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Do public subsidies affect the performance of new technology-based firms? The importance of evaluation schemes and agency goals

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New technology-based firms (NTBFs) greatly contribute to the dynamic efficiency of the economic system. To perform this role, NTBFs need external financing. However, private financing of this type of firm is particularly subject to market inefficiencies. This seems to recommend policy intervention and NTBFs often find support through payment of direct public subsidies. When these are based on ex ante selective screening procedures of applicants and awarded competitively, direct public support may exert a positive effect on the performance of NTBFs beyond the amount of the subsidy. By picking promising projects, governments may signal the quality of a firm to third parties, thereby lowering information asymmetries. This paper contributes to the literature on the differing impact of various subsidies on firm performance by crossing the evaluation dimension (i.e. selective vs. automatic subsidies) with the dimension of the specific goal (R&D-enhancing vs. other measures) for which a subsidy may be implemented. Our results show that the evaluation mechanism and the goal of the subsidy are both important dimensions in the policy design domain and that selective R&D subsidies outperform other types of scheme in fostering NTBF performance.

Introduction

In a global world, where knowledge shapes a broad range of economic activities (Rooney and Mandeville, 1998), the birth and consolidation of entrepreneurial ventures based on technologically intensive products and processes play a key role in determining the long-term performance of an economic system. There is consensus in the economics literature on the importance of new technology-based firms (NTBFs) as fundamental drivers of static and dynamic efficiency and important engines of economic growth (Audretsch, 1995; Acs and Audretsch, 2003).[1] To perform this role, NTBFs need adequate financing, but access to external financing is extremely problematic for NTBFs (Arrow, 1962; Westhead and Storey, 1997; Freel, 1999). Because of the technology-intensive nature of their activity, the absence of a consolidated track record, and because their assets are often firm-specific and intangible and hence cannot be pledged as collateral, NTBFs are very likely to face adverse selection and moral hazard problems in raising external capital (Berger and Udell, 1998; Carpenter and Petersen, 2002; Denis, 2004). Banks may not be able to identify

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good projects and separate them from 'lemons' in sectors usually characterised by skewed returns and asymmetric information.

Venture capital is generally considered by both academics and practitioners as the most suitable type of external finance for NTBFs (Sahlman, 1990; Gompers and Lerner, 2001; Kaplan and Strömberg, 2001; Denis, 2004; Croce *et al.*, 2010). However, venture capital is not a panacea and often shows its limitations in the financing of NTBFs (Lerner, 1999; Hall, 2002). Although venture capitalists are able to overcome information asymmetry problems by developing accurate context-specific screening procedures and by monitoring portfolio firms, they generally focus on a limited set of industries and back only a small fraction of firms in high technology sectors (Gompers and Lerner, 1998; Bottazzi and Da Rin, 2002).

It is perhaps not surprising, then, that national governments often seek to support NTBFs through direct policy measures (e.g. subsidies) as a means of promoting innovation and economic growth. The market failure argument sketched above provides a rationale for public support of NTBFs beyond the role of public funds as financial resources. In particular, direct public support may also exert a positive signalling effect towards young high technology firms, providing what the literature refers to as a 'certification' effect (Lerner, 1999; Väänänen, 2003). Government support, by picking promising business projects (with high social returns), can signal to third parties the quality of a firm or investment project. This may reduce information asymmetries between firms and other key actors (Kleer, 2010). Takalo and Tanayama (2010) show that, when government direct subsidies are based on *ex ante* screening of the subsidy application and awarded competitively, the selection scheme provides an informative signal for external investors (Narayanan *et al.*, 2000).[2]

The contribution of the present study on the impact of subsidies on NTBFs' performance, measured by firms' total factor productivity (TFP) growth, is twofold. First, we depart from most of the empirical literature on the topic by focusing on more than R&D subsidies alone. By extending the analysis performed by Colombo *et al.* (2011a), we also analyse the effectiveness of generic public subsidies to which NTBFs may have access, namely, those aimed at supporting a firm's general-purpose investments, employment growth and job training activities. Second, we cross this dimension of the specific goal for which a subsidy is implemented with the 'evaluation dimension' (i.e. selective *vs.* automatic subsidies). In a nutshell, we investigate not only the goal of the subsidy, but also the allocation evaluation mechanism to see how each influences the productivity of NTBFs. The decision to measure NTBF performance by TFP growth is justified below (see also Colombo *et al.*, 2009).

