Mansfield's Missing Link: The Impact of Knowledge Spillovers on Firm Growth

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ABSTRACT. The purpose of this paper is to provide a link between two of the seminal contributions of Edwin Mansfield. The first focuses on the determinants of firm growth and the second is concerned with university-based knowledge spillovers. By linking both firm-specific characteristics as well as access to knowledge spillovers from universities, the empirical evidence found in this paper suggests that knowledge spillovers as well as firm-specific characteristics influence firm growth.

Key words: university spillovers, firm growth

JEL Classification: M13, L20, R30

1. Introduction

Among his many compelling contributions, Edwin Mansfield ranked among the pioneers in economics focusing the determinants of the evolutionary process by which firms are created and then grow through an evolutionary process. According to Mansfield (1962, p. 1023), "Because there have been so few econometric studies of the birth, growth and death of firms, we lack even crude answers to the following basic questions regarding the dynamic processes governing an industry's structure. What are the quantitative effects of various factors on the growth of firms represented by Gibrat's law of proportionate effect? What have been the effects of successful innovations on a firm's growth rate?" It required no fewer than two sweeping articles in the Journal of Economic Literature (Caves, 1998; Sutton, 1997) at the end of the last century to review the literature on empirical tests of firm growth and Gibrat's Law spawned by Mansfield's pioneering research.

Towards the end of his career, Mansfield (1995), also pioneered a very different research trajectory, which focused on external sources of R&D, and in particular universities, as inputs into firm innovation.[1] Mansfield's research was instrumental in triggering a more recent wave of studies identifying the role that knowledge spillovers play, and in particular, knowledge spillovers from universities in generating innovative activity (Audretsch and Stephan, 1996; Jaffe, 1989).

Despite the enormous literatures triggered by Mansfield's seminal contributions, these two research trajectories remain separate. As the Caves (1998) and Sutton (1997) review articles confirm, the plethora of econometric studies focusing on firm growth in general, and Gibrat's law in particular, never consider the impact of external research on the growth of firms. Instead, this entire literature consists almost exclusively of trying to link firm-specific characteristics, principally size and age, but also in some cases R&D and other types of innovative activity, to firm growth. Similarly, the literature on knowledge spillovers has concentrated mainly on performance measures such as innovation and R&D, but has yet to consider the impact on firm growth (Audretsch *et al.*, 2005).

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The purpose of this paper is to provide the missing link between the literatures on firm growth and on university-based knowledge spillovers. In particular, we examine whether access to university-based knowledge spillovers has an impact on firm growth. In the second section we present the model relating not just firm characteristics, but also knowledge external to the firm, to firm growth. In the third section issues involving measurement are discussed. The results from estimating the growth rates of high-technology German firms are presented in Section 4. Finally, in the last section a summary and conclusion are provided. In particular, the results of this paper suggest that two of the seminal contributions made by Mansfield need to be linked together. Just as Mansfield discovered, not only is firm growth positively influenced by investments in knowledge, but accessing external knowledge generated by universities also contributes to firm growth.

2. Linking firm growth to university spillovers

Since the purpose of this paper is to link the two seminal contributions by Mansfield together, we introduce a model relating firm growth to characteristics specific to the enterprise as well as external knowledge from universities. The starting point is the most prevalent model for identifying the determinants of growth at the level of the firm, which has been based to test Gibrat's Law (Sutton, 1997).

Formalizing the relationship between size and growth, Gibrat's law assumes that the present size of firm i in period t may be decomposed into the product of a "proportional effect" and the initial firm size as:

$$\text{Size}_{i,t} = (1 + \varepsilon_t)\,\text{Size}_{i,t-1}, \qquad (1)$$

where $(1+\varepsilon_t)$ denotes the proportional effect for firm i in period t. Here the random shock ε_t is assumed to be identically and independently distributed. Taking the natural log and assuming that for small ε, $\ln(1+\varepsilon) \approx \varepsilon_t$,

$$\ln(\text{Size}_{i,t}) = \ln(\text{Size}_{i,0}) + \sum_{k=1}^{t} \varepsilon_{ik} \qquad (2)$$

It can be observed that as $t \to \infty$ a distribution emerges which is approximately log normal with properties that $\ln(\text{Size}_{i,t}) \sim N(t\mu\varepsilon,\ t\sigma^2_{\varepsilon})$. Firm growth can then be measured as the difference between the natural log of the number of employees as:

$$\text{Growth}_{it} = \ln(\text{S}_{i,t}) - \ln(\text{S}_{i,t-1}) \qquad (3)$$

where the difference in size for firm i between the current period t and the initial period $(t-1)$ equals Growth_{it}.

