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Do financial constraints hold back innovation and growth? Evidence on the role of public policy

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Abstract

This paper provides evidence that capital–market imperfections hold back innovation and growth, and that public policy can complement capital markets. We deliver the evidence by studying the effects of government funding on the behavior of SMEs in Finland. By adapting the methodology recently proposed by Rajan and Zingales [Rajan, R.G., Zingales, L., 1998. Financial dependence and growth. American Economic Review 88, pp. 559–587] to firm-level data, we show that government funding disproportionately helps firms from industries that are dependent on external finance. We demonstrate that the result is economically significant and robust to a variety of tests.

Keywords: Corporate finance; Financial constraints; Innovation; Firm growth; Subsidies

1. Introduction

Government finance of industrial R&D is an important tool of innovation policy (see, e.g. Nevo, 1998). This implies that governments think that where government finance of private R&D leads, innovation and growth follow (see, e.g. OECD, 2000). The evidence on the effectiveness of these policies is however mixed at best, as documented, e.g. by David et al. (2000) and Hall and van Reenen (2000). This is slightly surprising given that there is evidence that small and start-up firms face higher cost of capital than their larger competitors (Hall, 2002), and hence that there is room for such policies. One reason for the lack of evidence may lie in data, another in the research tools used (see Klette et al., 2000). This lack of evidence is unfortunate both in light of the importance of R&D subsidies as a tool of innovation policy, and their potential impact on innovation and economic growth. The objective of this paper is to

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provide evidence on the question of causality between finance in general and government finance to private R&D in particular, and firm growth.[1] We hope thereby to contribute to the discussion of the effectiveness or otherwise of these policies. To deliver the evidence we focus on the effects of public policy on innovation and growth of small and medium sized enterprises (SMEs) in Finland.

This paper's analysis tests a positive view of the role of active public policy in capital markets. To test the view, we borrow and combine insights from the literature on capital market restraints and growth (Hubbart, 1998 and Rajan and Zingales, 1998), and the research on the effects of public policy on firm performance (see, e.g. Lerner, 1999; Wallsten, 2000 and Lach, 2002)[2]. We argue that if there are economically significant imperfections in capital markets and if 'government finance leads' (i.e. if it successfully complements capital markets), government funding may *disproportionately* help innovation (R&D) and growth of firms in industries that are dependent on external finance. It is this hypothesis that we develop and test in this paper.

To provide new evidence on the role of government funding as a tool of innovation policy, we follow a recent paper of Rajan and Zingales (1998, RZ for short), where they made an important methodological contribution by identifying industries' *technological demand for external finance* and measuring it in the US. The main assumption of RZ is that there is a technological reason why some industries rely more on external finance than others. A prime example of such technological variation is the cross-industry differences in the gestation periods of products. Another is the variation in industry life cycles, such as that between the tobacco industry and biotechnology. RZ estimate industry-level growth equations on data from other countries and include industry and country fixed effects, and an interaction term between an industry's technological demand for external finance and a measure of a country's financial development.[3] RZ find that after controlling for industry and country fixed effects, the coefficient of the interaction term is positive and statistically significant. Their result suggests that industries that are relatively more in need of external finance develop disproportionately faster in countries with better-developed capital markets.

We build on RZ's methodology and amend it in two ways. First, in place of their financial development-variable, we use a measure of the regional availability of government funding to SMEs within a country. They argue that financial development liberates firms from the need of generating funds internally by helping firms raise capital from sources external to the firms at a reasonable cost. We think that government funding should lead to the same outcome, if it successfully augments capital markets. Second, we shift the focus to the effects of cross-regional, between-industry differences on a firm-level variable. By focusing on firm-level performance we can correct for region and industry characteristics. Importantly, we can simultaneously address the problem of reverse causality, which has been an important concern in the studies on finance and growth (see Rajan and Zingales, 1998), and selection effects, which have been an important concern in the literature on government funding and firm performance (see Wallsten, 2000).

We apply the amended methodology to recently collected firm-level data on Finnish SMEs that allow us to disaggregate SME funding by its sources, including external sources and the government. Using these data, we identify an industry's need for external finance from data on SMEs operating in the metropolitan Helsinki area that is the financial center and capital of Finland. Under the assumption that capital markets in Helsinki are relatively frictionless, this method allows us to identify an industry's technological demand for external financing. Like RZ, we make the further assumption that such technological demand carries over to other geographical areas in Finland and we examine whether the availability of government funding (outside the metropolitan Helsinki area) helps firms in indus-

[1] The sources and risk profile of funding for R&D can be quite different from that of funding for growth. These potential differences are precisely the reason why we treat R&D and growth symmetrically and use them side-by-side in our empirical analysis. Anticipating, we obtain similar results irrespectively of the measure used. This suggests that our conclusions do not depend on the choice of the dependent variable. It also suggests that at least in Finland, government funding is also important for growth (and not just for R&D).

[2] See also David et al. (2000) and Klette et al. (2000) for surveys.

[3] Recently, Cetorelli and Gampera (2001) have extended RZ's framework to examine the effects of banking market structure on growth. See also Carlin and Mayer (2003) who build on RZ's framework to evaluate the relationship between industrial activity and the structure of countries' financial and legal systems.

tries that are technologically dependent on external finance.

The findings of this paper suggest that SMEs face an upward-sloping capital supply curve and hence that the market for SME finance is imperfect. The evidence is consistent with the view that financial constraints hold back innovation and growth, and the hypothesis that government funding can alleviate capital market imperfections.[4] Beyond these conclusions, our results have no implications for public policy. In particular, one cannot draw conclusions about the welfare effects of government funding (cf. de Meza and Webb, 1987, 2000, and de Meza, 2002).

The paper is organized as follows. Section 2 discusses sources of capital market imperfections and various motives for providing government funding to SMEs. Section 3 explains our empirical approach, and Section 4 describes the data. In this section, the main sources of government funding in Finland are also briefly described. Section 5 presents the regression results and investigates the robustness of our findings. Section 6 summarizes the paper.

2. Theoretical background

2.1. Why do capital market imperfections matter?

To understand why capital market imperfections might constrain the growth and 'innovativeness' of firms, consider a simple model of firm-level investment (see, e.g. David et al., 2000) and growth (Carpenter and Petersen, 2002). Fig. 1 illustrates the main elements of the model. The horizontal axis measures both R&D investment and/or the growth of sales.[5] The vertical axis measures both the (private) marginal rate of return

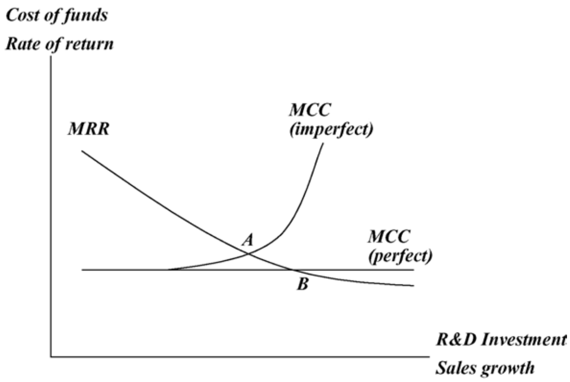

Fig. 1. The effect of financial market imperfections.

on investment and expansion as well as the marginal cost of capital.

The marginal cost of capital (MCC) schedule reflects the opportunity cost of investment and expansion. It is horizontal to the extent a firm has internal funds available but becomes upward sloping at some level of R&D investment and expansion. Standard textbook considerations about asymmetric information, adverse selection and moral hazard suggest that the marginal cost of financing is an increasing function of the amount raised. The MCC schedule captures the idea that in the presence of capital market imperfections, the firm's increased use of external financing eventually pushes the marginal cost of capital upwards. In perfect capital markets, the MCC schedule would be horizontal.

The marginal rate of return (MRR) schedule, slopes downwards, as it ranks the R&D projects and expansion possibilities of firms in descending order of expected return. The MRR schedule for growth could be more elastic than the MRR schedule for investment (Carpenter and Petersen, 2002).

