Does firm innovation lead to high growth? Evidence from Ecuadorian firms

Diego F. Grijalva* Valeria Ayala† Paúl Ponce‡ Yelitsa Pontón§

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Abstract

We analyze the determinants of: i) employment and sales growth, and ii) becoming a high-growth firm (HGF) among Ecuadorian firms for the period 2011-2014. We use a simplified CDM model (Crepon, Duguet & Mairesse, 1998) that controls for selection bias in the choice to innovate and apply it to the two rounds of the Ecuadorian National Innovation Activities Survey. We find that younger firms and firms that spend more on R&D activities per employee have significantly higher levels of employment growth and are significantly more like to become employment HGFs. We highlight, however, a negative positive correlation between employment growth and labor productivity growth, pointing to important policy challenges.

Keywords: Firm growth, high-growth firms, job creation, entrepreneurship, innovation, CDM model
JEL Codes: D22, L26, M21, O3, O54

1 Introduction

In recent years there has been a growing interest on high-growth firms (HGFs), as they contribute to several key objectives of public policy. Most importantly, HGFs play a role in generating economic growth (Schreyer, 2000). Several mechanisms explain why HGFs contribute to economic growth. First, following the work of Birch (1979), a large literature has shown that HGFs are typically responsible for a large fraction of employment creation despite constituting a small share of employment (Henrekson & Johansson, 2010).[1] In addition, HGFs generate business for other firms (SEAF, 2007), further contributing to employment and economic growth.

Second, there is evidence that the jobs created by HGFs tend to be better ones. Olafsen & Cook (2016) find that HGFs' jobs pay higher wages than national averages and that their employees tend to

*Universidad San Francisco de Quito USFQ, USFQ Business School, School of Economics and Instituto de Economía; corresponding author: dgrijalva@usfq.edu.ec.

†Universidad San Francisco de Quito USFQ, School of Economics.

‡Secretaría Nacional de Planificación y Desarrollo SENPLADES, Quito, Ecuador.

§Universidad San Francisco de Quito USFQ, School of Economics.

[1]For instance, Storey (1994) finds that in the United Kingdom around four percent of firms create approximately half of the new jobs over a decade.

report higher job satisfaction. This makes intuitive sense as HGFs are successful companies, capable of providing better working conditions.

Third, HGFs also contribute to product and process innovation, and thus to productivity (Bartelsman et al., 2005). Likewise, Olafsen & Cook (2016) argue that there is a set of high-growth firms that focus on innovation as a mechanism to grow. According to these authors, such firms are important because they enhance competition and diversification, and contribute to improved consumer choice.

HGFs thus constitute the cornerstone of the microfoundations of economic growth and, as a consequence, are considered central to economic development policy (Autio & Rannikko, 2016). If the growth of HGFs can be sustained over time, there is a case to be made in favor of policies that promote growth and support HGFs over time. The evidence however, though still scant, indicates that HGFs' growth is *not* persistent. For example, Daunfeldt & Halvarsson (2014) find that among Swedish firms high growth in a given period is associated with job losses in the previous one and a very low probability of high growth in the next one. The conclusions regarding persistence depend on how growth is measured (Hölzl, 2014), but it seems that HGFs cannot be predicted ex-ante (Hölzl, 2009). Indeed, Falkenhall & Junkka (2009) find that there is a replacement effect according to which HGFs in a given period are replaced by other HGFs in the next period. Only a very small fraction of enterprises manage to sustain high growth over longer periods of time.

This discussion is based on evidence about HGFs that comes mostly from OECD countries, which are significantly different from less developed countries regarding their economic structure, levels of innovation, distance to the technological frontier, nature of entrepreneurship, etc.. For this reason, it is important to expand our understanding of HGFs in non-OECD countries. In the specific case of Ecuador, to the best of our knowledge, there is no study about HGFs. This paper contributes to this gap by analyzing the determinants of Ecuadorian firms' growth and their likelihood of becoming HGFs.

We find that younger firms and those that spend more on R&D per employee have significantly higher levels of employment growth and are significantly more like to become employment HGFs. However, contrary to some results in the literature, size does not have an effect on either of these variables. Finally, belonging to a business group has a negative effect on both variables.

Our results on sales growth and sales HGFs are much less precise. Most importantly, R&D expenditure does not have an effect on either sales variable. The share of exports on sales are negatively associated with sales growth and smaller firms are more likely to become sales HGFs, although this result is only marginally significant.

Our results show how our conclusions on HGFs can vary significantly depending on the chosen growth variable, and Ttese differences can have important consequences for policy. Moreover, despite our main results that younger firms and those with higher R&D investment are associated with higher employment growth, the existence of a negative correlation between employment growth and labor productivity growth poses a central dilemma to policy makers.

2 Literature review

There exists a large literature on HGFs and their determinants that started with the work of Birch (1979). However, there is no common definition of what exactly constitutes a HGF. Therefore, it is hardly surprising that there is no consensus about which and how specific factors affect them. In this section we briefly discuss five dimensions that make the definition of HGFs problematic.[2] Considering

[2]See Moreno & Coad (2015) for an expanded discussion on most of these dimensions.

these limitations, we next present our preferred definition of HGF. Finally, we discuss the variables included in our econometric models and previous evidence regarding their effect on HGFs.

Why are high growth firms so difficult to define? The first reason is that there is no obvious indicator to measure a firm's growth. Most authors use either employment and/or sales (Delmar, 2006), but other indicators such as productivity, revenue, value added, profit, market share and asset growth have also been used.[3] This lack of consistency is problematic because different indicators lead to different sets of firms defined as HGFs, complicating the definition of policy recommendations aimed at promoting HGFs.[4] Moreover, as we show in section 5, the factors that influence HGFs vary depending on the chosen indicator.