This equation can be empirically estimated by:

$$\text{Growth}_{i,t} = \text{B}_1 \ln(\text{Size}_{i,t-1}) + \text{B}_2 \ln(\text{Size}_{i,t-1})^2 + \text{B}_3\text{Age}_{i,t-1} + \varepsilon_i \qquad (4)$$

where growth for firm i in period t is a function of initial firm size, size^2, age, and ε_i a stochastic error term.

Sutton (1997) and Caves (1998) survey and report on the large number of empirical studies estimating Equation (4). The evidence is systematic and compelling that both size and age are negatively related to firm growth.

Note that Equation (4) only considers characteristics specific to the enterprise. We extend this approach by including knowledge spillovers from universities,

$$\text{Growth}_{i,t} = \text{B}_1 \ln(\text{Size}_{i,t-1}) + \text{B}_2 \ln(\text{Size}_{i,t-1})^2 + \text{B}_3\text{Age}_{i,t-1}\text{B}_4\text{Knowledge}_{r,t-1} \times \text{B}_5\text{D}_{ind} + \varepsilon_i \qquad (5)$$

where D_{ind} is a vector of industry dummies controlling, for example, for the knowledge intensity of production in a specific sector. Knowledge_r, $t-1$ represents knowledge spillovers from universities.

3. Data set and descriptive statistics

To test the hypothesis that firm growth depends not only on firm size and age but also university spillovers, we use a unique dataset of 281 IPO firms in Germany. The dataset is collected combining individual data from IPO prospectuses, along with publicly available information from on-line data sources including the *Deutsche Boerse AG* (www.deutsche-boerse.com). We pooled this dataset by adding university-specific variables, which are individually collected from the 73 public universities in Germany. For each of those universities we collected the number of articles listed in the research database from the ISI (Information Sciences Institutes). Although this research database includes a small number of all the journals in one field, it ensures that it only contains the high-quality research journals. We further consider the amount of grants available to each respective university in 1997 (see Audretsch *et al.*, 2004).

We take the *log growth rates* of employees one year after the IPO as the dependent variable. The first two exogenous variables are firm age (AGE) and firm size (SIZE). Age is measured in years from foundation to IPO, and firm size by the number of employees before IPO. To capture effects from university spillovers we include the distance to the closest university as an exogenous variable. Since universities in Germany are more geographically concentrated compared to the US, we need a measure which is sensitive to small variations. The distance is measured in kilometers using the online database of the *German Automobile Club* (www.adac.de). All firms located within a radius of 1.5 km are classified as belonging to the distance category of 1 km.

In the first two models (models I, II), we estimate the following basic regressions to test Gibrat's Law, as proposed in the literature (see Sutton, 1997).

$$\text{(I)}\quad \text{LnGrowth} = const. + \beta_1 LnSize + \beta_2 LnSize^2 + \beta_3 LnAge + \beta_4 LnAge^2 + \varepsilon$$

$$\text{(II)}\quad \text{LnGrowth} = const. + \beta_1 LnSize + \beta_2 LNAge + \varepsilon$$

Then we test for the impact of university spillovers as an additional explanatory variable for firm growth (models III, IV):

$$\text{(III)}\quad \text{LnGrowth} = const. + \beta_1 LnSize + \beta_2 LNAge + (-1)\beta_3 University\,Spillovers + \varepsilon$$

$$\text{(IV)}\quad \text{LnGrowth} = const. + \beta_1 LnSize + \beta_2 LnAge + (-1)\beta_3 University\,Spillovers \times (LnUniversity\,Spending; \times LnSSCI; LnSCI)$$

We multiplied with (−1) to capture the effect that the closer the distance towards the next university, the higher should be the growth rate of the respective firm. Model (V), which is not explicitly shown, captures all variables.