In Fig. 1, the firm's profit maximizing levels of R&D investment (expansion) are found at *A* and *B*, where *A* refers to a firm facing imperfect and *B* to a firm facing perfect capital markets. It is evident that a firm facing a more elastic MCC schedule invests more in R&D (pursues more growth). The model thus predicts that SMEs that are dependent on external finance are more likely to fail to pursue some innovations and growth potential than SMEs that are not.[6]

[4] It is not our intention to suggest that governments provide ideas, and in that sense enterprise always leads. Our approach takes ideas as given, but assumes that without funding, they would not be developed (through R&D, for example) into inventions and innovations. Here, if government funding leads to R&D, and R&D leads to inventions and innovations, government may lead.

[5] Following the 'percentage of sales approach' we assume that the ratio of assets used to achieve a given level of sales is constant (see Higgins, 1977; Demirgüç-Kunt and Maksimovic, 1998, 2002). The assumption implies that the growth of sales is proportional to the change in assets, allowing us to measure sales growth on the horizontal axis rather than the change in assets as in Carpenter and Petersen (2002).

[6] Especially growth-oriented, technology-intensive SMEs may face a steeply upward-sloping MCC schedule because the profitabil-

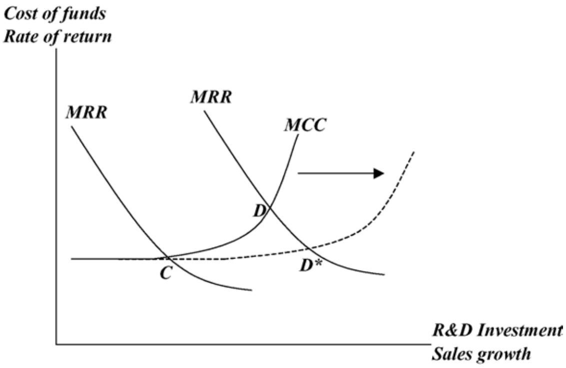

Fig. 2. The (direct) effect of shifting the MCC schedule.

2.2. Why subsidize SMEs?

Economic theory suggests various rationales for governments to provide (subsidized) funding to SMEs, especially to technology-intensive SMEs (see, e.g. Lerner, 1999). First, public finance theory posits that if SMEs are an important source of new ideas and growth that generate positive externalities to other industries and firms, supporting them is appropriate. For example, because the social return from the SMEs' R&D expenditures may exceed their private returns due to 'knowledge' spillovers (Griliches, 1992; Lach, 2002), firms will tend to underinvest in R&D. Second, capital market imperfections may constrain investment and growth of SMEs.

Fig. 2 illustrates the rationale for providing government funding to SMEs facing capital market imperfections. Holding the MRR schedule constant, awarding government funding to an SME has two effects on the MCC schedule. They both depend on whether the firm is dependent on external finance or not. First, the award of government funding has a direct effect by shifting the MCC to the right, because it permits the undertaking of additional projects using capital that has a lower marginal cost than at the pre-award equilibrium. Second, the award may have an indirect effect (as suggested by Lerner's (1999) results) as it may convey information about the quality of the firm both to the equity holders of the firm and to other (potential) investors. This reduces informational asymmetries and lowers the cost of internal and external funds, implying both a downward shift in the MCC schedule (the effect on the required rate of return by current owners and other corporate insiders) and a change in the slope of the upward-sloping part of the schedule (the effect on the required rate of return by corporate outsiders).

Fig. 2 shows the first of these two effects. The direct effect is larger for firms positioned on the upward-sloping part of the MCC schedule, i.e. for firms dependent on external finance, than for firms positioned on the horizontal part. When the MCC schedule shifts to right, the position of a firm who is originally on the horizontal part (at point *C*) does not change, whereas those firms that initially are on the upward-sloping part of the MCC schedule (such as point *D*) increase their R&D (growth) investments (to point D^*).[7]

There are thus reasons to think that the effects of government funding should vary with the elasticity of the marginal cost of capital schedule that firms face. The hypothesis put forward by the model is that if there are significant imperfections in capital markets, government funding should *disproportionately* help firms in industries that are (more) dependent on external finance. These firms are more likely to face a less elastic marginal cost of capital schedule than firms that are less dependent on external finance. This is the distinctive channel on which the test of this paper focuses.

While government funding is not always homogenous (i.e. supporting industrial R&D and provision of subsidies to deprived regions may have different motivations), a key to our empirical testing strategy is that organizations providing government funding try at least to some extent to rectify capital market imperfections. This is the case in Finland.

ity of growth opportunities is unknown and because R&D projects are highly uncertain investments in untapped market niches and in tacit knowledge that becomes embedded in the human capital of employees (see, e.g. Hall, 2002). These tend to worsen the adverse selection problem and increase the lemons premium (Myers and Majluf, 1984). They also create scope for moral hazard problems, especially because agency and contracting costs may be a characteristic feature of R&D projects (Holmström, 1989) and because it is difficult, if not impossible, to contract for a delivery of a specific innovation (Aghion and Tirole, 1994). Finally, technology-intensive small businesses may find it difficult to convey the quality of their ventures to the providers of external finance due to appropriability problems and the confidential nature of R&D projects (Anton and Yao, 1994, Bhattacharya and Chiesa, 1995).

[7] Provided that the downward shift in the MCC schedule is moderate compared to the change in the schedule's slope, also the indirect effect works to the same direction as the direct effect.

3. The empirical approach

To test our hypothesis we estimate several variants of the following basic model:

$$Y_i = \alpha + \beta(\text{External dependence}_j \times \text{Government funding}_a) + \Phi_1 \times \text{Industry dummies}_j + \Phi_2 \times \text{Area dummies}_a + \Phi_3 \times \text{Controls}_i + \text{Error}_i \quad (1)$$

In (1), subscript i refers to firm, j to industry and a to area; α and β are parameters, and uppercase coefficients Φ_k ($k = 1, 2, 3$) indicate vectors of parameters.

The dependent variable is a measure of firm i's investments in R&D or its growth (we define the various measures in Section 4.1). The independent variable of primary interest is the interaction term between an industry (External dependence$_j$) and an area (Government funding$_a$) characteristic. If we can measure industry j's dependence on external finance and the amount of government funding available in area a, then—provided that we correct for area and industry effects—we should find that the coefficient estimate for the interaction is positive in the presence of capital market imperfections. To correct for area and industry specific effects, we include Industry dummies$_j$ and Area dummies$_a$. The vector of Controls$_i$ (described in detail below) is included to control for a number of firm specific effects that potentially affect the dependent variable(s).

Model (1) differs from that of RZ in two ways, as already mentioned in Section 1. First, in place of RZ's financial development-variable, we use a measure of the local availability of government funding to SMEs.[8] If it successfully augments capital markets, government funding should help firms grow by liberating firms from the need of generating funds internally. Second, we shift the focus to the effects of cross-regional, between industry differences on a firm-level variable. In RZ's model, the dependent variable is measured in industry j of area (country) a, whereas our dependent variable refers to firm i from industry j and area a. Together with the inclusion of industry and area fixed effects this means that Error$_i$ measures firm-level deviations (those not controlled for by the vector of firm-level Controls$_i$) from the industry–area mean.