We estimate the effect of different types of public financing on a sample of 247 Italian NTBFs in the period 1994–2003 and control for the potential endogeneity of public financing by adopting a Generalized Method of Moments (GMM)-system estimator. The results show that the evaluation mechanism and the goal of the subsidy are both important dimensions in the policy design domain and that, for the sample analysed here, selective R&D subsidies outperform all the other types of schemes in fostering the performance of NTBFs.

This paper is structured as follows. It reviews the literature and illustrates the conceptual framework of our empirical analysis. We then offer some brief remarks on the characteristics of direct subsidy schemes for high technology entrepreneurship available in Italy during the observation period. After describing the data collection from the sample of NTBFs on which the empirical analysis is based, we illustrate the econometric models and describe the variables used in the empirical

analysis. Finally, we highlight the results of the econometric estimates and offer some concluding remarks.

Literature review

A considerable body of literature has evaluated the effectiveness of public subsidies in enhancing firm performance (e.g. Lerner, 1999; Wallsten, 2000; Wren and Storey, 2002; Hussinger, 2008; Bèrubè and Mohnen, 2009). Irwin and Klenow (1996), evaluating the SEMATECH program, conclude that participating firms did not improve their labour productivity more than non-participating firms. While there are some studies pointing to the beneficial effects of subsidies (e.g. Harris and Robinson, 2004), a disturbing number of analyses in different geographical contexts raises concerns about the capacity of direct policy measures to increase significantly the efficiency of recipient firms (e.g. Beason and Weinstein, 1996 in Japan; Bergström 2000, in Sweden; Sørensen *et al.*, 2003 in Denmark).

One possible reason for failure to detect strong positive linkages in these studies may be insufficient attention to the heterogeneity of these subsidies. Very few studies have tried to evaluate the differential impact on firm performance caused by different types of subsidies. Among them, Colombo *et al.* (2011a) consider exclusively R&D subsidies and show that these are beneficial to firms' TFP growth only if they are allocated through a competitive mechanism. Colombo *et al.* (2011b) also assess the impact of public subsidies on the employment growth of NTBFs. Their results show that selective support schemes are more beneficial to Italian NTBFs than automatic schemes, but only if awarded in the very early period of the recipient firm's life. Girma *et al.* (2007), using a unique plant-level dataset from Ireland and a wide range of subsidy schemes, found that a firm's TFP was improved only by measures with the goals of increasing R&D, capital and training investments and of promoting technology acquisition.

This study aims to improve our understanding of the effects of subsidy heterogeneity by taking into account diverse facets of public subsidies for high technology entrepreneurial ventures and identifying those most beneficial. More specifically, we jointly analyse the differential impact of selective and automatic subsidies according to the goal of the subsidy (e.g. R&D-enhancing subsidies *vs.* other types of subsidies). To our knowledge, this is the first time this approach has been attempted.

Theoretical background

Surprisingly little attention has been paid to the evaluation mechanisms through which public funds are actually allocated and, in particular, to the possible backlash in terms of subsidy effectiveness that different allocation mechanisms might cause. The evaluation methods adopted by public authorities are a crucial component of technology policy design and empirical studies should take into account how governments allocate funds (Klette *et al.*, 2000). The evaluation procedure embedded in different subsidy programmes may differ in many aspects (e.g. the design of technical evaluation, the weights assigned to applicant characteristics, etc.). For the purpose of our analysis, we adopt a simple classification of policy measures: automatic and selective. With an automatic scheme, every firm that fulfils the requirements indicated by the law is eligible for public support (i.e. there is no selection of applications on the part of public authorities). In contrast, with a selective scheme, applicants compete to receive a financial subsidy and they are judged by expert committees nominated by the national authority.