Second, growth can be measured in relative and absolute terms. The former is biased in favor of small firms, while the latter is biased in favor of large firms (Delmar, 1997). In either case, it is not clear what threshold to use and whether the threshold should be defined with respect to growth (e.g. growth in employment of 25% or more per year as in Haltiwanger et al. (2013)) or with respect to the relative performance of the firms (e.g. the 5% of firms with the highest growth in employment as in Coad et al. (2014)). As a response to this problem, several authors have used the Birch index, which combines relative and absolute growth.[5] Alternatively, to deal with the bias in favor of small firms when using relative growth, OECD/Eurostat (2008) propose to use a relative measure of growth but to include among HGFs only firms with 10 or more employees.

Third, because growth implies a change in quantity over time, either one of these two dimensions can be emphasized. As a consequence, some authors have emphasized the quantity dimension (high-growth firms)[6] while others have focused on the time dimension (fast-growth firms or similar definitions).[7] This distinction is key because recent research has shown that HGFs are not in general able to sustain their levels of growth over longer time-frames (Hölzl, 2014), and indeed are characterized by low profits and a weak financial position *before* their high growth periods (Daunfeldt & Halvarsson, 2015). As a consequence, (Braennback et al., 2014) argue that growth and in particular high and fast growth is not always good for the firm and emphasize instead the role of profitability and sustainability.

Fourth, related to the previous point, it is not clear over what period to measure growth. Indeed, it varies from the shortest, typical analysis of Henrekson & Johansson (2010), who consider HGFs those that grow more than 20% for a period of 3 or 4 years, to Fritsch & Weyh (2006), who use a period of 18 years. Of course, part of this variation responds to the issue of sustainability and availability of data. In particular, as more data becomes available, it is possible to look at HGFs' behavior over longer time-frames.

Finally, the nature of a firm's growth is important. Firms can grow organically (internal growth) or by acquisition (mergers or acquisitions) (Delmar et al., 2003). Conceptually, this distinction is clear, and OECD/Eurostat (2008) recommends not considering a firm a HGF when its growth has been due to a merger or an acquisition. In practice, however, research has focused on total growth (the sum of organic growth and acquisition growth) mainly due to limitations in the datasets (Coad et al., 2014).

[3] See Daunfeldt et al. (2010) and Daunfeldt et al. (2013) for a discussion of the implications of using different indicators to measure firms' growth.

[4] Coad (2010), however, shows that the correlation is moderately high when using employment and sales.

[5] Letting L_i represent the number of employees in firm i, the formula for the Birch index is given by: $BI = (L_{i,t+1} - L_{i,t})\frac{L_{i,t+1}}{L_{i,t}}$.

[6] See e.g. Segarra & Teruel (2014)

[7] Birch (1981) uses "gazelles", Almus (2002) uses "fast-growth firms", Schreyer (2000) uses "rapidly expanding firms", and Coad & Rao (2008) use "'superstar fast-growth firms".

Considering these limitations, in our analysis we follow OECD/Eurostat (2008), who define a HGF as a firm with average annualized growth greater than 20% per year over a three-year period (i.e. 72.8%) and with ten or more employees at the beginning of the observation period.[8] We measure growth in terms of both employment and sales. Furthermore, we do not include firms that have experienced a merger or an acquisition over the period of analysis.

In spite of the methodological limitations, there is an extensive literature that explores the potential factors that contribute to firms' high-growth. Olafsen & Cook (2016) provide a review of these determinants in general and Nichter & Goldmark (2009) present a detailed analysis for the case of developing countries, specifically for micro and small enterprises. The factors that contribute to growth can be grouped into four categories: i) Individual entrepreneur's characteristics (e.g. education, work experience, gender, age, and psychological traits), ii) Firm characteristics (e.g. age, size, firm's sector, formality, foreign ownership, exports, access to finance, etc.),[9] iii) Relational factors (e.g. entrepreneur's social networks, characteristics of the value chain, and interfirm cooperation), and iv) Contextual factors (e.g. business cycle, price volatility, regulatory and institutional environment, and even cultural characteristics).

Although we agree that many of these factors do play an important role in the case of Ecuadorian HGFs, in this paper we focus only on some of them –mainly because of the nature of the dataset–. Most importantly, we are not able to include individual entrepreneurship, relational and contextual characteristics. We focus only on *some* firm characteristics, specifically age, size, investment in fixed capital, participation in a business group, exports, available skills and, most importantly, innovation expenditure. We next consider the empirical evidence on these factors.

Consider first firm's age. A robust finding is that firm's age and high growth are inversely related (Henrekson & Johansson, 2010). Among developed countries, Schreyer (2000) confirms this result for Italy, Germany, Netherlands, Spain, Sweden, and Quebec, Canada. Similar results are confirmed in developing countries. Burki & Terrell (1998) find that firm's average growth rate decreases with age in the case of Pakistan. Mead & Liedholm (1998) find a similar results among micro and small enterprises (MSEs) in five African countries and the Dominican Republic. Still, for the United States, Acs et al. (2008) find that the average age of high-impact firms is around 25 years old, which is considerably larger than what is commonly found in the literature.

Regarding the effect of firm's size on HGFs, the evidence is still mixed. Following the seminal paper by Birch (1979) –who showed that in the United States small firms are responsible for a disproportionate share of job creation–, a debate ensued. Birch's result was later confirmed in Portugal (Mata, 1998) and other countries. However, Schreyer (2000) finds that in the countries that he analyzes, small and large firms contribute to employment gains, with the more significant role coming from larger firms. Importantly, he measures growth using the Birch index. More recently, Haltiwanger et al. (2013) finds that in the case of the United States firm's size ceases to have a significant effect on growth once age is controlled for.

There is limited evidence on the effect of fixed capital investment, participation in a business group, and exports. Almeida et al. (2015) show that Korean groups were able to sustain the investment of high-growth firms during the Asian crisis through cross-firm equity investments. Hölzl & Friesenbichler (2007) find strong evidence that exports are positively related to high growth in the case of Austrian firms.

Finally, there has been a recent interest on the effect of innovation on high growth. Despite the

[8] OECD/Eurostat (2008) explicitly distinguish gazelles as HGFs that are less than five years old.