RZ's methodology and our modifications to it allow us to simultaneously address a number of econometric issues that arise in standard firm-level analyses of the effects of government funding on firm performance in which some measure of firms' performance is regressed on a measure of government funding (the subsidy) awarded to the firm:

- *Reverse causality and selection*: Receiving government funding may be endogenous to a firm's activities: e.g. firms that do more R&D could be more likely to receive government funding. This may either result in a selectivity problem that may bias upward econometric estimates of the effect of government funding on firm R&D in standard firm-level regressions (David et al., 2000; Klette et al., 2000; Wallsten, 2000) or indicate reverse causality. Our specification should not suffer from the selectivity problem because the interaction term is measured at industry and area level, *not* at the level of individual firms. Recall, in particular, that the error term in Eq. (1) measures the firm-level deviation from the area-industry mean of R&D or growth. It is hard to imagine a channel through which the availability of government funding in area a or the external dependence of industry j would be correlated with the deviation in R&D expenditures or growth of firm i from its industry–area mean. Thus, should we find a positive coefficient for the interaction term, reverse causality is unlikely to explain it.
- *Omitted variables*: Omitted latent variables that are correlated with both R&D or growth decisions and government funding could give arise to endogeneity (David et al., 2000, and Klette et al., 2000). As the industry and area dummies capture first-order effects, i.e. the effects of potentially omitted industry and area regressors, our analysis of the interaction term should be relatively immune to criticism about an omitted variable bias.
- *Identification*: As government funding may shift MRR and MCC schedules simultaneously (David et al., 2000), it may be difficult to say whether gov-

[8] Unlike RZ's financial development-variable that varies across countries, our measure of the availability of government funding only varies within a country. This allows us to abstract from the problem of country-specific omitted variables.

ernment funding matters because it alleviates capital market imperfections or because it opens up additional R&D and growth opportunities. Our framework should be able to deal with this issue for two reasons. First, we analyze government funding, not public contracts that are expected to assist a public agency in better fulfilling its mission objectives. As David et al. (2000) argue, government funding is less likely to have an effect on the MRR schedule than public contracts. Second, and more importantly, by looking at interaction effects rather than direct effects (as usually is done), we reduce the possibility that government funding shifts the MRR schedule. The only effects, if any, of government funding that are identified are those that arise because there is within region variation in external dependence across industries.

- *Measurement error*: One of the most difficult tasks in RZ's approach is measuring industry *j*'s technological dependence on external finance. If it is measured inaccurately, measurement error might be a cause of concern to us. However, we have no a priori reason to believe that the industry-level measurement error would be correlated with the deviation in R&D expenditures or growth of firm *i* from its industry–area mean. Moreover, had we a bad proxy for the technological dependence on external finance, we would presumably be biased against finding any statistically significant effects for the interaction term. And, finally, to the extent that there is systematic variation in the industry-level measurement error, the industry dummies should capture the first-order effects of that. These same considerations apply also to measuring the amount of government funding available in area *a*.

4. The data

The empirical evidence of this paper is based on a new data set originating from a recently conducted survey in Finland. The survey was administrated by the Research Institute of the Finnish Economy (ETLA) and its subsidiary research unit and it was conducted between December 2001 and January 2002. The survey respondents were drawn from a population of active, for—profit, non-financial and non-farm corporations registered in Finland. Proprietorships, partnerships as well as subsidiaries were excluded. The data covers all major sectors, as only farm (agricultural), financial, and real-estate sectors were fully excluded.[9]

In what follows we develop our measures of: (i) innovativeness and growth; (ii) dependence on external finance; and (iii) government funding. The data are described in detail thereafter.

4.1. Measures of innovativeness and firm growth

We measure (investments in) innovativeness as the R&D expenditure of firm *i* (denoted $R\&D_i$). As $R\&D_i$ is a source of future technological improvements and a manifestation of systematic search for inventions and innovations we can view it as a measure of long-term growth opportunities.

The second dependent variable is the average sales growth rate over the next three years, as projected by the entrepreneurs themselves (denoted $GROWTH_i$).[10] It is a measure of mid-term growth opportunities.

4.2. Measures of dependence on external finance

Unlike Carlin and Mayer (2003) and Cetorelli and Gampera (2001), we do not have the option of using RZ's estimates of external dependence for manufacturing industries. In our view, it would not be prudent to assume that the industry-specific technological demands for external finance that RZ identify using large listed US firms would also apply to the Finnish SME sector. For example, firms in the RZ data are at a much later stage in their lifecycle than the firms in our data. The option is also precluded because we have only very few, if any, observations for many of RZ's manufacturing industries.

There are two problems that we need to overcome before we can construct our own estimates for external dependence. First, like RZ, we do not have data on actual use of external financing at industry level. Even if data on actual use of external financing were

[9] A more detailed description of the survey, data and the Finnish SME finance is presented in the Appendix to this paper (available from the authors on request) and in Hyytinen and Pajarinen (2003). For recent developments in the corporate finance environment and Finnish financial system, see Hyytinen et al. (2003).

[10] The variable is based on Question 11 of the survey, in which entrepreneurs were asked: "What is your average annual target rate of sales growth for the next three years?".

available by industry, it would not be useable because it would reflect the equilibrium between the demand for external finance and supply. As our test rests on the assumption that government funding matters because of market failure in capital markets, we cannot identify an industry's technological dependence on external financing by simply computing it for each industry using a selected measure. The estimate would not reflect the technological dependence, because if the capital markets are truly imperfect, actual use reflects more supply constraints than demand.

Second, our data are based on a survey that includes only few items from financial statements. This fact is a mixed blessing for us. On the one hand, it implies that we cannot use the same measure for external dependence as RZ. Moreover, because our data consists of a cross-section, we would not be able to smooth temporal fluctuations.[11] On the other hand, the data is rich in other details, including the sources of equity (ownership) and debt.

We overcome the problem of not having industry-level data on external finance in the same way as RZ do. We assume that there is a technological reason why some industries rely more on external finance than others and that these technological differences persist across different geographical areas. Provided that the differences persist, we can identify an industry's need for external finance from data on SMEs operating in the metropolitan Helsinki area under the assumption that capital markets in Helsinki are relatively frictionless. If they are, the actual amount of external funds raised by an SME residing the Helsinki metropolitan area equals its desired amount.

While we are not claiming that the capital markets in Helsinki are as perfect as the US capital markets are, the assumption is not inconsistent with the facts. First, Helsinki is the financial center and capital of Finland where the only stock exchange resides and where all major deposit banks, finance companies, venture capital firms as well as investment banks have their headquarters. Second, almost all foreign financial institutions that are present in Finland also have their offices in Helsinki. Finland and particularly the Helsinki metropolitan area have also attracted a non-negligible amount of foreign capital, including cross-border venture capital, since long-term capital movements were liberalized in 1993. Third, venture capital activity is concentrated to southern Finland, as 65% of all Finnish venture capital investments in 2000 were made in firms residing there. Fourth, household and corporate wealth, which are a potential source of initial finance to start-ups, angel finance and trade credit, are also concentrated in the Helsinki metropolitan area. Finally, even if the supply of capital was not perfectly elastic in the metropolitan Helsinki area, the methodology provides a reasonable measure of the *relative* demand for funds by different industries under the weaker assumption that the elasticity of the supply curve does not change substantially in the cross-section of industries (RZ, p. 564). As we already discussed earlier, also the inclusion of industry dummies into the regression and our focus on the interaction term alleviate the concerns that an industry-level measurement error might give rise to.

In order to overcome the problem of paucity of items from financial statements, we measure dependence on external finance in four different ways. First, we utilize our survey questions (and the information on firms' balance sheets available to us) to calculate the fraction of total debt and equity that is attributable to corporate outsiders, i.e. to investors that belong neither to the management nor the personnel of the firm. This fraction, denoted EXDEPOUT_i, is computed as the sum of outside equity and credit supplied by corporate outsiders. Outside equity consists of the fraction of total shareholders' equity not owned by the management or personnel of a firm.[12] Outside loan financing consists of credit supplied by financial institutions (such as banks, finance firms, other domestic financial institutions), non-financial businesses (trade credit, loans from other firms) and government.

Second, we estimate a firm's dependence on external finance using a financial planning model (called

[11] To the extent that an industry's technological dependence on external finance *changes* as it emerges, matures and dies (like industries typically do), we would probably like to measure the degree of dependence for industry *j* that is currently prevailing. In this sense, having just one cross-section is not as problematic as it may first sound.

[12] Because shareholders' equity consists mainly of share capital and retained earnings and because outsiders would have been entitled to receive retained earnings as dividends in proportion to their ownership in the firm, we assume that the part of the retained earnings that can be attributed to outside owners on the basis of their ownership represents capital infusions by outsiders.

also the 'percentage of sales' approach; see Higgins, 1977; Demirkgüç-Kunt and Maksimovic, 1998, 2002). Under certain assumptions, the financial planning model allows us to compute the 'excess growth' made possible by external finance. The measure, denoted $\mathrm{EXDEPSG}_i$, is defined as a dummy set to one if the difference between a firm's realized sales growth rate, ΔS_i, and its maximum sustainable growth, SG_i, is positive. The maximum sustainable growth rate assumes that the firm does not pay dividends and that it obtains enough short-term and long-term credit to maintain a constant ratio of debt to equity.[13] Whilst this measure is attractive because it is based on a standard model, and because it has been extensively used before, it does have the drawback that it does not take into account the long-term nature of R&D investments. We expect it to perform less well in the R&D than in the growth regressions, as the latter are explicitly taking a mid-term view, consistent with this measure of financial dependence.

