The microeconomics of growth of manufacturing firms and technological innovation: evidence from Brazil and 7 European countries

Extended Abstract

Alexandre M. Silva — **IPEA** — Alexandre.silva@ipea.gov.br
Bruno César Araújo — **IPEA** — Bruno.araujo@ipea.gov.br
Julio Raffo — **University of Paris 13** — jraffo@gmail.com

This paper brings two contributions to the debate on the microeconomic determinants of firm growth. First of all, regarding the selection and endogeneity biases that arise from the relation between R&D spending and firm performance, we test a growth equation based on the CDM framework - Crépon, Duguet e Mairesse (1998)[1].

Furthermore, we estimate growth equations not only for a single country, but indeed for Brazil along with seven European ones ï Germany, France, Spain, Portugal, Hungary, Slovakia and Lithuania. In order to do that, we made use of the 2000 Industrial Research of Technological Innovation (PINTEC) - carried out by the Brazilian Institute of Geography and Statistics (IBGE) ï and the micro aggregated data from the Community Innovation Survey (CIS3). Both surveys provide information concerning the period ranging from 1998 to 2000.

Summing up, we tried to tackle three research questions:

(i) is technological innovation relevant to explain short-run firmsô growth?

(ii) if so, does R&D spur firmsô growth, through innovation?

(iii) is the intensity of innovation effects related to firmsô initial size?

First of all, based on Calvo (2006)[2], we implemented a specification of Gibratôs law, intending to identify the relevance of the innovation outputs to short-run firmsô growth. In fact, we employed three distinct versions: the first one includes the probability of innovation either in process or in product; the second one, differently, takes into account the probabilities of innovation only in process, only in product, and in both of them; finally, the third one uses share of innovative products in total sales. Therefore, the equations are as follows:

$$\ln G_{2000i} = f(\ln size_{1998i}, (\ln size_{1998i})^2, \text{þ}(inova_i), dtech\_ml_i, dtech\_mh_i, dtech\_h_i) \quad (1)$$

$$\ln G_{2000i} = f(\ln size_{1998i}, (\ln size_{1998i})^2, \text{þ}(inpdt_i), \text{þ}(inpcs_i), \text{þ}(inpdt\_inpcs_i), dtech\_ml_i, dtech\_mh_i, dtech\_h_i) \quad (2)$$

$$\ln G_{2000i} = f(\ln size_{1998i}, (\ln size_{1998i})^2, \ln turnover_i, (\ln turnover_i)^2, (\ln turnover_i) * (\ln size_{1998i}), dtech\_ml_i, dtech\_mh_i, dtech\_h_i) \quad (3)$$

---

[1] CREPON, B., DUGUET, E., MAIRESSE, J. Research, innovation, and productivity: An econometric analysis at the firm level. *NBER Working Paper n. 6696*. 1998

[2] CALVO, J. *Testing Gibratôs Law for Small, Young and Innovating Firms.* Small Business Economics, Vol. 26 (1), pp. 117-123, 2006.

All these equations allow for FGLS estimations which take into account heteroscedasticity, and their variables are: $\ln G_{2000i}$ is the natural logarithm of the ratio between the firm *i* total sales in 2000 and 1998; $\ln size_{1998i}$ is the natural logarithm of 1998 total sales; $\hat{p}(inova_i), \hat{p}(inpdt_i), \hat{p}(inpcs_i), \hat{p}(inpdt\_inpcs_i)$ are, respectively, the estimated probabilities of innovation either in process or in product, only in process, only in product, and in both of them; $\ln turnin_i$ is the natural logarithm of the estimated sales share of innovation products; $dtech\_ml_i, dtech\_mh_i, dtech\_h_i$ are industry-level dummies representing, respectively, medium-low, medium-high and high technology sectors, as in Calvo (2006).