[9] Olafsen & Cook (2016) argue that access to finance is part of the contextual factors. However, in the specific case of Ecuador we believe that there are systematic differences in access to finance depending on firms' characteristics. In other words, we deem it more appropriate to consider it a feature of the firm and not of the aggregate context.

natural prior that high-growth firms should be innovative, there is conflicting evidence on the effect of innovation. At the theoretical level, based on the idea of creative destruction (Schumpeter, 1942), Nelson & Sydney (1982) argue that innovation is a key driver of firm growth. However, innovation is a highly uncertain process and the results may appear only after a lag. Also, there are important differences across countries. Hölzl (2009) finds that HGFs in countries far from the technological frontier require less R&D investment. In addition, certain types of innovation may have different effects. For instance, while (Hölzl & Friesenbichler, 2007) find that product innovation has a positive effect on employment growth, Coad & Rao (2008) and Hall et al. (2008) find that process innovation leads to employment decline. This result is confirmed by Goedhuys & Sleuwaegen (2010) in the case of 11 African countries. They find that product innovation is positively associated with becoming a HGF but process innovation is negatively associated with it.

In line with this debate, Henrekson & Johansson (2010) survey the literature on HGFs and find that they are not over-represented in high-tech sectors. Indeed, in the case of Swedish firms, Daunfeldt et al. (2016) find that HGFs are less frequent in sectors with high levels of R&D investment. Likewise, Parker et al. (2010) find that large gazelles in the United Kingdom tend to avoid new product development.

3 High-growth firms in Ecuador

In this section we provide a brief description of the main characteristics of Ecuadorian HGFs. Before that, we discuss briefly the datasets used in the analysis.

3.1 Datasets

We use the two rounds of the Ecuadorian National Innovation Activities Survey of 2013 and 2015, implemented by the National Institute of Statistical and Census (INEC).[10] These surveys are based on the methodology proposed by OECD/Eurostat (2005) and aim to compile representative data on the innovative activities undertaken by firms in Ecuador. In particular, they provide information about basic firms' characteristics including start date, size, industry, international orientation, and participation in business groups. Likewise, the surveys provide information on different types of innovation: product, process, organizational, and marketing. Finally, they include information on spending on innovation, sources of financing, R&D expenditures, patents and licenses, constraints to innovation, among others.

The 2013 Innovation Survey includes data for the years 2009-2011 for a representative stratified sample of 2,815 firms with more than 10 employees from the manufacturing, services and commerce sectors. The 2015 Innovation Survey includes data for the years 2012-2014, has a sample of 6,275, of which 237 are from the mine sector, 1,619 from manufacturing, 2,509 from services and 1,910 from commerce. The surveys include significant heterogeneity in terms of firm size, age, industry, international orientation, and participation in business groups.

The two rounds include a panel of 1,065 firms, which we use as the starting point of our analysis. We restrict our sample in two ways. First, we exclude firms that have experienced a merger or an acquisition at any point during the whole period (2009-2014). Second, to control for outliers, we exclude firms that had a growth of more than 250% per year. Our final sample includes 993 firms. From this total, 91 firms (9.16%) are HGFs in terms of employment and 180 firms (18.13%) are HGFs in terms of sales.

[10] This survey is known as *Encuesta Nacional de Actividades de Innovación*.

Table 1: Ecuadorian Firms' Employment, Sales and Productivity, 2011-2014

Employment			
Deciles by employment	Average growth rate of employment	Average growth rate of sales	Average growth rate of productivity
1	-60.04	39.40	605.99
2	-23.50	56.47	101.47
3	-10.55	8.97	21.24
4	-1.85	83.09	86.46
5	4.17	41.46	35.83
6	10.91	89.06	71.20
7	20.03	46.81	22.60
8	31.98	91.20	46.21
9	52.01	83.36	21.76
10	184.33	216.39	15.80
Sales			
Deciles by sales	Average growth rate of employment	Average growth rate of sales	Average growth rate of productivity
1	2.76	-78.48	-62.52
2	-10.42	-35.78	325.86
3	1.12	-16.30	-6.99
4	-1.87	-4.02	89.07
5	19.23	6.62	8.08
6	14.41	16.74	10.44
7	19.72	28.91	15.78
8	21.61	51.01	37.62
9	47.05	105.37	59.53
10	90.46	687.62	570.15
Total sample	**20.37**	**75.88**	**104.43**

Source: Authors' estimations based on INEC (2012) and INEC (2015).

3.2 Descriptive statistics of Ecuadorian HGFs

Table 1 provides an overview of employment, sales, and productivity growth for the period 2011-2014 among 993 Ecuadorian firms, classified by deciles based on employment growth (top panel) and sales growth (bottom panel).[11] It provides several interesting results. First, in the full sample employment grew by 20.37% for the whole period, sales by 75.88% and productivity by 104.43%. These are remarkable changes and are consistent with a period of strong economic growth characterized by the peak of the commodities boom in Ecuador (Gachet et al., 2017). Second, there is large variation across deciles, consistent with a strong process of creative destruction. The number of employees falls

[11] Our measure of productivity corresponds to labor productivity only. It is measured as the ratio of sales to the number of employees.