The remaining two of our four measures for dependence for external finance are profitability-based. $\mathrm{EXDEPLOSS}_i$, classifies firm i as dependent on external finance if its return on assets was negative in the last fiscal year. $\mathrm{EXDEPPROF}_i$, classifies firm i as dependent on external finance if the entrepreneur answered in the survey that her firm's current profitability is *not* better than it has been over the last three years on average.[14]

To aggregate the four measures across companies in the metropolitan Helsinki region we calculate industry averages.[15] The resulting industry-level variables (denoted with subscript j, not i), provide us with four alternative measures for industry j's need for external finance. In other words, External dependence_j is a generic measure, taking four different forms:

$$-\text{External dependence}_j \in \times \left\{\mathrm{EXDEPOUT}_j,\ \mathrm{EXDEPSG}_j,\ \mathrm{EXDEPLOSS}_j,\ \times\mathrm{EXDEPPROF}_j\right\}$$

To check how robust the assumption of equal financial dependence within industries is in our data, we did the following: using data on firms in Helsinki only, we decomposed the variance in the different measures of financial dependence into within and between industry variation. While within industry variation is the largest component, we comfortingly found that even when we took all the firm-level explanatory variables in Table 5 (see below) into account, between industry variation explained about a third of the total variation captured by the model.

We present descriptive statistics for the measures of external dependence both at the firm-level and industry-level in Section 4.4, where the data are described.

4.3. Measures of government funding

Ideally, the availability of government funding should be measured with the ease at which SMEs, especially those suffering from capital market imperfections, obtain finance from various government sources. There is little agreement on how this kind of availability is appropriately measured and, typically, even less data available.

To develop a measure for the regional availability of government funding, we begin by calculating the amount of government funding received by each SME in our sample from all the agencies providing public SME support in Finland. What's instrumental to our empirical set-up, all organizations providing government funding in Finland have been assigned the task to rectify capital market imperfections (even if there are some differences in focus). It is this aspect of government funding on which our empirical tests focus. Further, it simplifies matters that Finland provides no tax incentives for R&D or growth, but emphasizes government funding (see, e.g. Georghiu et al., 2003 for a recent description of the Finnish Innovation Policy).

The National Technology Agency (Tekes), Finnvera plc (a specialised financing company owned entirely by

[13] It is computed as $\mathrm{SG}_i = \mathrm{ROE}_i/(1 - \mathrm{ROE}_i)$, where ROE_i is defined as the ratio of profit (loss) for the fiscal period to shareholders' equity.

[14] The variable is based on Question 20 in the survey. In the question, entrepreneurs were asked: "Is the current profitability of your firm better than the firm's profitability has been over the last three years on average?".

[15] We group the firms into 14 broad industry categories based on two- and three-digit SIC-like industry codes. We end up with 14 industries, because we need to have industries for which there are firms operating within the metropolitan Helsinki area (so that we can estimate industry j's dependence for external finance) and for which there are firms operating outside the metropolitan Helsinki area (so that we can estimate Eq. (1)). The industries are listed in Section 4.4, where the data are described.

the Finnish state), and the Finnish National Fund for Research and Development (Sitra), are the most prominent sources of public support to firms in Finland. Tekes finances R&D projects of companies and universities and its funds are awarded from state budget via the Ministry of Trade and Industry. It grants loans and capital loans, which are not gratuitous (i.e. they are repayable and priced at a below-market interest rate), as well as pure R&D subsidies, which are gratuitous (i.e. they are not repayable). Sitra provides government venture capital funding for early stage technology companies and for commercialization of innovations. It uses equity and equity-linked instruments, which are not gratuitous (i.e. capital is injected only in exchange for a ownership stake in the company). Through its nationwide branch network, Finnvera offers various financing services, such as subsidized loans and guarantees, to promote the domestic operations and internationalization of Finnish SMEs. Some of its financial services are gratuitous (guarantees) while some are not (loans). Of these agencies, Tekes and Finnvera explicitly take the location of the firm into account in making their decisions. In addition to Tekes, Sitra and Finnvera, there are 15 regional employment and economic development centres ('TE Centres') that provide public support, both financial and non-financial, to SMEs. The financial support that TE Centres provide is mainly awarded from state budget via the Ministry of Labour. They all are gratuitous. Finally, some government funding to SMEs is provided through Finnish Industry Investment (FII) Ltd. (a government-owned fund of funds, which also invests directly in Finnish firms), as well as through relatively small regional, semi-governmental and municipal-owned venture capital firms. Financing provided by these organizations is typically non-gratuitous.

The survey data allows us to compute for each firm in the sample the fraction of total debt and equity that is attributable to any of the above-described government agencies providing public SME support and R&D finance in Finland. We denote the fraction GOVFUN_i. The measure captures only the extent to which firm i relies on government funding that is not gratuitous, i.e. that is either repayable or that is provided only in exchange for an ownership stake and is thus recorded in their balance sheets. We address this issue and other characteristics of GOVFUN_i below.

In similar vein to RZ's financial development variable, we measure government funding regionally. To aggregate GOVFUN_i geographically, we compute area averages of it within each of the 15 TE Centres. TE Centres together cover the entire Finland and naturally, the areas in which individual TE Centres are active do not overlap.[16] Aggregation provides us with a measure for the amount of governmental funding available in area a, GOVFUN_a.

It is important to emphasize the nature and limitations of GOVFUN_a:

- GOVFUN_a does not account for government funding that is not recorded in the balance sheet of firms. Examples of such government funding include subsidies (aid) that are recognized as revenue when received and that effectively are gratuitous. While we do not have data on the *amount* of such subsidies, the survey data include qualitative information on them. We can therefore address the limitation by showing that an omitted subsidy variable is not driving our results (see Section 5.2).
- Previous analyses, including Lichtenberg (1988) and Wallsten (2000), have used government funds 'potentially awardable' to firms as an instrument for a firm-level subsidy variable like GOVFUN_i when estimating the effects of government funding on firm performance. Our GOVFUN_a is similar in nature to the instrument. However, firms may do more R&D or pursue stronger growth (by running down current cash holdings and using short-term credit, etc.) in areas where there is a lot of 'potentially awardable' government funds around, *anticipating* that they can rely on government funding in future if needed. The exclusion restriction used in the previous analyses is therefore not totally unproblematic,

[16] The TE Centres are the natural unit of analysis, because their primary function is the provision of public support, both financial and non-financial, to local economies and especially to firms. The Business Departments of TE Centres advise start-ups, provide services to promote internationalization of firms, encourage firms to adopt new technologies and supply capital to partially finance firm's investment and development projects. By design, the geographical distribution of TE Centres reflects the geographical distribution of the relevant local capital markets better than that of municipalities or provinces. While TE Centres are a preferred regional unit of ours, we show in Section 5.2 that our results are robust to using an alternative geographical division.

because $GOVFUN_a$ can, similarly to financial development in RZ, be an important determinant of R&D and growth decisions, especially to firms in industries that are more dependent on external finance. The benefit of the definition of $GOVFUN_a$ is, from our point of view, that it captures this kind of (previously overlooked) indirect effects (not unlike the financial development-variable in RZ).[17]

- By relying on $GOVFUN_a$ we only observe the equilibrium between the demand for government funding and its supply in each TE Centre. In areas where capital market imperfections are more severe, firms are keener to rely on government funding. $GOVFUN_a$ also provides us with information about the regional supply of government funding because the more government funding is available, the easier it is for SMEs to obtain some. Whichever of these is the more important source of variation, $GOVFUN_a$ is relatively more important for firms in industries that are more dependent on external finance.[18]

Finally, we need to emphasize the assumption that the capital markets for SMEs are at least partly local. While a growing number of studies support the assumption (Lerner, 1995; Petersen and Rajan, 2002), it is a potential source of bias. A violation of this assumption creates a bias against finding any statistically significant effects.