As long as innovation variables are distinct across those versions, so are also their second stage estimations. The stage prior to equation (1) was estimated by a probit model of firm innovation throughout the period 1998-2000. In what concerns equation (2), we made use of a bivariate probit model of process and product innovations. Finally, the second stage related to equation (3) was estimated by FGLS, along with a logistic transformation of the sales share of innovation products. This said, second stage equations are specified as follows:

$$inova_i = \Phi f(rdinx\_turn_i, dpull_i, tech\_push_i, invta_i, groupfg_i, size_{2i}, size_{3i}, \mathbf{Dsct_i}) \quad (4)$$

$$\begin{cases} inpdt_i = \Phi f(rdinx\_turn_i, dpull_i, tech\_push_i, groupfg_i, size_{2i}, size_{3i}, \mathbf{Dsct_i}) \\ inova_i = \Phi f(rdinx\_turn_i, dpull_i, tech\_push_i, invta_i, groupfg_i, size_{2i}, size_{3i}, \mathbf{Dsct_i}) \end{cases} \quad (5)$$

$$\lambda_i = \Phi f(rdinx\_turn_i, dpull_i, tech\_push_i, invta_i, groupfg_i, size_{2i}, size_{3i}, \mathbf{Dsct_i}) \quad (6)$$

In the above equations, $rdinx\_turn_i$ is the first-stage estimated R&D/turnover ratio, $invta_i$ is the investment in tangible goods/turnover ratio, and $dpull_i, tech\_push_i, groupfg_i, size_{2i}, size_{3i}, \mathbf{Dsct_i}$ are demand pull factors, technological push factors, a dummy indicator if the firm *i* belongs to a foreign group, and size (50-250 and above 250 employees) and sector dummies, respectively.

Finally, the R&D decision and amount is common to all stages, and is given by the following Heckit estimation:

$$\begin{cases} drdeng_i = \Phi(f(comp_i, mktshare_i, funpub_i, groupfg_i, size_{2i}, size_{3i}, \mathbf{Dsct_i})) \\ rdinx\_turn_i = f(comp_i, coop_i, mktshare_i, funpub_i, groupfg_i, dpull_i, tech\_push_i, \\ cst\_push_i, size_{2i}, size_{3i},, Mills^{-1}, \mathbf{Dsct_i}) \end{cases} \quad (7),$$

Which is basically the same employed in the original CDM model.

Figure 1 summarizes the empirical strategies employed in this paper.

Figure 1: Empirical Strategies

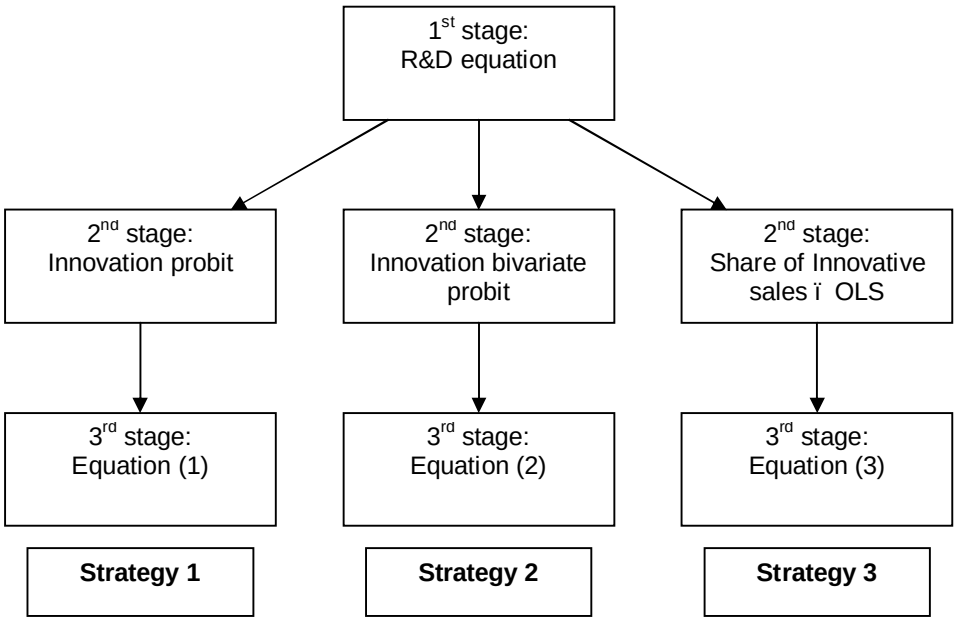

Table 1 depicts the results of first empirical strategy. In the first two columns, one can see the parameters related to the binary innovation variable in equation (1), obtained, respectively, by FGLS and the equation system comprising three stages. In the third column, marginal effects of R&D spending on firm innovation probability are shown. Finally, the last column exhibits the estimated elasticities of firm growth with respect to R&D spending, obtained by the product of innovation marginal effect on growth and the mean effect of R&D spending on innovation probability. Similarly, Table 2 shows the results obtained from the second strategy.[3]