Table 2: Characteristics of High Growth Firms (HGF)

	HGF by employment		Non-HGF by employment		HGF by sales		Non-HGF by sales	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Number of firms (2011)	91		902		180		813	
Number of employees (2011)	146.49	45.00	277.76	72.00	148.89	47.50	291.60	79.00
Age of firms (2011)	21.64	20.00	28.88	24.00	24.77	20.00	28.98	24.00
Growth rate of employment (2011-14, %)	194.33	116.79	2.82	3.92	71.29	29.29	9.09	4.01
Growth rate of sales (2011-14, %)	225.49	84.76	60.79	8.61	429.25	194.80	-2.35	2.58
Growth rate of productivity (2011-14, %)	14.85	-20.78	113.46	6.56	342.87	134.82	51.64	-2.89
Firms with R+D activities (2009-11, %)	27.47	-	31.04	-	28.89	-	31.12	-
R+D expend. per employee (2009-11, US$ of 2016)	446.75	0.05	378.26	0.04	269.42	0.05	410.02	0.04
Fixed capital expenditure per employee (2009-11, US$ of 2016)	8,675.38	1,732.46	6,891.82	908.68	4,432.74	799.01	7,635.90	974.59
Firms belonging to a business group (2011, %)	21.98	-	23.06	-	17.78	-	24.11	-
Foreign capital in firms (2011, %)	13.80	0.00	11.70	0.00	9.60	0.00	12.40	0.00
Firms that are public (2011, %)	1.10	-	2.99	-	2.22	-	2.95	-

Source: Authors' estimations based on INEC (2012) and INEC (2015).

in the lowest decile by 60.04% but it increases by 184.33% in the highest one. Likewise, sales in the first decile fall by an average of 78.48%, while they increase by an impressive 687.62% in decile 10. Third, the table also shows that productivity growth is very high in the *lower* deciles of employment growth, but it tends to fall as we move towards the upper deciles. The opposite occurs with sales deciles, where in general productivity growth is low or negative in the lower deciles and it increases thereafter. Indeed the correlation between the growth rates of employment and productivity is -0.076 and the correlation between the growth rates of sales and productivity is 0.2101.

Table 2 looks specifically at HGFs vs. non-HGFs by employment and sales. The first feature of Ecuadorian HGFs is that there are many more HGFs by sales than by employment growth (180 vs. 91). This is consistent with previous studies (see e.g. Segarra & Teruel (2014)) and is what we would expect given rational behavior by firms. Faced with a positive shift in demand that is uncertain to be permanent, firms should try to modify the variable factor of production (i.e. hours per worker); only if they expect the shift to be permanent, should they modify the fixed factor of production (i.e. number of workers). The second feature is that HGFs in Ecuador tend to be significantly smaller. On average, they have around half the number of employees compared to non-HGFs. Third, HGFs are younger than their counterparts. They are seven years younger in the case of employment and four years younger in the case of sales. Fourth, independently of whether we measure growth in terms of employment or sales, HGFs are very different from their non-HGFs counterparts. In the case of employment, the median rate of employment growth among HGFs is almost 18 times that of non-HGFs. In the case of sales, this is even higher: the median rate of growth of HGFs is almost 22 times that of non-HGFs.

As we mentioned before, a key distinction between employment HGFs and sales HGFs is their productivity growth. While the average growth of productivity among sales HGFs is almost seven times the average growth among their counterparts, average productivity growth among employment HGFs is more than seven times *smaller* than their counterparts. In fact, the meian growth rate of productivity among HGFs by employment is -20.78%. Regarding the relationship between R&D expenditure and HGFs in particular, there are two interesting results. On the one hand, relatively fewer HGFs decide to perform innovation activities compared to non-HGFs, both for employment and sales-based HGFs. On the other hand, however, HGFs based on employment spend on average almost 54% more on R&D per employee relative to their counterparts. HGFs by sales, however, spend *less* on R&D per employee relative to their counterparts.[12]

Figures 1 and 2 provide a comparison of the distribution of HGFs and non-HGFs based on employment and sales in terms of R&D expenditure per employee, capital expenditure per employee, size and age. The figures also report Kolmogorov-Smirnov tests for the equality of the distributions. As can be seen in Figure 1, Ecuadorian HGFs tend to invest significantly more in R&D than non-HGFs. Employment HGFs also invest more in fixed capital. This type of investment is no different among sales HGFs relative to their counterparts.

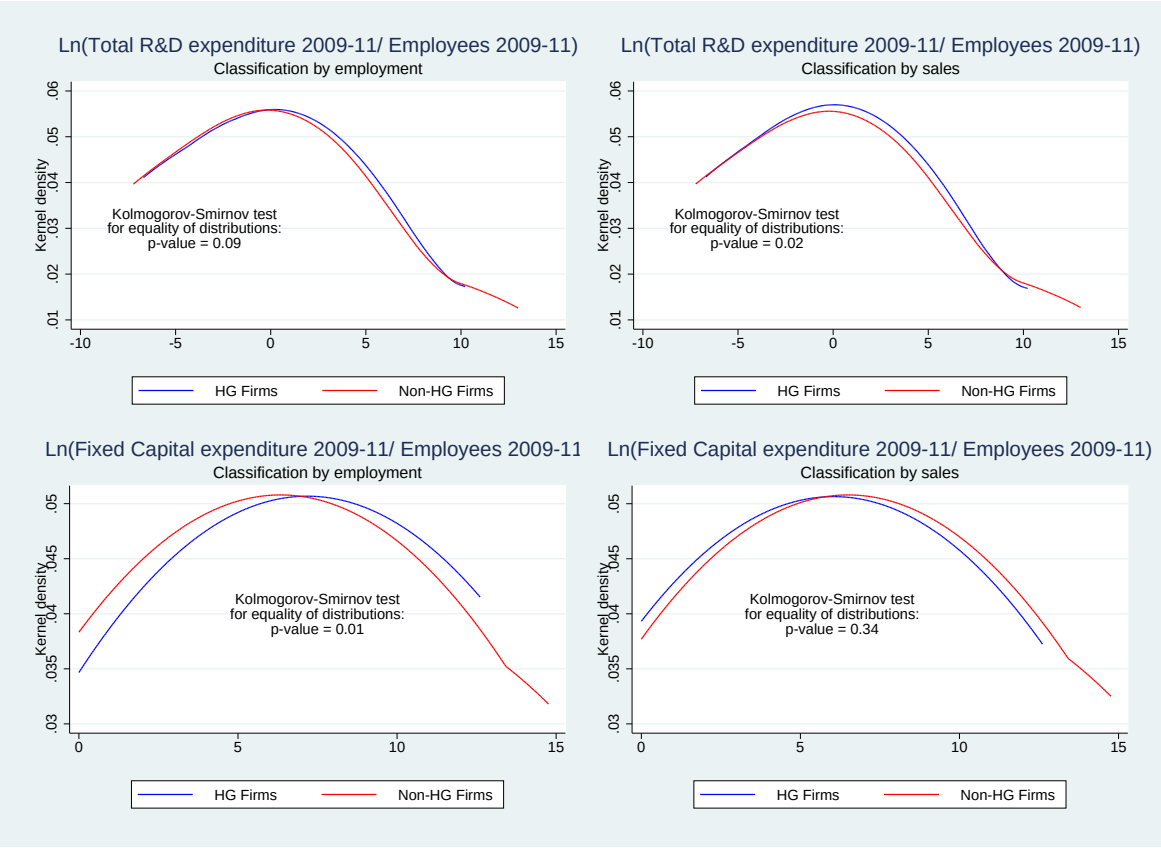
Figure 2 shows that Ecuadorian HGFs are both smaller and younger than non-HGFs. Interestingly, as shown in section 5, the age effect dominates when analyzing the case of employment HGFs (Table 5), but size dominates in the case of sales HGFs (Table 7).