4.4. Descriptive statistics

We present firm-level summary statistics in Table 1. The first thing to note is that the number of observations for an explanatory variable may exceed the number observations for the dependent variables. The reason is that we lack data on $R\&D_i$ for some firms for which we have data on $GROWTH_i$, and vice versa. The mean of $R\&D_i$ is 0.11 millions of euros, while that of $GROWTH_i$ is as high as 19%.[19] There is more variation in $R\&D_i$ than in $GROWTH_i$, and the maximum of both variables is large relative to the mean. Although not shown in the table, 38% of the 618 $R\&D_i$ observations are zero. The corresponding number for $GROWTH_i$ is 27%.

Table 1 also reports descriptive statistics for $EXDEPOUT_i$, $EXDEPSG_i$, $EXDEPLOSS_i$, and $EXDEPPROF_i$, as well as $GOVFUN_i$, measured here

Table 1
Firm-level descriptive statistics

	Obs.	Mean	S.D.	Min	Max
$R\&D_i$	618	0.11	0.69	0.00	15.47
$GROWTH_i$	675	0.19	0.49	0.00	10.00
$EXDEPOUT_i$	723	0.40	0.34	0	1
$EXDEPSG_i$	646	0.36	0.48	0	1
$EXDEPLOSS_i$	724	0.10	0.31	0	1
$EXDEPPROF_i$	675	0.33	0.47	0	1
$GOVFUN_i$	715	0.07	0.16	0	1
AGE_i	723	15.92	16.69	0	118
EMP_i	724	17.16	26.60	1	230
$CEOAGE_i$	706	9.34	7.07	0	42
$CEOEDUC_i$	709	0.29	0.45	0	1
$PRINSOWN_i$	724	0.69	0.46	0	1
$SHAREAGR_i$	712	0.24	0.43	0	1
$CONCOWN_i$	723	0.96	0.21	0	1
$FOREOWN_i$	724	0.04	0.20	0	1
$BOARDOWN_i$	723	0.88	0.33	0	1
$BOARD_i$	723	2.85	1.49	0	12
$BOARDINS_i$	723	1.76	1.03	0	8
$CEOCHAIR_i$	722	0.50	0.50	0	1
$INPROD_i$	720	0.44	0.50	0	1
$INPROC_i$	716	0.30	0.46	0	1
$PATENT_i$	723	0.12	0.33	0	1
$INTANG_i$	722	0.22	0.41	0	1
$LOANDEN_i$	724	0.05	0.21	0	1
$AUDIT_i$	721	0.24	0.43	0	1
$AWARD_i$	724	0.45	0.50	0	1

Notes: This table reports firm-level descriptive statistics (number of observations, mean, standard deviation, minimum and maximum). The number of observations for an explanatory variable may exceed the number observations for the dependent variables, because we lack data on $R\&D_i$ for some firms for which we have data on $GROWTH_i$, and vice versa. All the information is obtained from a primary survey administrated by the Research Institute of the Finnish Economy (ETLA) and its subsidiary Etlatieto Ltd. between December 2001 and January 2002. The survey covered SMEs that are not proprietorships, partnerships, or subsidiaries and that are not from farm, financial, or real-estate sectors.

[17] We address the potential limitation of model (1) that it does not include the firm-level $GOVFUN_i$ in the estimating equation by showing that our results remain intact even if it is included. The results of this robustness test are presented in Section 5.2.

[18] If there were no variation cross TE Centres in capital market conditions, the measure for government funding would only reflect variation in the regional supply of government funding. Similarly, if there were no variation in the regional supply, our measure would only reflect variation in capital market conditions cross TE Centres. In other words, even if there was no deliberate public policy to allocate different amounts of funding to different regions, we can proceed with our tests as long as there is variation in the data.

[19] Median of $R\&D_i$ and $GROWTH_i$ are .008 million euros and 10%.

Table 2
Industry-level descriptive statistics for external dependence

Panel A	Means			
	$EXDEPOUT_j$	$EXDEPSG_j$	$EXDEPLOSS_j$	$EXDEPPROF_j$
ICT services, excluding software	0.49	0.33	0.14	0.29
R&D services	0.49	0.38	0.22	0.75
Wood-processing and chemicals	0.46	0.50	0.50	0.67
Printing and publishing	0.46	0.67	0.20	0.50
Mechanical engineering	0.46	0.22	0.00	0.20
Trade and transport	0.40	0.29	0.04	0.36
Electrical engineering n.e.c.	0.40	0.00	0.00	0.50
Food, beverages, textiles	0.37	0.33	0.00	0.50
Scientific instruments	0.34	0.0	0.00	0.20
ICT manufacturing n.e.c.	0.32	0.36	0.00	0.31
Computers	0.31	0.60	0.29	0.57
Software	0.27	0.43	0.21	0.43
Metals, construction, energy supply	0.18	0.25	0.00	0.33
Services n.e.c.	0.16	0.26	0.05	0.35

Panel B	Summary statistics			
	Mean	S.D.	Min	Max
$EXDEPOUT_j$	0.37	0.11	0.16	0.49
$EXDEPSG_j$	0.37	0.18	0.00	0.67
$EXDEPLOSS_j$	0.12	0.15	0.00	0.50
$EXDEPPROF_j$	0.43	0.17	0.20	0.75

Notes: n.e.c. = not elsewhere cited. Panel A of this table reports the mean of the four measures of external dependence for 14 industries (defined using two-level SIC-like industry codes), measured using data on SMEs residing in the metropolitan Helsinki area. Panel B of the table reports summary statistics for the four measures. All the information is obtained from a primary survey administrated by the Research Institute of the Finnish Economy (ETLA) and its subsidiary Etlatieto Ltd. between December 2001 and January 2002. The survey covered SMEs that are not proprietorships, partnerships, or subsidiaries and that are not from farm, financial, or real-estate sectors.

at the firm-level. What the table reveals is that on average, 40% of the total funds of SMEs can be attributed to outside investors; 36% of firms have grown using external finance, i.e. faster than the maximum sustainable growth rate; 10% of the firms are making losses; and the profitability of every third firm is currently lower than or the same as it has been during the past three years. Finally, on average, 7% of the total funds of SMEs can be attributed to government sources.

As Table 1 reveals, the data also include several firm-level control variables. Firms in our sample are on average 16 years old (AGE_i), and have 17 employees (EMP_i). The current CEOs have managed the firm nine years on average ($CEOAGE_i$), and 29% of them have a university degree ($CEOEDUC_i$). Sixty-nine percent of firms have a strong principal, controlling, owner ($PRINSOWN_i$); in 96% of firms the combined ownership of the three largest shareholders exceeds 50% ($CONOWN_i$); 4% have foreign shareholders ($FOREOWN_i$); and in 88% of firms, the ownership of board members exceeds 50% ($BOARDOWN_i$). The average number of board members ($BOARD_i$) is 2.85, and that of firm's executives and other personnel on the board ($BOARDINS_i$) is 1.76. The CEO is the chairman of the board ($CEOCHAIR_i$) in half of the firms. Forty-four percent of firms have made a product innovation during the last three years ($INPROD_i$), and 30% have made a process innovation during the last three years ($INPROC_i$). Every eighth firm has patents ($PATENT_i$), and 22% have intangible assets ($INTANG_i$ = dummy set to 1 if the entrepreneur evaluates that his/her firm owns other intangible assets than patents). The firms in the sample seem to be what we would expect for a group of small, high-tech firms.[20]

[20] Finally, Table 1 reports descriptive statistics for three variables that will be used to evaluate the robustness of our results. The

Table 3
TE Centre-level descriptive statistics for government funding

Panel A	Mean $GOVFUN_a$
Kainuu	0.17
Pohjois-Pohjanmaa	0.12
Etelä-Savo	0.11
Varsinais-Suomi	0.11
Keski-Suomi	0.11
Pohjois-Karjala	0.10
Pohjois-Savo	0.09
Lappi	0.06
Häme	0.06
Etelä-Pohjanmaa	0.05
Satakunta	0.05
Pirkanmaa	0.04
Kaakkois-Suomi	0.04
Pohjanmaa	0.04
Uusimaa	0.04

Panel B	Summary statistics			
	Mean	S.D.	Min	Max
$GOVFUN_a$	0.08	0.04	0.04	0.17

Notes: n.e.c. = not elsewhere cited. Panel A of this table reports the mean of government funding for 15 TE Centres, measured using data on SMEs residing in each TE-Centre. Panel B of the table reports summary statistics for the measure. All the information is obtained from a primary survey administrated by the Research Institute of the Finnish Economy (ETLA) and its subsidiary Etlatieto Ltd. between December 2001 and January 2002. The survey covered SMEs that are not proprietorships, partnerships, or subsidiaries and that are not from farm, financial, or real-estate sectors.