Selective and automatic procedures adopted by public agencies may have substantially different impacts on firm performance for two reasons. First, the design of a dedicated technical committee and strict competition rules allow for a precise screening of projects and the selection of those with the greatest potential social returns (Lerner, 1999; Klette *et al.*, 2000). Conversely, automatic subsidies are awarded after a procedural assessment of firms fulfilling the criteria specified by law. Second, selective subsidies may provide firms with certification of their quality. If government screening is viewed as reliable by third parties, then a signal through public financial support that a firm has a good quality project may help the firm in overcoming asymmetric information problems and thus facilitate access to debt and equity capital markets (Väänänen, 2003). In other words, selective awards, in contrast to automatic ones, have a certification effect that attracts private investors who see the awards as a guarantee of quality, thus reducing the uncertainty inherent in early-stage investments. Of course, this certification effect will be taken much more seriously when the 'stamp of approval' provided by the policy maker refers to the core activities of the firm (Lerner, 2002, p.78), as in the case considered here, where a firm receives a selective subsidy directed towards R&D activities.

This certification effect is likely to be particularly important in high technology industries (Lerner, 1999). This is because external private investors are likely to find it difficult to evaluate accurately the R&D projects or investments in intangible assets of small innovative entities that lack track records. Small, young companies may be reluctant to provide information immediately and completely to third parties as there is a serious risk of appropriation (which is higher the younger and smaller the firm). Once information is completely disclosed, private investors might replicate a firm's technology to the detriment of the NTBF (Bhattacharya and Ritter, 1983; Ueda, 2004). The certification provided by the public sector (in the presumption that committees have gone through all relevant aspects of the project) may attract external private parties, even if they are not completely aware of all the details of the project.

All of the above arguments lead us to expect that selective R&D subsidies will have a more positive effect on the performance of NTBFs than other sorts of subsidies. This is attributable mainly to the certification effect exerted by these types of subsidies for such firms. It is worth noting that if the subsidy is important for its indirect certification effect, then the direct channel may be much less relevant in the context of NTBFs. There are two possible explanations. First, NTBFs are R&D-intensive firms; thus, they might use a subsidy to enhance R&D activities even if the formal goal of the public incentive is not to increase R&D activities. For instance, a subsidy whose goal is to favour employment growth might be used to hire R&D personnel by NTBFs. Second, the receipt by a NTBF of a subsidy not aimed at increasing R&D expenses may engender an efficiency gain (e.g. purchase of new machinery). Through such efficiency gains, the NTBF can invest more resources in its core (R&D) activities.

Italian national policy direct support schemes towards high technology entrepreneurship

During the observation period (1994–2003), Italy had very few national financial support measures directly targeted at NTBFs. Key schemes were Law 388/2000, Article 106, which explicitly focused on new firms operating in high technology sectors, and Law 297/1999, which aimed at the creation and support of academic

start-ups. Indeed, most of the measures implemented by the Italian Government were directed to all firms, or in some circumstances were limited to small and medium enterprises, of which NTBFs are only a subset. However, 28 national laws have provided some sort of financial help to the NTBFs included in our sample up to 2003. We categorise these laws on the basis of the evaluation method of applicants and their specific objectives.

As to the first dimension, we distinguish support measures based on automatic criteria from those schemes that contemplate a selective and competitive procedure. Both automatic and selective modalities (16 of the former and 12 of the latter) were equally pursued by sample NTBFs in the period under consideration.[3] It is worth noting that automatic subsidies did not guarantee automatic support to all firms. For all considered automatic schemes, the subsidy was conditional on the availability of funds. It was first come first served and demands from eligible firms always (and greatly) exceeded the allocated budget with funds exhausted in a short time. With selective schemes, screening of applications was performed with the help of technical committees composed of experts nominated by the governmental institution in charge of the scheme. Usually, projects were judged and ranked on the basis of criteria and parameters known *ex ante* by participants (e.g. profitability and social impact of the project) and financed by government agencies until the allocated funds were exhausted. Reportedly, application procedures were cumbersome and application costs were quite high (on average, much higher than those prescribed by automatic subsidies).