Regarding investment in fixed capital per employee, at the median, HGFs by employment spend more than 3.75 times relative to non-HGFs. HGFs by sales, however, spend *less* than their counterparts.

In line with the previous literature, Ecuadorian firms thus show the importance of the indicator used to classify HGFs. Using employment or sales gives rise to different sets of firms with different characteristics. Most importantly, HGFs that create jobs are those that invested more in R&D but

[12]Medians are not informative in this case due to the large number of firms with zero R&D investment.

Figure 1: Kernel densities of R&D and fixed capital expenditure (HGFs vs. non-HGFs)



Source: Authors' elaboration based on INEC (2012) and INEC (2015).

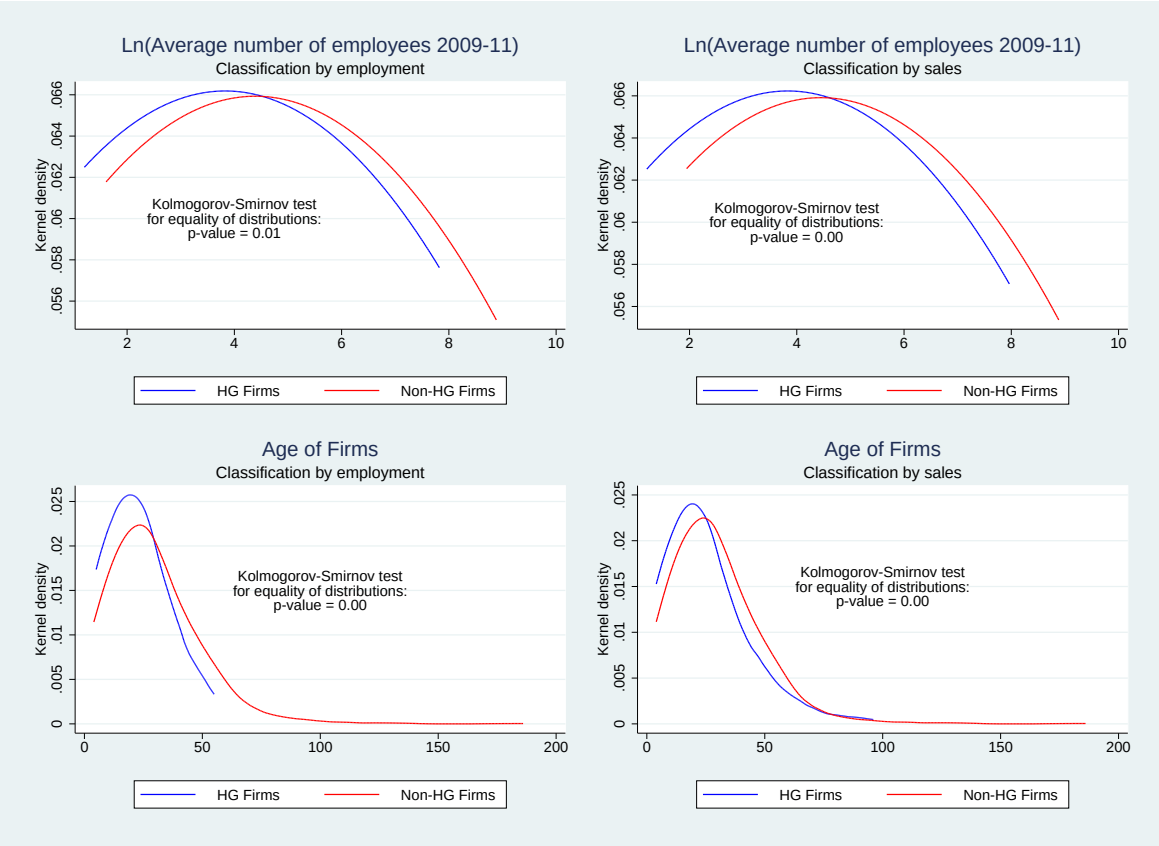
they also tend to have lower productivity growth. This might be a reason for the lack of sustainability of this type of firms observed in previous studies.

4 Econometric analysis

Our main purpose is to estimate the effects of innovation expenditure on firms' growth and the likelihood of firms of becoming HGFs. There are two econometric issues that need to be addressed. First, our model can be affected by selection bias because many Ecuadorian firms choose not to invest in innovation. As a consequence, the group of firms that spend on innovation is not random. Second, simultaneity should be taken into account, as reverse causation cannot be ruled out. In particular, while our analytical perspective considers the effect of innovation on firms' growth, it is possible that firms that experience higher levels of growth choose to invest more in innovation.

To correct for selection bias, we implement an econometric model that is a simplified version of the most recent versions of the Crepon et al. (1998) CDM model, as specified in e.g. OECD

Figure 3: Kernel densities of size and age (HGFs vs. non-HGFs)



Source: Authors' elaboration based on INEC (2012) and INEC (2015).

