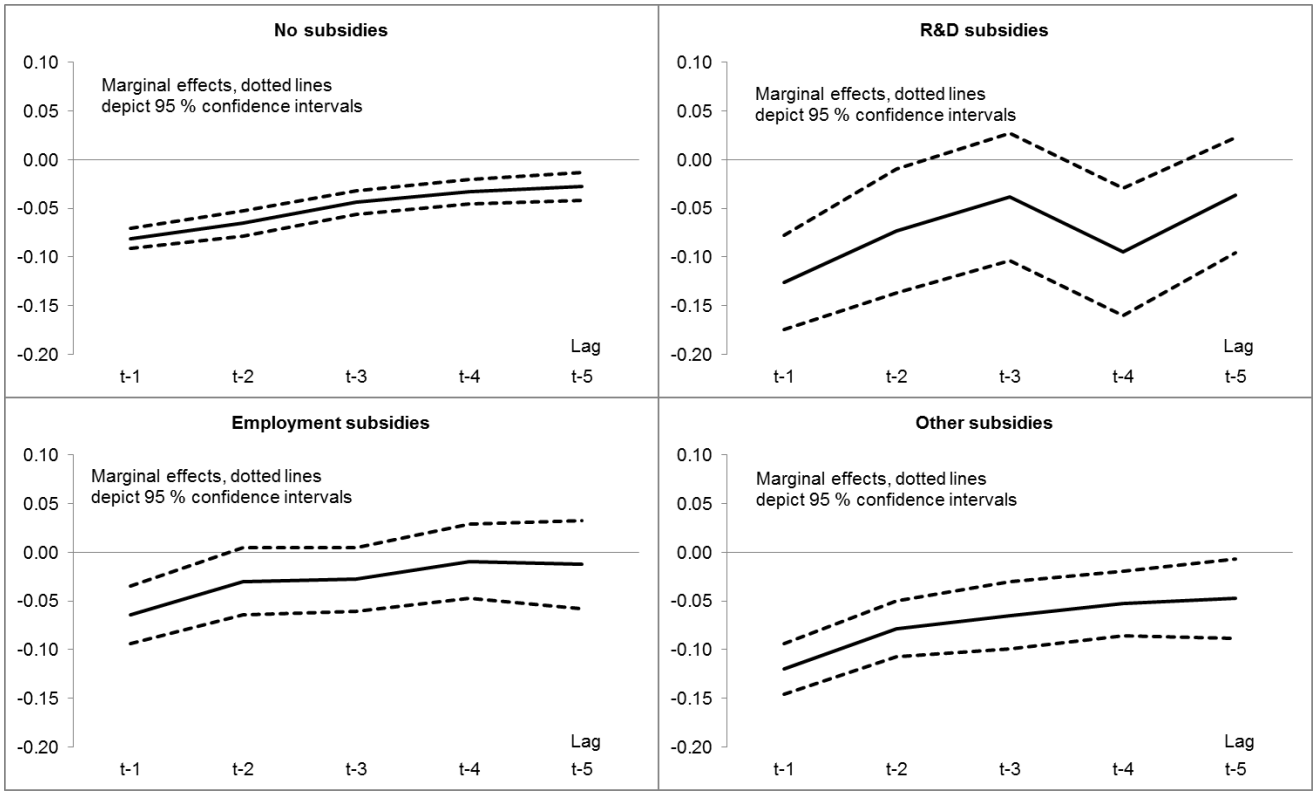
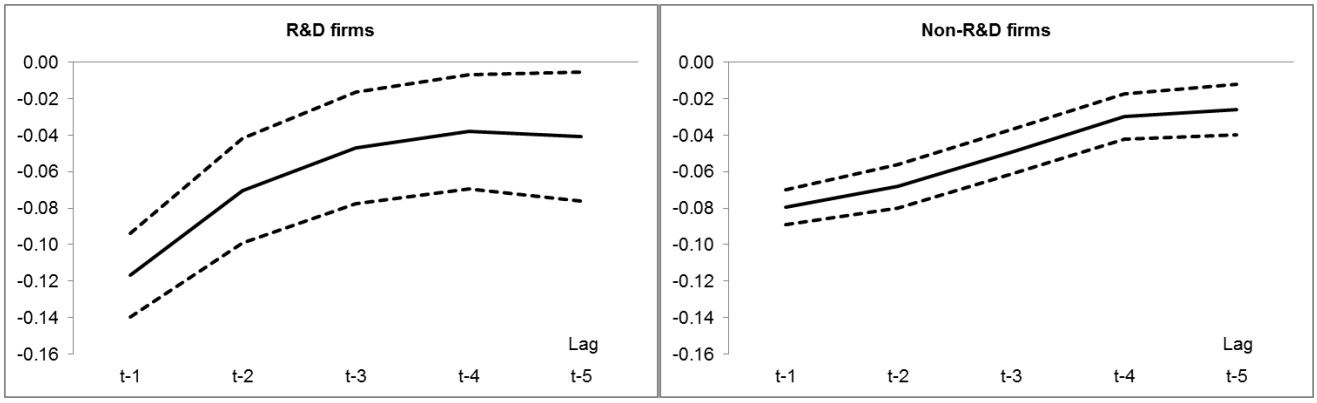


Figure 3. Shadow of death and productivity: R&D firms vs. non-R&D firms



Figures illustrate marginal effects, dotted lines depict 95 % confidence intervals.