Table 2 reports the external dependence for each of our industries, as measured using data on SMEs residing in the metropolitan Helsinki area. The table shows that according to $EXDEPOUT_j$, '*ICT services, excluding software*' is the most and '*Services n.e.c.*' the least dependent industry on external finance. The ranking of the industries naturally varies with the measure used. The measures are, however, positively correlated. While not reported in the table, the largest correlation (between $EXDEPSG_j$ and $EXDEPLOSS_j$) is 0.52, while the smallest one (between $EXDEPOUT_j$ and $EXDEPSG_j$) is 0.12. Note, finally, that $EXDEPLOSS_j$ has more variation cross industries than the other three measures.

Finally, Table 3 reports the average reliance by firms on government funding for each TE Centre. The table shows that in a TE Centre situated in '*Kainuu*' firms rely most (on average 17%) and in '*Uusimaa*' and in '*Pohjanmaa*' least (to be precise, on average 4.0 and 4.2%, respectively) on government funding. These patterns are remarkably intuitive, because '*Uusimaa*' includes the metropolitan Helsinki area and because '*Kainuu*' lies in North-Eastern Finland (located nearby the Russian border) and suffers from persistent structural problems and a shrinking economy. The mean of $GOVFUN_a$ cross TE Centres is 8%.

5. Empirical results

5.1. Basic results

We have estimated Eq. (1) using a number of methods. We concentrate, however, on reporting standard Tobit estimates for two reasons: First, our results turned out to be robust to using alternative estimation methods, such as OLS and the nonparametric (heteroscedasticity-robust) censored least absolute deviation (CLAD) estimation method proposed by Powell (1984). Second, using the standard Tobit means that we explicitly allow for the possibility that R&D expenditures or expected growth is censored at zero.[21]

In Table 4 we report our basic Tobit results, obtained using the four different measures of external dependence (one column each), and using our two dependent variables ($R\&D_i$ in Panel A, $GROWTH_i$ in Panel B). Besides the interaction term, the specification also includes industry and area dummies, AGE_i, EMP_i and their squares. Age and employment control for size, unobserved managerial talent and firm reputation (through survival), and also to some extent for physical capital (as it is known to correlate positively with age and employment). While these variables may also control for, e.g. capital market access, we include later

variables are $AUDIT_i$ (= dummy set to 1 if firm is audited by one of the internationally recognized 'Big Five' accounting firms), $LOANDEN_i$ (= dummy set to 1 if firm's loan applications has been turned down because of lack of collateral and/or guarantees during the last two years) and $AWARD_i$ (= dummy set to 1 if firm has during the last fiscal year or prior to it received gratuitous government awards of any kind (or if it has loans guaranteed by a governmental agency) that are not recorded in the balance sheet).

[21] No firm reported a negative expected growth. We treat this as a reporting bias: it is likely that some of the firms that report zero expected growth actually expect negative growth, but were reluctant to answer so. Our framework allows for such a possibility.

Table 4
R&D and firm growth regressions

Panel A	Dependent variable: $R\&D_i$							
	(1)		(2)		(3)		(4)	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
$GOVFUN_a{}^*$								
$EXDEPOUT_j$	26.88	2.04	–		–		–	
$EXDEPSG_j$	–		13.02	1.54	–		–	
$EXDEPLOSS_j$	–		–		29.73	3.46	–	
$EXDEPPROF_j$	–		–		–		22.21	2.41
AGE_i	−8.5E − 03	−1.11	−7.7E − 03	−1.01	−6.9E − 03	−0.91	−7.4E − 03	−0.96
$AGE\hat{}2_i$	3.7E − 05	0.43	3.0E − 05	0.35	2.0E − 05	0.24	2.4E − 05	0.29
EMP_i	0.02	5.29	0.02	5.13	0.02	5.24	0.02	5.25
$EMP\hat{}2_i$	−1.0E − 04	−3.49	−1.0E − 04	−3.44	−1.0E − 04	−3.45	−1.0E − 04	−3.50
Ind. dummies	Yes		Yes		Yes		Yes	
Area dummies	Yes		Yes		Yes		Yes	
Observations	476		476		476		476	
Censored obs.	173		173		173		173	
Log likelihood	−472.28		−473.19		−468.43		−471.49	
LR chi-square	82.14		80.33		89.84		83.73	
Degree of freedom	32		32		32		32	
Significance	0.00		0.00		0.00		0.00	
R^2_{pseudo}	0.08		0.08		0.09		0.08	

Panel B	Dependent variable: $GROWTH_i$							
	(1)		(2)		(3)		(4)	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
$GOVFUN_a{}^*$								
$EXDEPOUT_j$	12.22	1.80	–		–		–	
$EXDEPSG_j$	–		10.39	2.20	–		–	
$EXDEPLOSS_j$	–		–		19.93	4.15	–	
$EXDEPPROF_j$	–		–		–		14.83	2.89
AGE_i	−0.01	−3.30	−0.01	−3.19	−0.01	−3.06	−0.01	−3.21
$AGE\hat{}2_i$	1.1E − 04	2.28	1.1E − 04	2.19	9.8E − 05	2.05	1.1E − 04	2.19
EMP_i	8.2E − 03	3.58	7.8E − 03	3.43	7.9E − 03	3.53	7.9E − 03	3.51
$EMP\hat{}2_j$	−4.1E−05	−2.74	−3.9E − 05	−2.68	−3.9E − 05	−2.68	−4.0E − 05	−2.74
Ind. dummies	Yes		Yes		Yes		Yes	
Area dummies	Yes		Yes		Yes		Yes	
Observations	519		519		519		519	
Censored obs.	97		97		97		97	
Log likelihood	−398.09		−397.30		−391.28		−395.56	
LR chi-square	69.45		71.04		83.07		74.51	
Degree of freedom	32		32		32		32	
Significance	0.00		0.00		0.00		0.00	
R^2_{pseudo}	0.08		0.08		0.10		0.09	

Notes: This table reports Tobit regressions of the model: $Y_i = \alpha + \beta(\text{External dependence}_j \times \text{Government funding}_a) + \Phi_1 \times \text{Industry dummies}_j + \Phi_2 \times \text{Area dummies}_a + \Phi_3 \times \text{Controls}_i + \text{Error}_i$. In Panel A, the dependent variable is R&D in millions of euros. In Panel B, it is the average sales growth rate over the next three years, as projected by the entrepreneurs themselves. The coefficients corresponding to rows $EXDEPOUT_j$, $EXDEPSG_j$, $EXDEPLOSS_j$, and $EXDEPPROF_j$ are those of the interaction term because we are not able to identify any direct effects of these variables because of the inclusion of industry and area specific dummies (coefficients are for brevity not reported). Since we use data from the Helsinki metropolitan area to identify dependence on external finance, we have dropped SMEs residing in that area from the regressions.