As to the main objective of the 28 policy measures accessed by Italian NTBFs, these schemes may be categorised as giving support for R&D investments or as giving support for general-purpose investments, employment growth and job training activities. Considering support for R&D investments, the Italian Government constituted two main funds. The first, Fondo Speciale Rotativo per l'Innovazione Tecnologica (Special Fund for Technological Innovation), was introduced by Law 46/1982 to support pre-competitive R&D efforts, namely, activities that developed previous research in technological applications. The second was the Fondo Rotativo per le Agevolazioni alla Ricerca (Fund for Research Facilitations) constituted by Law 297/1999 and intended to support firms investing in industrial research and pre-competitive development and university–industry collaborations. Other laws related to general purpose investments, such as employment and skills upgrading and measures to promote investments in physical assets. For instance, Law 1329/1965 (also called the Sabatini Law), Law 215/1992 and Law 266/1997 were all direct measures aimed at supporting production investments conducted by small firms, such as the purchase of new plants and machinery or modernisation. Law 113/1986 supported the recruitment of a young and feminine workforce through direct financial contributions or fiscal incentives. Similar measures for young employees were provided by Law 451/1994 and by Law 196/1997. Finally, Law 236/1993 provided financial contributions with the aim of improving the skills of the workforce through continuous training projects.

In this non-R&D subsidy category, we also include laws aimed at sustaining productive activities in the south of Italy. There has long been an economic gap between this area and the rest of the country. The Italian Government has adopted special measures to support the development of the region ever since the end of the Second World War.[4] Important policy schemes include Law 64/1986, Intervento Straordinario nel Mezzogiorno (Extraordinary Intervention for the South of Italy),

which provided financial contributions and guarantees for southern small and medium enterprises to promote their access to capital markets, and Law 488/1992, which gave free grants for general purpose investments in a wide range of industries in such depressed areas.

Sample

In this paper, we use a unique hand-collected longitudinal dataset relating to a sample of 247 Italian NTBFs observed over a 10-year period (1994–2003). Most sample firms were privately owned. These NTBFs were established in 1980 or later, were independent when founded and remained so until the end of 2003 (i.e. they are not controlled by another business organisation, even though other organisations may hold minority shareholdings). They operate in the following high technology sectors in manufacturing and services: computers; electronic components; telecommunication equipment; optical, medical and electronic instruments; biotechnology; pharmaceuticals and advanced materials; robotics and process automation equipment; multimedia content; software; Internet services (e.g. e-commerce and web-related services); telecommunication services.

The sample firms were extracted from the Research on Entrepreneurship in Advanced Technologies (RITA) database, developed at Politecnico di Milano. The RITA database constitutes the most complete source of information presently available on Italian NTBFs.[5] The database provides (basic) information on a population of 1974 Italian NTBFs that comply with the above-mentioned criteria as to age, ownership status and sector of operation. The RITA population was constructed from a large number of sources. These include lists provided by national industry associations, online and offline commercial firm directories and lists of participants in industry conferences and expositions. Information provided by the national financial press, specialised magazines, sectoral studies and regional chambers of commerce was also included.

Data contained in the RITA database were collected from two types of information sources. First, existing data sources of information were used. For instance, financial and accounting data were obtained from the Accessible Information on Development Activities (AIDA) and Cerved commercial databases. Data in these databases are available from 1994 onward only for a subset of RITA firms (i.e. limited liability firms). Second, additional information on sample NTBFs was obtained through a series of national surveys administered in the first half of the years 2000, 2002 and 2004 (for details on the surveys, see Colombo *et al.*, 2006). The sample considered in this paper includes all NTBFs that participated in the 2004 survey, for which we were able to build a complete dataset relating to the variables of interest. An important strength of the dataset is that it covers the full history of the subsidies received by firms from national governmental bodies.

As shown in Table 1, firms operate in three macro-industries (resulting from the aggregation of the previously mentioned industries):[6] manufacturing (36% of the firms); software (35%); web services (29%). The sample is large and quite heterogeneous. Overall, government granted 74 subsidies to NTBFs: 30 were selective and 44 were automatic (41% and 59% respectively); 39 were R&D subsidies and 35 were directed to general purpose investments, employment growth and job training activities (53% and 47% respectively). Only 11 were selective R&D subsidies (15%).