(2013). We divide our analysis into two main stages. In the first one we analyze the determinants of innovation expenditure correcting for selection bias. We use the Heckman two-step method. The first step considers the determinants of the firms' decision to innovate. The inverse Mills ratio obtained from this regression is added to the second step, which considers the determinants of innovation expenditure. We decided to use the two step method instead of a maximum likelihood estimation because it is more robust and does not require the errors of the selection and output models to be bivariate normal (Wooldridge, 2002).

The second stage varies depending on our response variable. When we analyze firms' growth, we run an OLS model with continuous growth as the dependent variable, including again the inverse Mills ratio. When we analyze the likelihood of becoming a HGF, we use a probit model. This stage is analogous to the third stage in the CDM model, except that the CDM models aims to explain the effect of innovation on productivity instead of growth. In addition, the CDM model includes a previous stage in which innovation expenditure serves to explain innovation output. We do not include this stage because our interest is not on the innovative outputs but on the innovative efforts (as measured by R&D expenditure) and their effect on growth.

To (partially) correct for simultaneity we specify our dependent variables in the second stage forwarded a period with regard to the regressors. In particular, all growth variables are defined for the period 2011-2014, while all regressors are defined for the period 2009-2011.

The details of our approach is explained next. First, following Heckman (1979) we specify the selection equation by modeling the propensity of a firm to be part of the sample using a probit regression of y_1, which indicates whether the firm decides to innovate or not:

$$Pr[y_1^* > 0] = \Phi(\mathbf{x_1'}\beta_\mathbf{1}), \tag{1}$$

where $\mathbf{x_1}$ is a vector of explanatory variables that include the logarithm of the firm's average number of employees between 2009 and 2011 to control for size, firm's age in 2011, the logarithm of the firm's average capital expenditure per employee from 2009 to 2011, the firm's average exports as a percentage of sales from 2009 to 2011, the firm's foreign capital percentage in 2011 and the percentage of employees with a higher education degree in 2011. The choice of variables in the selection equation is based on factors that could directly affect whether a firm decides to innovate or not. From this regression, we obtain the inverse Mills ratio defined as:

$$\lambda(x_1'\hat{\beta}_1) = \frac{\phi(x_1'\hat{\beta}_1)}{\Phi(x_1'\hat{\beta}_1)} \tag{2}$$

In the second step, we estimate firms' innovation expenditure y_2 using an OLS regression of the form:

$$y_2 = x_2'\beta_2 + \sigma_{1,2}\lambda(x_1'\hat{\beta}_1) + v_i, \tag{3}$$

where $\mathbf{x_2}$ includes the logarithm of the firm's average number of employees between 2009 and 2011, the firm's age in 2011, an indicator variable for whether the firm is part of a business group, an indicator variable for whether the firm is public,the firm's percentage of foreign capital and the percentage of employees with a higher education degree in 2011.

For the second stage, in the case of continuous growth we use an OLS model for growth y_3 as follows:

$$y_3 = x_3'\beta + u_i + \lambda(x_1'\hat{\beta}_1), \tag{4}$$

where $\mathbf{x_3}$ is a vector of explanatory variables including the logarithm of the firm's average number of employees from 2009 to 2011, its age in 2011, the logarithm of average capital expenditure per employee from 2009 to 2011, the logarithm of R&D expenditure from 2009 to 2011, a dummy variable to show if the firm is part of a business group, the share of exports on sales, the percentage of employees with a higher education degree and the inverse Mills ratio from the first stage.

For HGFs we use a regular probit of the form:

$$Pr[y_3' = 1|x_3] = \Phi(x_3'\beta_3) = \int_{-\infty}^{x_3'\beta_3} \phi(z)dz, \tag{5}$$

where y_3 takes a value of one when the firm is a high growth firm for each case (employment or sales).

5 Results

The results from the two-step Heckman selection model are shown in Table 3. From the selection equation we can conclude that bigger firms are more likely to engage in innovation. Additionally, a higher capital expenditure per employee increases the propensity to participate in R&D activities,

whereas a higher percentage of foreign capital reduces it. Our findings are congruent with the existing literature, as well as the CDM analysis performed for Ecuador by Lluvichuzca & Tenesaca (2016). In our case the firm's age, average exports as a percentage of sales and percentage of employees with a higher education degree do not appear to be relevant for the selection model.

For the outcome equation (R&D expenditure), we observe the opposite effect of firm size. A one per cent increase of average employment is associated with a fall in R&D expenditure of 0.50%. In addition, being part of a business group rises innovation expenditure by 67%. A one point growth in the percentage of employees with a higher education degree, represents a 1% rise in the R&D expenditure. The inverse Mills ratio is significant at a 1% confidence level, which indicates that the sample selection correction is necessary.

In the second stage we analyze the determinants of continuous growth and HGFs for both employment and sales. In each case we run three different models that allow to distinguish the effect of correcting for selection. Column (1) analyzes the full sample, which includes firms that choose to innovate and those that do not. Column (2) provides results on the restricted sample, without correcting for selection. Finally, column (3) shows the results correcting for selection. Consistent with the literature and the results in Table 4, our preferred model is column (3), and we conduct our analyzes based on these results. As will be seen, it is important to restrict the sample to those firms that choose to innovate. But, as shown by an insignificant Mills ratio, controlling for selection in the second stage is not very important.

The results for employment growth and HGFs based on employment are shown in tables 4 and 5. Consider first employment growth in Table 4. The first result is that younger firms are associated with higher employment growth. An additional year of existence is associated with a 0.34 percentage points reduction in employment growth. We find no evidence, however, that firm's size is related to employment growth. Regarding our main variable of interest, we find that a one per cent increase in R&D expenditure per employee implies an increase of 4.9 percentage points in employment growth. This shows that innovation plays a very large role on firm's growth. We also find that being part of a business group reduces employment growth by almost 20 percentage points.