Table 1: Results Summary - Empirical Strategy 1

Countries	Number of firms[a]	FGLS[b]	System[b]	R&D[c]	Elasticity[d]
Germany	49.257	0,051***	0,114***	0,468***	5,49
Brazil	39.220	0,129***	0,204***	0,495***	10,63
Spain	42.382	0,123***	0,122***	0,205***	2,53
France	24.512	0,054***	0,094***	0,191***	1,81
Portugal	15.618	0,157***	0,174***	0,366***	6,59
Slovakia	3.254	0,268***	0,238***	0,021	-
Hungary	7.943	0,172**	0,207**	-0,012	-
Lithuania	1.651	0,153***	0,159***	1,935***	36,07

*** Significant at 1%; ** significant at 5%; * significant at 10%.

[a] Expanded number of firms, restricted to firms with more than 20 employees.

[b] Estimated parameters related to the innovation dummies.

[c] Mean estimated marginal effect of R&D spending on innovation.

[d] Elasticity of firm growth with respect to R&D spending.

Source: created by the authors, based on the referenced databases.

[3] In both strategies, growth elasticities regarding R&D are given by $\frac{\partial G_{2000i}}{\partial rdinx\_turn_{2000i}} = \sum\sum \frac{\partial G_{2000i}}{\partial \text{var}\_inov_{2000i}} . \frac{\partial \text{var}\_inov_{2000i}}{\partial rdinx\_turn_{2000i}}$, where var_inov_{2000i} are innovation variables.

Table 2: Results Summary - Empirical Strategy 2

	Innovation					
	Product and Process			Only Product		
Countries	**FGLS[a]**	**System[a]**	**R&D[b]**	**FGLS[a]**	**System[a]**	**R&D[b]**
Germany	0,063**	0,194***	0,230***	0,031	0,003	0,038
Brazil	0,189***	0,156***	0,111***	0,006	-0,203	0,018
Spain	0,167***	0,187***	0,042***	0,099***	0,504***	0,000
France	0,053***	0,091***	0,056***	0,069***	0,007	0,043**
Portugal	0,133***	0,124***	0,046**	0,165**	0,571**	-0,024
Slovakia	0,237***	0,483***	0,002	0,278***	0,12	0,036
Hungary	0,171	0,321*	-0,007	0,138	-0,229**	-0,079
Lithuania	0,195***	0,166**	0,146***	0,085	0,052**	0,226***

*** Significant at 1%; ** significant at 5%; * significant at 10%.

[a] Estimated parameters related to the innovation dummy.

[b] Mean estimated marginal effect of R&D spending on innovation.

Source: created by the authors, based on the referenced databases.

Tabela 2 (continuation):

	Innovation			
	Only Process			
Países	**FGLS[a]**	**System[a]**	**R&D[b]**	**Elasticity[c]**
Alemanha	0,064*	0,438***	0,100*	9,01
Brasil	0,131***	0,828***	0,297***	29,59
Espanha	0,095***	0,000	0,125***	0,79
França	0,02	0,676***	0,052***	4,05
Portugal	0,174***	0,324***	0,18***	6,59
Eslováquia	0,29*	-0,323	0,003	-
Hungria	0,233**	0,934*	0,002	-
Lituânia	0,185*	0,995***	0,278***	34,31

*** Significant at 1%; ** significant at 5%; * significant at 10%.

[a] Estimated parameters related to the innovation dummies.

[b] Mean estimated marginal effect of R&D spending on innovation.

[c] Elasticity of firm growth with respect to R&D spending.

Source: created by the authors, based on the referenced databases.

In all countries but France, initial size influences short-run growth. Interestingly, the coefficient of the square of size is positive in most countries.

Regarding estimations for strategy 3, interaction terms showed that in Germany, Lithuania and Portugal, innovation outputs seemed to spur faster growth in small firms. In other countries, no differences were found in this regard between small and large firms.

Innovation affects firmsô growth in all countries. In Brazil, 1 p.p. increase in R&D/turnover investments fosters short-run growth in 10-30%. These outcomes from estimation strategies indicate that, in Brazil, technological innovation exerts great influence on firmsô growth, especially under the comparative point of view employed in this paper. The pattern which arose from our empirical work suggests the presence of diminishing marginal returns to innovation, due to its greater impact on firmsô growth seen in less knowledge-intensive countries. Therefore, Brazilian firms, as well as the Eastern European ones, can indeed achieve higher marginal benefits by investing in technological innovation.