Table 1. Descriptive statistics by industry

	Total sample firms		Subsidies		Selective subsidies		R&D subsidies	
Industry	*n*	%	*n*	%	*n*	%	*n*	%
Web services	71	28.74	7	9.46	2	6.67	1	2.56
Software	87	35.22	35	47.30	11	36.67	19	48.72
Manufacturing	89	36.03	32	43.24	17	56.67	19	48.72
Total	247	100.00	74	100.00	30	100.00	39	100.00

Econometric specification

To estimate the impact of different types of public subsidy on the TFP growth of the firm, we specify the following equation:

$$TFP_{it} = \beta_0 + \beta_1 TFP_{it-1} + \beta_2' Subs_{it-1} + \gamma' X_{it} + \gamma_t + \varepsilon_{it}. \quad (1)$$

where TFP_{it} is the firm's TFP estimated through the semi-parametric approach suggested by Olley and Pakes (1996); $TFP_{it\text{-}1}$ is the autoregressive term; $Subs_{it\text{-}1}$ is a vector of impulse dummy variables representing different types of subsidy; X_{it} includes controls, namely, firm age (Age_{it}), debt to total assets ratio (DTA_{it}), cash flow to sales ratio (CFS_{it}), a set of industry dummies and a composite index reflecting the level of infrastructure and resource development in the province in which the firm is located (LI_{it}, source: Centro Studi Confindustria);[7] γ_t is a full set of time dummies and ε_{it} is the error term.

In Table 2, we describe in detail the variables included in Equation (1). Among the covariates, we do not insert firm size because this variable already enters in the construction of the dependent variable. This approach is well established in the productivity literature (e.g. Javorcik, 2004; Castellani and Zanfei, 2006).

Table 2. Description of variables

Variable	Description
TFP_{it}	Firm's total factor productivity
LI_{it}	Value of the index measuring regional infrastructures (mean value among Italian regions = 100; source: Centro Studi Confindustria)
Age_{it}	Number of years since firm's foundation at time *t*
$DTA_{it\text{-}1}$	Debts to total assets ratio at year *t-1*
$CFS_{it\text{-}1}$	Cash flow to sales ratio at year *t-1*
$Subs_{it\text{-}1}$	Time varying dummy variable that equals unity if firm *i* received a subsidy at time *t-1*
$R\&DSel_{it\text{-}1}$	Time varying dummy variable that equals unity if firm received an R&D selective subsidy at time *t-1*
$R\&DAut_{it\text{-}1}$	Time varying dummy variable that equals unity if firm received an R&D automatic subsidy at time *t-1*
$NoR\&DSel_{it\text{-}1}$	Time varying dummy variable that equals unity if firm received an other than R&D selective subsidy at time *t-1*
$NoR\&DAut_{it\text{-}1}$	Time varying dummy variable that equals unity if firm received an other than R&D automatic subsidy at time *t-1*

Note: TFP_{it} is estimated through Olley-Pakes methodology.

The dependent variable

We use TFP growth to measure NTBF performance. NTBFs perform better if they produce the same output with fewer inputs, or if they produce more output from the same inputs than other NTBFs in the same industry. The use of TFP growth as an indicator of NTBF performance is well established. Examples of applications in samples partially or totally constituted by high technology firms are Hall and Mairesse (1995), Javorcik (2004), Driffield *et al.* (2008) and Aghion *et al.* (2009). Examples of applications in samples of young or small firms are Acs *et al.* (1999), Aitken and Harrison (1999) and Cingano and Schivardi (2004). This indicator of firm performance is particularly appropriate in the context of our study (Colombo *et al.*, 2009). First, as TFP reflects both output performance and efficiency in the use of inputs, it is suitable for measuring the performance impact of public subsidies that may have beneficial effects on both sides. Second, costs arising from the procedures of application (especially related to selective subsidies), and bureaucracy in general, may be high, especially for small, young firms lacking resources. By definition, productivity is a performance indicator that also brings this element into the picture.

The TFP of NTBFs is estimated through a semi-parametric procedure originally proposed by Olley and Pakes (1996), which allows for firm-specific productivity differences exhibiting idiosyncratic changes over time.[8] This semi-parametric approach, increasingly used in the industrial organisation literature (e.g. Pavcnik, 2002; Cingano and Schivardi, 2004; Blalock and Gertler, 2007), presents several advantages in dealing effectively with the typical simultaneity problem in the choice of inputs (Griliches and Mairesse, 1998).[9] The procedure is applied separately for each industry.