Examining the determinants for the probability of becoming a HGF based on employment, we observe that a firm's age has a negative effect. We also find that R&D expenditure per employee has a significant and positive impact on the propensity of becoming a HGF. But, being part of a business group reduces this likelihood. A firm's size and capital expenditure per employee do not appear to be significant determinants of HGFs. In general then, we find that the determinants of employment growth are the same as the determinants of a firm becoming a HGF based on employment. Mos importantly, and consistent with Haltiwanger et al. (2013), we find that once we control for age, a firm's size is not relevant for either employment growth or becoming a HGF based on employment.

Tables 6 and 7 show the OLS and probit models for sales growth. There are a few conclusions that we can drawn from these models. When analyzing the results for continuous growth, we observe that average exports as a percentage of sales reduces growth considerably. Additionally, this factor is the only significant one.

From the probit model for high growth sales one can infer that a bigger firm's size reduces the propensity of it becoming a HGF. A firm's age, capital expenditure per employee, being part of a business group and average exports as a percentage of sales do not affect this likelihood. In general, from the models based on sales, we conclude that the standard variables found in the literature do a poor job in explaining a firm's growth in terms of sales or the likelihood of becoming a HGF based on sales. In particular, it is notable that R&D expenditure is not relevant. A possible explanation is that sales growth during the peak of the commodities boom may be explained by other factors, which is a topic for future research.

Table 3: Two-step Heckman model for the log of R&D expenditure per employee

Probit selection equation	
Log of average employment$_{09-11}$	0.140***
	(0.036)
Firm's age$_{11}$	0.003
	(0.003)
Log of k expenditure per employee$_{09-11}$	0.114***
	(0.013)
Average exports as a percentage of sales$_{09-11}$	0.245
	(0.212)
Percentage of foreign capital$_{11}$	-0.004**
	(0.002)
Percentage of employees with a higher education degree$_{11}$	0.003
	(0.194)
Constant	-2.059***
	(0.175)
Outcome equation	
Log of average employment$_{09-11}$	-0.504***
	(0.113)
Firm's age$_{11}$	-0.004
	(0.007)
Business group$_{11}$	0.671**
	(0.271)
Public company$_{11}$	-0.497
	(0.582)
Percentage of foreign capital$_{11}$	0.001
	(0.004)
Percentage of employees with a higher education degree$_{11}$	0.011**
	(0.533)
Constant	9.796***
	(0.954)
Error terms	
Inverse Mills ratio	-1.443***
	(0.510)
Sigma	2.277
Rho	-0.634
Observations	993 (688 censored)
R^2	0.117
Adjusted R^2	0.096
Note:*p<0.1;**p<0.05;***p<0.01	

Source: Authors' estimations based on INEC (2012) and INEC (2015).

Table 4: OLS model for employment growth

	Dependent variable:		
	Employment growth		
	Full sample	Uncensored	Uncensored corrected
Log of average employment$_{09-11}$	−7.410***	1.348	1.193
	(2.463)	(2.707)	(2.682)
Firm's age$_{11}$	−0.210*	−0.333*	−0.340*
	(0.118)	(0.173)	(0.175)
Log of k expenditure per employee$_{09-11}$	0.622	1.954	1.886
	(0.833)	(1.329)	(1.313)
Log of R&D expenditure$_{09-11}$	0.313	4.882***	4.911***
	(0.513)	(1.858)	(1.864)
Business group$_{11}$	10.132	−21.264***	−20.266**
	(9.538)	(8.006)	(7.876)
Average exports as a percentage of sales$_{09-11}$	−4.888	1.943	1.933
	(13.683)	(30.694)	(30.814)
Percentage of employees with a higher education degree$_{11}$	0.245**	0.200	0.199
	(10.058)	(13.219)	(13.400)
Inverse Mills ratio			−10.978
			(8.027)
Constant	46.349***	−24.104	−9.535
	(13.246)	(18.142)	(20.085)
Observations	993	305	305
R^2	0.027	0.066	0.071
Adjusted R^2	0.020	0.044	0.046
Residual Std. Error	82.992 (df = 985)	63.666 (df = 297)	63.609 (df = 296)
F Statistic	3.913*** (df = 7; 985)	3.011*** (df = 7; 297)	2.831*** (df = 8; 296)

Note: *p<0.1; **p<0.05; ***p<0.01

Source: Authors' estimations based on INEC (2012) and INEC (2015).

Table 5: Probit model for employment HGFs

	Dependent variable:		
	Employment HGF		
	Full sample	Uncensored	Uncensored corrected
Log of average employment$_{09-11}$	-0.120^{**}	0.082	0.080
	(0.051)	(0.094)	(0.097)
Firm's age$_{11}$	-0.014^{***}	-0.018^{**}	-0.019^{**}
	(0.005)	(0.008)	(0.009)
Log of k expenditure per employee$_{09-11}$	0.035^{**}	-0.002	-0.006
	(0.016)	(0.043)	(0.044)
Log of R&D expenditure$_{09-11}$	0.001	0.159^{**}	0.158^{**}
	(0.013)	(0.068)	(0.068)
Business group$_{11}$	0.116	-0.837^{**}	-0.837^{**}
	(0.152)	(0.351)	(0.364)
Average exports as a percentage of sales$_{09-11}$	-0.407	-0.106	-0.081
	(0.355)	(0.497)	(0.500)
Percentage of employees with a higher education degree $_{11}$	0.002	-0.000	-0.000
	(0.243)	(0.497)	(0.501)
Inverse Mills ratio			-0.485
			(0.299)
Constant	-0.786^{***}	-2.151^{***}	-1.506^{*}
	(0.217)	(0.677)	(0.781)
Observations	993	305	305
Log Likelihood	-287.718	-76.179	-74.778
Akaike Inf. Crit.	591.436	168.359	167.555

Note: *p<0.1; **p<0.05; ***p<0.01

Source: Authors' estimations based on INEC (2012) and INEC (2015).