Table 5
R&D and firm growth regressions with further firm-level controls

Panel A	Dependent variable: $R\&D_i$							
	(1)		(2)		(3)		(4)	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
$GOVFUN_a{}^*$								
$EXDEPOUT_j$	29.26	2.15	–		–		–	
$EXDEPSG_j$	–		10.98	1.29	–		–	
$EXDEPLOSS_j$	–		–		31.83	3.57	–	
$EXDEPPROF_j$	–		–		–		24.92	2.60
AGE_i	−0.01	−1.21	−9.7E − 03	−1.04	−9.7E − 03	−1.05	−0.01	−1.08
$AGE\hat{}2_i$	3.8E − 05	0.37	2.4E − 05	0.23	2.2E − 05	0.22	2.6E − 05	0.26
EMP_i	0.02	4.28	0.02	4.09	0.02	4.26	0.02	4.25
$EMP\hat{}2_i$	−9.2E − 05	−2.98	−9.1E − 05	−2.93	−9.1E − 05	−2.98	−9.4E–05	−3.04
$CEOAGE_i$	−5.9E − 04	−0.07	−1.5E − 03	−0.18	−4.9E − 04	−0.06	−4.6E − 04	−0.06
$CEOEDUC_i$	0.23	2.01	0.23	2.01	0.21	1.86	0.23	1.98
$PRINSOWN_i$	−0.03	−0.29	−0.02	−0.18	−0.01	−0.12	−0.02	−0.15
$SHAREAGR_i$	−0.15	−1.26	−0.15	−1.28	−0.15	−1.27	−0.13	−1.12
$CONCOWN_i$	0.07	0.26	0.07	0.26	0.08	0.27	0.10	0.34
$FOREOWN_i$	−0.10	−0.39	−0.09	−0.35	−0.06	−0.22	−0.09	−0.37
$BOARDOWN_i$	0.15	0.81	0.12	0.65	0.12	0.64	0.12	0.64
$BOARD_i$	0.12	2.94	0.12	2.98	0.12	3.08	0.13	3.16
$BOARDINS_i$	−0.13	−2.39	−0.12	−2.13	−0.13	−2.32	−0.13-2	−2.26
$CEOCHAIR_i$	−0.01	−0.11	−0.01	−0.10	7.1E − 03	0.06	0.01	0.13
$INPROD_i$	0.13	1.22	0.11	1.04	0.14	1.35	0.17	1.54
$INPROC_i$	0.09	0.84	0.09	0.89	0.05	0.45	0.05	0.50
$PATENT_i$	0.38	2.69	0.39	2.73	0.35	2.54	0.35	2.50
$INTANG_i$	0.26	2.17	0.25	2.12	0.27	2.32	0.25	2.10
Ind. dummies	Yes		Yes		Yes		Yes	
Area dummies	Yes		Yes		Yes		Yes	
Observations	448		448		448		448	
Censored obs.	157		157		157		157	
Log likelihood	−431.36		−432.85		−427.39		−430.31	
LR chi-square	124.32		121.34		132.25		126.41	
Degree of freedom	46		46		46		46	
Significance	0.00		0.00		0.00		0.00	
R^2_{pseudo}	0.13		0.12		0.13		0.13	

Panel B	Dependent variable: $GROWTH_i$							
	(1)		(2)		(3)		(4)	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
$GOVFUN_a{}^*$								
$EXDEPOUT_j$	12.39	1.80	–	–			–	
$EXDEPSG_j$	–		9.94	2.10	–		–	
$EXDEPLOSS_j$	–		–		20.99	4.28	–	
$EXDEPPROF_j$	–		–		–		16.17	3.10
AGE_i	−0.01	−2.61	−0.01	−2.45	−0.01	−2.40	−0.01	−2.51
$AGE\hat{}2_i$	8.5E − 05	1.56	7.7E − 05	1.43	7.2E − 05	1.35	7.8E − 05	1.45
EMP_i	5.6E − 03	2.27	5.0E − 03	2.07	5.0E − 03	2.31	5.4E − 03	2.22
$EMP\hat{}2_i$	−2.9E − 05	−1.87	-2.7E − 05	−1.76	−2.7E − 05	−1.86	−2.9E − 05	−1.89

Table 5 (*Continued*)

Panel B	Dependent variable: $GROWTH_i$							
	(1)		(2)		(3)		(4)	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
$CEOAGE_i$	−5.5E − 03	−1.23	−5.8E − 03	−1.34-5	−5.8E − 03	−1.34	−5.5E − 03	−1.26
$CEOEDUC_i$	0.09	1.36	0.08	1.31	0.08	1.24	0.09	1.39
$PRINSOWN_i$	8.5E − 03	0.13	0.02	0.26	0.01	0.23	0.01	0.20
$SHAREAGR_i$	−0.06	−0.91	−0.06	−0.97	−0.06	−0.93	−0.05	−0.70
$CONCOWN_i$	0.03	0.20	0.03	0.21	0.03	0.19	0.04	0.26
$FOREOWN_i$	−0.16	−1.13	−0.15	−1.04	−0.12	−0.88	−0.15	−1.05
$BOARDOWN_i$	0.10	1.04	0.08 0.8	0.08	0.83		0.08	0.82
$BOARD_i$	0.06	2.54	0.06	2.49	0.06	2.58	0.06	2.70
$BOARDINS_i$	−0.05	−1.84	−0.05	−1.61	−0.05	−1.77	−0.05	−1.84
$CEOCHAIR_i$	−0.03	−0.53	−0.04	−0.64	−0.02	−0.39	−0.03	−0.41
$INPROD_i$	−0.02	−0.26	−0.02	−0.42	5.3E − 04	0.01	.2E − 03	0.07
$INPROC_i$	−3.3E − 03	−0.06	−3.4E − 03	−0.06-0.04-0.6	−0.04	−0.69	−0.03	−0.59
$PATENT_i$	0.31	3.82	0.32	3.87	0.29	3.60	0.29	3.54
$INTANG_i$	0.13	1.87	0.13	1.93	0.14	2.06	0.13	1.87
Ind. dummies	Yes		Yes		Yes		Yes	
Area dummies	Yes		Yes		Yes		Yes	
Observations	491		491		491		491	
Censored obs.	90		90		90		90	
Log likelihood	−363.28		−362.72		−356.00		−360.17	
LR chi-square	109.06		110.18		123.63		115.28	
Degree of freedom	46		46		46		46	
Significance	0.00		0.00		0.00		0.00	
R^2_{pseudo}	0.13		0.13		0.15		0.14	

Notes: see Table 4.

(see Table 5) a much longer vector of firm controls to illustrate that our findings are not due to this particular (and admittedly rather parsimonious) choice of the controls at this stage. Since we use data from the Helsinki metropolitan area to identify dependence on external finance, we drop SMEs residing in that area from all regressions.[22]

In the first column, the measure for external dependence is $EXDEPOUT_j$. We find that the coefficient for the interaction term is positive and statistically significant at the 5% level in the R&D and at the 10% level in the growth equation. As the second column shows, when our measure for external dependence is $EXDEPSG_j$, the interaction term is significant at standard levels only in the growth equation. As we discussed earlier, this measure of financial dependence does not take into account the long-term nature of R&D, and was therefore expected to perform less well in the R&D equation. In column three, external dependence is measured using $EXDEPLOSS_j$. The interaction term carries a highly significant positive coefficient in both equations. Finally, in column four, external dependence is measured using $EXDEPPROF_j$. Again, the interaction terms' coefficients are positive and highly significant. These results suggest that the R&D investments and perceived growth prospects of firms that operate in industries that are dependent on external financing are disproportionately positively affected by the availability of government funding in their area. This is evidence both for imperfections in (local) capital markets, as well as for positive (additionality) effects of government funding.

[22] This means that we 'lose' in total 165 firm-observations. We have also run the regressions reported in Table 4 including these firms with a Helsinki dummy variable for the excluded firms and the product of the interaction term and the Helsinki dummy. The results do not differ from those reported here.

Table 4 also reveals that $R\&D_i$ and $GROWTH_i$ are initially directly related to the size of the SME, as measured by EMP_i, but begin to decrease with size after a threshold. AGE_i has a non-linear effect only on $GROWTH_i$.