The estimation method

Because there may be systematic differences between subsidised and non-subsidised firms and between firms subsidised through different types of scheme, a simple comparison of the mean impact of the subsidies between different categories of NTBF (e.g. subsidised as distinct from non-subsidised) may lead to a selection bias (Grilli and Murtinu, 2011). A positive or negative effect of the subsidy could be attributable simply to the fact that subsidised firms are simply the best or the worst firms in the slot. Therefore, the problem is that we must estimate the treatment effect in the case of a non-random selection of the group of treated firms (David *et al.*, 2000; Klette *et al.*, 2000; Blanes and Busom, 2004; Feldman and Kelley, 2006). As is customary in evaluation studies (e.g. Lach, 2002), we resort to the generalised method of moments procedure and estimate models through the GMM-system estimator (Blundell and Bond, 1998). As is typical in this type of analysis (e.g. Girma *et al.*, 2007; Colombo *et al.*, 2011a,b), we formulate the weakest possible assumption: we consider the subsidies as potentially correlated with the error term and so treat them as endogenous. The validity of the selected instruments was verified through a Hansen test.[10]

Econometric results

The results of the econometric analysis are shown in Table 3. We can see that the Hansen test statistics of over-identifying restrictions provide support for our use of instruments in both our two specifications. In the first specification (model I), GMM estimates show that subsidies lumped together do not have a significant

Table 3. Econometric results

	Model I		Model II	
TFP_{it-1}	0.5343	***	0.5871	***
	(0.0616)		(0.0673)	
$Subs_{it-1}$	−0.0111			
	(0.0601)			
$R\&DSel_{it-1}$			0.2545	**
			(0.1137)	
$R\&DAut_{it-1}$			–0.0287	
			(0.0941)	
$NoR\&DSel_{it-1}$			0.1699	
			(0.1629)	
$NoR\&DAut_{it-1}$			–0.0772	
			(0.1147)	
DTA_{it}	0.1598		0.1874	
	(0.3268)		(0.2773)	
CFS_{it}	0.3440		0.3732	
	(0.2860)		(0.2498)	
Age_{it}	0.0098	**	0.0076	*
	(0.0049)		(0.0045)	
LI_{it}	0.0019	**	0.0017	**
	(0.0008)		(0.0007)	
Constant	1.6539	***	1.4241	***
	(0.3375)		(0.3141)	
Industry dummies	Yes		Yes	
Year dummies	Yes		Yes	
Obs.	1198		1198	
n groups	247		247	
Hansen test	106.51 (118)		111.35 (160)	

*, **, *** indicate statistical significance at 10%, 5% and 1% levels respectively. Lagged dependent and subsidy variables considered as endogenous. To limit possible finite sample bias (e.g. Bond, 2002), we restrict moment conditions of endogenous variables to the interval t-2 (t-1) and t-5 (t-4) for instruments in levels (differences).
Note: robust standard errors are shown in parentheses.

positive effect on the TFP growth of Italian NTBFs, while potential important drivers of productivity are represented by age and local development. Old firms are likely to be more productive than young ones (for similar results, see Girma *et al.*, 2007; Colombo *et al.*, 2011a), while ventures located in developed areas should benefit from positive externalities that may arise from external assets of a public good nature (e.g. transport systems, telecommunications infrastructure, efficient markets for support services; Holtz-Eakin, 1994; Fernald, 1999).

In the second specification (model II), we classify subsidies by the two investigated dimensions: selective *vs.* automatic and R&D-enhancing *vs.* other than R&D-enhancing (i.e. subsidies aimed at supporting general-purpose investments, employment growth and job training activities). We find that only R&D-selective schemes have a significant positive impact (at 5%). In this case, the estimated TFP short-run increase is 25%. All the other variables of interest ($R\&DAut_{it-1}$,

$NoR\&DSel_{it-1}$ and $NoR\&DAut_{it-1}$) show a statistically negligible impact on the dependent variable. This result supports our main argument that R&D-selective subsidies have a more positive effect on NTBF performance than all the other types of subsidies. We also find that age and local development exert a positive impact on NTBF TFP growth.