The descriptive statistics are depicted in Table I. The closest location between firms and universities is 1 km and the maximum distance is 177 km away from the nearest university. The data also demonstrate that most of the firms are strikingly young. Half of the firms in our sample are 8 years old or less. The firms also differ extremely in their size as measured by the number of employees before IPO. The mean firm before IPO employed about 180 workers. Finally, the table shows that on average the log growth rate is about 0.475. All the variables show high differences between the minimum and maximum values.

4. Empirical evidence

Table II presents the results from the four regressions. Models (I) and (II) replicate the standard tests of Gibrat's Law as known from the literature. The negative and statistically coefficient on firm size suggests that smaller firms grow faster than do their larger counterparts. The coefficient of firm age and firm age as well as the squared term shows no statistically significant impact on firm growth.

The estimation of model (III) shows no significant impact of university spillovers as measured by the distance towards the closest university of a firm. However, if we instrument this variable model (model IV) using the spending for the

TABLE I
Descriptive statistics

Variable	Mean	SD.	Min.	Max.
Distance (km)	16.69	23.45	1	177
Firm size (#employees)	180.20	256.52	2	1,700
Firm age (years)	10.27	11.11	0.1	107
Ln growth rates	0.4969	1.6121	−4.106	7.5183

TABLE II
Regressions on firm growth

	OLS (I)	OLS (II)	OLS (III)	OLS (V)	2SLS (IV)	2SLS (V)
LnSize	−0.7895 (2.75)[b]	−0.9290 (15.33)[c]	−0.9117 (14.10)[c]	−0.8537 (1.86)[b]	−0.8554 (10.22)[c]	−1.1272 (2.31)[c]
Ln Size2	−0.0152 (0.47)			−0.0059 (0.12)		0.03133 (0.58)
LnAge	0.0859 (1.29)	0.07390 (1.40)	0.0613 (1.19)	0.0731 (0.96)	0.1688 (2.00)[b]	0.1929 (1.83)[a]
LnAge2	−0.0114 (0.41)			0.0092 (0.34)		−0.0099 (0.31)
University spillover			−0.0423 (0.92)	−0.0430 (0.92)	0.7131 (1.78)[b]	0.7263 (1.79)[b]
Const.	4.3187 (7.03)[c]	4.5762 (17.27)[c]	4.4339 (13.75)[c]	4.3289 (4.11)[c]	5.430 (8.25)[c]	6.001 (4.43)[c]
R	0.4749	0.4779	0.4856	0.4860	0.0236	0.0094

This table presents the result from OLS on firm growth. The endogenous variable is growth rates of employees one year after the IPO. University Spillover is measured in log kilometers from the next university. This variable is instrumented in the 2SLS approach by the number of research spending, the number of papers published in the natural sciences and in the social sciences. All OLS-estimations are done using the White-heteroskedasticity robust estimator. Absolute *t*-values in parentheses, [a, b, c] Statistically significant at the 10, 5 1% level, respective. The coefficient of university spillovers are multiplied with (−1) to capture the positive effect of a close location towards the next university.

respective university as well as the academic papers published in the natural sciences and the social sciences, we find the missing link: Spillovers matter for firm growth. The closer the distance towards the next university and the higher the amount of academic papers published, the higher the growth rates of firms. This result is also robust in model 2SLS (V), which includes all the variables.

5. Conclusion

Perhaps had Edwin Mansfield's career been extended, he would have had the opportunity to bring together two of his seminal contributions—firm growth and university research spillovers. In this paper, we have followed in the footsteps of Mansfield by linking these two seminal contributions together. Not only does firm growth depend upon characteristics specific to the firm, but also on external characteristics as well, and in particular, the spillover of knowledge from universities. We would anticipate future research to further pursue the intellectual tradition pioneered by Ed Mansfield and further examine how firm growth is shaped by other types of knowledge spillovers external to the firm.

Note

1. An earlier study focusing on knowledge spillovers is Link and Rees (1991).

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