Table 5 repeats the exercise but now the results are based on an extended specification with 14 additional firm characteristics. We lose 28 observations compared to Table 4. The new variables aim to control for managerial talent (CEO age and education), effects of ownership and corporate control (principal owner, shareholder agreement, ownership concentration, foreign ownership, owner a board member, board size, number of insiders on the board, CEO chair of the board), innovation (product, process innovation), intellectual property (patent) and intangible capital. While these new variables allow us to control for firm-specific access to capital markets, for variation around the industry–area mean in the technological need for external finance, as well as for an array of known R&D determinants, this extended control of firm characteristics comes at the price of possible endogeneity problems. As our main interest is however in the coefficient of the interaction term, not in the coefficients of the firm characteristics, we regard their inclusion is an important robustness exercise. It is promising to note that the results do not change; even the point estimates are very close to those in Table 4. Our results on capital market imperfections and effects of government financing are not driven by omitted firm-level characteristics.

It is of some independent interest to observe that $CEOEDUC_i$, $BOARD_i$, $PATENT_i$ and $INTANG_i$ have a statistically significant positive correlation with $R\&D_i$, while $BOARDINS_i$ correlates negatively with it. These qualitative results are similar in the $GROWTH_i$ regression, with the exception that correlation with $CEOEDUC_i$ is not statistically significant. These findings are what one would expect, though the positive correlation with board size is a bit surprising. The other firm-level control variables do not obtain statistically significant coefficients in either equation.

5.2. *Economic significance of results*

A first question to ask if one is interested in the effectiveness of R&D subsidies as a policy tool is: Are the documented effects economically significant? To address this question, we display in Table 6 a set of marginal effects evaluated at the means of the independent variables for the models reported in Table 5 (i.e. using the full set of firm-level control variables and the four measures for external dependence). The marginal effects are presented for the expected value of the dependent variable conditional on being uncensored, the unconditional expected value of the dependent variable, and the probability of being uncensored.

To begin with, consider the marginal effects reported in Panel A for the interaction term that is based on $EXDEPOUT_j$. If there was a two percentage point (half the cross area standard deviation) increase in government funding in the area where a firm resides, then in an industry where, say, every fifth euro is attributable to outside financiers, (i) the firm would, on average, invest about 0.05 million euros more in R&D ($0.2 \times 0.02 \times 11.460 \approx 0.046$); (ii) the firm would, provided that it already does R&D, invest about 0.04 million euros more in R&D ($0.2 \times 0.02 \times 9.005 \approx 0.036$) on the top it is currently investing; and (iii) the probability of the firm doing R&D would be around 5% higher ($0.2 \times 0.02 \times 13.374 \approx 0.053$). Given that the unconditional mean R&D in the estimation sample is 0.10 million euros, the mean R&D conditional on doing R&D is 0.15 million euros and the probability of being censored is 0.35, the effects are economically not negligible. The effects are of similar magnitude for the other measures of external dependence and for the growth equation. We have also calculated the figures using the alternative approach of calculating them for each firm (at the values of the explanatory variables for each firm), and averaging over firms. The results are very close to those reported.

What the reported marginal effects also illustrate is that government funding *disproportionately* helps firms in industries that are *more* dependent on external finance. For example, in an area where every thirtieth euro of the total debt and equity is attributable to government agencies, the *differential* in the probability of doing R&D is about 5% points ($(0.33 - 0.2)0.03 \times 13.374 \approx 0.052$) between firms in industries where every third euro is attributable to outside financiers and firms in industries where every fifth euro is attributable to outside financiers. The corresponding differential in the probability of becoming a growth firm is nearly four percentage points ($(0.33 - 0.2)0.03 \times 9.415 \approx 0.036$).

Table 6
Marginal effects

Panel A	Dependent variable: $R\&D_i$		
	Marginal effects at the means of explanatory variables		
	Unconditional expected value	Conditional on being uncensored	Probability uncensored
$GOVFUN_a$*			
$EXDEPOUT_j$	11.46	9.00	13.37
$EXDEPSG_j$	4.31	3.39	5.01
$EXDEPLOSS_j$	12.49	9.80	14.76
$EXDEPPROF_j$	9.78	7.68	11.45
	Unconditional mean value	Mean conditional on being uncensored	Probability uncensored
$R\&D_i$	0.10	0.15	0.65
Panel B	Dependent variable: $GROWTH_i$		
	Marginal effects at the means of explanatory variables		
	Unconditional expected value	Conditional on being uncensored	Probability uncensored
$GOVFUN_a$ x			
$EXDEPOUT_j$	7.10	5.02	9.42
$EXDEPSG_j$	5.71	4.04	7.58
$EXDEPLOSS_j$	12.11	8.56	16.25
$EXDEPPROF_j$	9.29	6.57	12.38
	Unconditional mean value	Mean conditional on being uncensored	Probability uncensored
$GROWTH_i$	0.18	0.21	0.82

Notes: This table reports the marginal effects of the Tobit regressions for the models that include area and industry fixed effects and the full vector of control variables (reported in Table 5): In Panel A, the dependent variable is R&D in millions of euros. In Panel B, it is the average sales growth rate over the next three years, as projected by the entrepreneurs themselves. The marginal effects have been evaluated at the means of the explanatory variables. The unconditional mean, mean conditional on being uncensored and probability uncensored of the dependent variables refer to the estimating sample.

5.3. Robustness tests

We have run an extensive battery of robustness tests, resulting in over *80* new estimates for the interaction term. The robustness tests are reported in detail in a separate appendix, available upon request.

Summing up, these estimates show that our results are robust to using a variety of alternative definitions of the key independent variables (i.e. measures of external dependence and government funding) and to including (possibly endogenous) firm-level subsidy variables in the estimating equation. The robustness tests also provide evidence for our claim that government funding disproportionately helps firms in industries that are dependent on external finance *because* capital markets are imperfect. Finally, the robustness tests indicate that our results hold also when we estimate the model with OLS, use a transformed dependent variable, or allow for non-normal, heteroscedastic and asymmetric errors (the CLAD estimation) when estimating our censored regression model.

Overall, the results support the view that the growth and innovativeness of small firms is constrained by access to external finance, and that government funding is able to alleviate these constraints.

6. Conclusions

The hypothesis put forward and tested in this paper is that if there are economically significant imperfections in capital markets, government funding may *disproportionately* help firms in industries that are dependent on external finance. We deliver evidence supporting this hypothesis. We do so by studying the effects of government funding on the

R&D investments and growth orientation of SMEs in Finland. Our analysis shows, in particular, that firms in industries that are more dependent on external financing invest relatively more in R&D and are relatively more growth-oriented when they have more government funding (potentially) available.

The findings of this paper suggest that SMEs face an upward-sloping capital supply curve and hence that the market for SME finance is imperfect. The evidence is consistent with the view that financial constraints hold back innovation and growth, and the hypothesis that government funding can alleviate capital market imperfections. These findings are not inconsistent with the view that government finance of industrial R&D can be an important tool of innovation policy. Nor are they incompatible with the well-known international comparisons of World Economic Forum (WEF, 2001) and International Institute of Management Development (IMD, 2002), and those of Global Entrepreneurship Monitor (GEM, 2001), suggesting that the efforts of the Finnish government may have been an important element of the recent economic development in Finland.

While our results portray a positive picture of the efficacy of government funding in the presence of capital market imperfections, it is worth reminding the reader that well-intended but badly designed policies can do more harm than good. While this is true for any country, it is especially so for Finland, where the public institutions providing government funding are collectively a considerable actor in the market place. As the Finnish financial system matures further, there is almost by definition less room for government funding, whose allocation is not based on a price mechanism. We should therefore not overlook the risk that government funding may end up crowding out potentially profitable businesses of private financiers, distorting the private sector's investment incentives and even sustaining socially wasteful business activity.

The finding that government funding may alleviate capital market imperfections is of interest to academics too, because it qualifies the picture portrayed by the recent papers of La Porta et al. (2002) and Sapienza (2004) on the effects of government ownership of financial institutions. While these papers have convincingly shown that the government ownership of financial institutions leads to misallocation of capital that can be detrimental to economic growth, our findings suggest that the *type* of government involvement may matter. It is very important to stress that beyond these conclusions, our results have no implications for public policy. In particular, one cannot draw conclusions about the welfare effects of government funding (cf. de Meza and Webb, 1987, 2000, and de Meza, 2002). Measuring these remains an important and challenging topic for future research.

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