In summary, according to our estimates, the impact of public subsidies on the TFP growth of NTBFs is positive and of considerable economic magnitude, but only if subsidies are provided on a competitive basis and their goal is to enhance R&D activities. This evidence is consistent with the presence of a strong certification effect associated with selective support schemes when they are directed towards R&D activities. Conversely, automatic schemes with no specific goal other than to assist NTBFs are ineffective.

Conclusions

The importance of knowledge-based economic activities has attracted the attention of Organisation for Economic Co-operation and Development (OECD) countries in their evaluation of government schemes to help NTBFs. This is because such firms have an inordinate influence on the dynamic efficiency of the economic system and on economic growth. This paper evaluates the effectiveness of national public financing of Italian NTBFs. In particular, we address the rarely asked question of the efficacy of policy measures characterised by different project evaluation methods and goals of the subsidy. According to our estimates, the treatment effect of subsidies on the TFP growth of NTBFs is positive and significant, but only if subsidies are provided competitively and are targeted to enhance R&D investments. This evidence is consistent with the certification effect associated with selective support schemes. This is likely to be particularly pronounced for NTBFs when the focus of the policy scheme is R&D activities.

Of course, our study has a number of caveats that encourage further research. First, we consider only Italy, and it is questionable whether our results will hold for other countries. Then, even if TFP is accepted as an appropriate indicator of performance for NTBFs, one should still investigate the impact of subsidies on other important firm dimensions (e.g. sales, employment). A larger sample size, the inclusion of firms located in different countries and the consideration of different measures of performance would all help check the generalisability of our results. Second, in our database, we have only dummy variables with a value of one if the focal NTBF had received a subsidy. It would be interesting to test whether our hypotheses hold with not only these dummy variables but also the amount received by NTBFs through subsidies. This way, we could discriminate between the direct and indirect effect of public subsidies, evaluate the presence of a certification effect exerted by selective subsidies and test whether there is a non-linear relationship between the amount of the subsidy and NTBF productivity growth. Unfortunately, data on the amount of subsidy received by sample firms is not available. The figure is not systematically recorded in public sources and as the mechanisms through which public subsidies are allocated to firms differ (e.g. tax credit, social security payment release, grants, low interest loans), it is not possible for firms to provide reliable figures for this crucial factor.

Despite these limitations, our findings shed a positive light on the impact of public subsidies on young high technology firms and, in particular, on the government's desire to 'build efficiency'. The evidence in favour of selective R&D

subsidies, together with the observation that these are uncommon in Italy, are worthy of reflection by Italian policy makers. Automatic schemes are quite popular in Italy and in several other countries,[11] and our results cast doubt on the effectiveness of this sort of public support for NTBFs in these nations. European countries lag already behind their international competitors in fostering NTBFs:

> R&D spending in Europe is below 2%, compared to 2.6% in the US and 3.4% in Japan, mainly as a result of lower levels of private investment. It is not only the absolute amounts spent on R&D that count – Europe needs to focus on the impact and composition of research spending and to improve the conditions for private sector R&D in the EU. Our smaller share of high-tech firms explains half of our gap with the US'. (European Commission, 2010, p.10)

High technology entrepreneurial ventures able to grow rapidly and eventually become leaders in new, technological markets (companies like Intel, Microsoft, Google or Genentech) are a rarity in Europe (Lockett *et al*., 2002). Their fostering is a priority of the European Commission, which has recently shown renewed interest in supporting small and medium enterprises facing the financial crisis. The Commission has been paying particular attention to those involved in innovative activities in technology-intensive sectors (European Council, 2008).

Italy, too, is making an effort in this direction at the public policy level. Recent policy initiatives have been focused on the aggregation of strategic guidelines for both research and innovation policies, on the recognition of specific research strategic areas of primary interest and on the promotion of technology districts. Previous policy initiatives were inspired by a generalised and horizontal perspective. More attention should be devoted to young firms operating in high technology industries. Even if the current policy measures are insufficient to tackle the challenge of innovation financing (considered one of the key weaknesses of the Italian economic system), some interesting steps have been taken in the recent past. Examples include the rationalisation of public guarantee and risk/venture capital funds and the consequent constitution of a unique Fondo per la Finanza di Impresa (Fund for Enterprise Financing), introduced in 2007 with the primary objective of sustaining the innovative projects of technological-intensive start-ups. In our view, initiatives of this type need to be sustained, systematised and consolidated in order to fulfil their intended purpose.