Table 6: OLS model for sales growth

	Dependent variable:		
	Sales growth		
	Full sample	Uncensored	Uncensored corrected
Log of average employment$_{09-11}$	-25.058^{***}	-9.774	-10.290
	(7.822)	(7.234)	(7.319)
Firm's age$_{11}$	0.232	-0.704	-0.727
	(0.494)	(0.598)	(0.602)
Log of k expenditure per employee$_{09-11}$	-4.777^{*}	0.050	-0.174
	(2.750)	(4.910)	(4.843)
Log of R&D expenditure$_{09-11}$	-0.533	-11.563	-11.470
	(1.365)	(11.836)	(11.794)
Business group$_{11}$	-8.722	-24.256	-20.941
	(16.678)	(16.851)	(16.713)
Average of exports as a percentage of sales$_{09-11}$	-38.903^{**}	-48.265^{**}	-48.299^{**}
	(18.325)	(21.584)	(21.956)
Percentage of employees with a higher education degree$_{11}$	0.278	0.168	0.164
	(40.712)	(50.376)	(50.670)
Inverse Mills ratio			-36.462
			(27.457)
Constant	206.368^{***}	200.533^{***}	248.920^{***}
	(41.064)	(77.345)	(89.488)
Observations	993	305	305
R^2	0.029	0.045	0.051
Adjusted R^2	0.022	0.022	0.026
Residual Std. Error	282.186 (df = 985)	181.117 (df = 297)	180.785 (df = 296)
F Statistic	4.229^{***} (df = 7; 985)	1.982^{*} (df = 7; 297)	2.002^{**} (df = 8; 296)

Note: *p<0.1; **p<0.05; ***p<0.01

Source: Authors' estimations based on INEC (2012) and INEC (2015).

Table 7: Probit model for sales HGFs

	Dependent variable:		
	Sales HGF		
	Full sample	Uncensored	Uncensored corrected
Log of average employment$_{09-11}$	-0.157^{***}	-0.121	-0.129^{*}
	(0.041)	(0.075)	(0.076)
Firms age$_{11}$	-0.004	-0.007	-0.007
	(0.003)	(0.006)	(0.006)
Log of k expenditure	-0.008	0.013	0.011
per employee $_{09-11}$	(0.012)	(0.034)	(0.034)
Log of R&D expenditure$_{09-11}$	0.007	-0.011	-0.012
	(0.011)	(0.046)	(0.046)
Business group$_{11}$	-0.004	-0.308	-0.268
	(0.127)	(0.223)	(0.224)
Average exports as a	-0.045	-0.331	-0.327
percentage of sales$_{09-11}$	(0.254)	(0.427)	(0.428)
Percentage of employees with	0.012	0.000	-0.000
a higher education dregree$_{11}$	(0.203)	(0.387)	(0.390)
Inverse Mills ratio			-0.303
			(0.219)
Constant	-0.136	-0.130	0.302
	(0.173)	(0.502)	(0.585)
Observations	993	305	305
Log Likelihood	-454.584	-132.104	-131.123
Akaike Inf. Crit.	925.168	280.207	280.245

Note: *p<0.1; **p<0.05; ***p<0.01

Source: Authors' estimations based on INEC (2012) and INEC (2015).

6 Conclusion

In this paper we present the first analysis of HGFs in Ecuador based on the two rounds (2013 and 2015) of the National Survey of Innovation Activities. To reduce the problem of simultaneity, we analyze firm's growth over the period 2011-2014 based on lagged variables corresponding to the period 2009-2011. Likewise, to correct the problem of selection bias on innovation activities, we estimate a two-stage model that in the first stage includes a two-step Heckman selection model.

Our main results regarding employment growth are the following. First, innovation plays a key role on firm's employment growth in terms of continuous growth and the likelihood of becoming a HGF. Second, younger firms tend to create more jobs. These results are important because they highlight areas where policy can contribute to the generation of employment through its effect on firm growth. Providing incentives for innovation and for young firms seems to be the right approach if the goal is to encourage job creation.

In the case of Ecuador, there is ample space to implement these policies. For instance, according to INEC (2016), between 2009 and 2014, total expenditure on R&D reached between 0.39% and 0.44% of GDP. While this represents a significant improvement from early years (in 2001 it was 0.06% of GDP and before 2006 it was at most 0.09%) it still lags behind the regional average of around 0.75% (RICYT, 2017). This is particularly worrisome considering that the estimated social return to investment in R&D in Ecuador is 47% Guaipatin & Schwartz (2014) and also that Latin America as a whole lags behind other regions Devlin & Moguillansky (2011). Furthermore, these levels of innovation occurred in a period of abundance of resources marked by the commodities boom. It is likely that the current economic slowdown in Ecuador might restrict innovation.

Previous research shows that effective innovation requires much more than financial resources (Guaipatin & Schwartz, 2014). Also, it emphasizes the need for better public institutions, timely identification of priorities, greater public-private interaction, increased human talent and support for entrepreneurship (Guaipatin & Schwartz, 2014).

Importantly, because size does not seem to affect employment growth, an emphasis on small firms seems unwarranted.

Despite the policy implications regarding innovation and young firms based on our econometric analysis, there are several caveats that need to be considered. First, as mentioned in the literature review, there is evidence that growth tends to be unsustainable and firms that manage to grow quickly in a given period do not do so before or after. We are not able to analyze this limitation with the available data, but it is something that needs to be considered.

Second, we showed that the faster a firm increases its number of employees, the lower its labor productivity. This is worrisome. Ecuador lags behind in terms of competitiveness and productivity relative to other Latin American countries, and there is clearly much space for improvement. Thus, an emphasis on innovation and young firms might limit productivity improvements. This seems particularly relevant when we consider that R&D expenditure does not affect sales growth or the likelihood of becoming a HGF based on sales.

In the end, our results need to be considered preliminary and need to be complemented with other analysis that address specifically the sustainability of high growth among Ecuadorian firms, and the effect of R&D expenditure on productivity.

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