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Notes

1. Definitions of static and dynamic efficiency have been provided by several streams of academic literature: organisation theory (Burns and Stalker, 1961), technology and operations management (Abernathy, 1978), strategic management (Heskett, 1987) and economics (Stigler, 1939; Hart, 1942; Marschack and Nelson, 1962; Jones and Ostroy, 1984; Klein, 1984; Carlsson, 1989). In this paper, we adhere to the ideas of Klein (1984). The author defines static efficiency as the optimal combination of disposable inputs subject to the constraints imposed by a given (fixed) production function.

Conversely, dynamic efficiency is defined as 'changing the production function in profitable directions' (p.46). To some extent, NTBFs might engender technological shifts on the production function through product, process and organizational innovations.

2. The Small Business Innovation Research program in the US is a typical example of a selective subsidy. The French Credit Impôt Recherche and Jeunes Entreprises Innovantes schemes are emblematic examples of automatic subsidies.
3. The responsibility for administration of these policy measures was assigned to different governmental institutions. They include the Ministry of Economic Development, the Ministry of University and Research, the Internal Revenue Service, the Ministry of Labour and Welfare, the Ministry of Agricultural Food and Forest Policies, the Ministry of International Trade, the Institute for Foreign Trade, SIMEST (Italian Society for Foreign Firms) and Finance Company for Entrepreneurs located in the North-East. There was no single public agency in charge of innovation policy measures.
4. In 1950, the Italian Government founded the Cassa del Mezzogiorno (Fund for the South), a public agency to construct public works and infrastructure for the development of the south of Italy; it ceased operations in 1992.
5. In Italy, data provided by official national statistics do not include a reliable description of the universe of Italian NTBFs. Most individuals defined as 'self-employed' by official statistics are actually salaried workers with atypical employment contracts. Thus, on the basis of official data, such individuals cannot be distinguished from the entrepreneurs who created new firms.
6. Note that we aggregate the previously exposed sectors into three macro-industries to give a sufficient number of observations in each industry to estimate our performance variable.
7. It is calculated as the average of the following indices at NUTS (Nomenclature of territorial units for statistics) 3 level: per capita value added; share of manufacturing of total value added; employment index; per capita bank deposits; automobile:population ratio; consumption of electric power per head. For a seminal discussion and a critical review of the empirical literature on the relationship between public infrastructure capital and firm productivity, see Holtz-Eakin (1994) and Fernald (1999).
8. For a survey of the various estimation techniques for total factor productivity and a more detailed description of Olley and Pakes' methodology, see Levinsohn and Petrin (2003) and van Biesebroeck (2007).
9. Firms choose their current input levels knowing possible unobserved productivity shocks, which are known to the firm, but unobserved by the researcher. This leads to a correlation between production inputs and the composite error term of the production function and to a biased estimation of the coefficients of production inputs through ordinary least squares estimation. For a detailed discussion on this aspect, see Eberhardt and Helmers (2010).
10. Note also that the use of survey information necessarily implies a potential survivorship bias in our data. We tested the possible presence of the problem by adapting to our specific framework a recent methodology proposed by Semykina and Wooldridge (2010) for testing the existence of selection bias in panel data in the presence of unobserved heterogeneity and endogenous regressors. We estimated the two models of Table 3 with the addition of an inverse Mills ratio type of firm exit (for details, see Colombo *et al.*, 2009). Its coefficient turns out not to be statistically significant and excludes the presence of any remarkable survivorship bias ($p > |Z| = 0.247$ and $p > |Z| = 0.164$ in model I and model II respectively).
11. In addition to France, many other countries give automatic subsidies for R&D. For instance, in Canada, the Scientific Research and Experimental Development provides tax credits to businesses conducting R&D (they must meet the Frascati definition of R&D). In Belgium, there is a partial exemption of advance tax payments in favour of companies employing researchers. In Norway, tax support for industrial R&D (the SkatteFUNN scheme) was established in 2002.

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