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ARTÍCULO

DOES FIRM INNOVATION LEAD TO HIGH GROWTH? EVIDENCE FROM ECUADORIAN FIRMS

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We analyze the determinants of: i) employment and sales growth, and ii) the likelihood of becoming a high-growth firm (HGF) among Ecuadorian firms for the

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Este artículo fue recibido el 01 de diciembre de 2017, ajustado el 28 de mayo de 2018, y su publicación aprobada el 31 de mayo de 2018.

period 2011-2014. We apply a two-stage econometric model that controls for selection bias in the choice to innovate in regards 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.

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

Grijalva, D. F., Ayala, V., Ponce, P. A., & Pontón, Y. (2018). ¿La innovación empresarial conduce al alto crecimiento? Evidencia de empresas ecuatorianas. *Cuadernos de Economía*, 37(75), 697-726.

Analizamos los determinantes de: 1) crecimiento del empleo y de las ventas, y 2) la probabilidad de convertirse en una empresa de alto crecimiento entre las compañías ecuatorianas para el periodo 2011-2014. Aplicamos un modelo econométrico de dos etapas que controla el sesgo de selección en la elección de innovar con respecto a las dos rondas de la Encuesta Nacional de Actividades de Innovación de Ecuador. Encontramos que las empresas más jóvenes y aquellas que invierten más en actividades de investigación y desarrollo por empleado tienen niveles significativamente mayores de crecimiento del empleo y son significativamente más propensas a convertirse en empresas de alto crecimiento de empleo.

Palabras clave: crecimiento empresarial, empresas de alto crecimiento, creación de empleo, espíritu emprendedor, innovación.
JEL: D22, L26, M21, O3, O54.

Grijalva, D. F., Ayala, V., Ponce, P. A., & Pontón, Y. (2018). L'innovation dans l'entreprise conduit-elle à la forte croissance ? L'exemple des entreprises équatoriennes. *Cuadernos de Economía*, 37(75), 697-726.

Nous analysons les facteurs déterminants de : 1) la croissance de l'emploi et des ventes, et 2) la possibilité de se transformer en entreprise à forte croissance pour les compagnies équatoriennes pour la période 2011-2014. Nous utilisons un modèle économétrique en deux étapes qui contrôle le biais de sélection dans la décision d'innover par rapport aux deux séries de l'Enquête Nationale d'Activités d'Innovation de l'Equateur. Nous observons que les entreprises les plus jeunes et celles qui investissent davantage dans des activités de recherche et de développement par employé ont des niveaux significativement plus importants de croissance de l'emploi et sont plus significativement propices à se convertir en entreprises à forte croissance d'emploi.

Mots-clés: Croissance de l'entreprise, entreprises à forte croissance, crétaion d'emploi, esprit d'entreprise, innovation.
JEL: D22, L26, M21, O3, O54.

Grijalva, D. F., Ayala, V., Ponce, P. A., & Pontón, Y. (2018). A inovação nos negócios leva a um alto crescimento? Evidências de empresas equatorianas. *Cuadernos de Economía*, 37(75), 697-726.

Analisamos os determinantes de: 1) crescimento do emprego e das vendas, e 2) a probabilidade de se tornar uma empresa de alto crescimento entre as empresas equatorianas para o período 2011-2014. Aplicamos um modelo econométrico de dois estágios que controla o viés de seleção na escolha de inovar em relação às duas rodadas da Pesquisa Nacional de Atividades de Inovação do Equador. Descobrimos que as empresas mais jovens e aquelas que investem mais em atividades de pesquisa e desenvolvimento por funcionário têm níveis significativamente mais altos de crescimento de emprego e são significativamente mais propensas a se tornarem empresas de alto crescimento de emprego.

Palavras-chave: crescimento empresarial, empresas de alto crescimento, criação de empregos, espírito empreendedor, inovação.
JEL: D22, L26, M21, O3, O54.

INTRODUCTION

In recent years there has been a growing interest in high-growth firms (HGFs), as they contribute to several key objectives of public policy. Most importantly, HGFs seem to generate economic growth (Schreyer, 2000) through the following mechanisms. First, following the work of Birch (1979), a large amount of literature has shown that HGFs are typically responsible for a large fraction of employment creation despite constituting a small share of total employment (Henrekson & Johansson, 2010). 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. 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 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, Scarpetta & Schivardi, 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 these firms over time. However, the scant existing evidence indicates that HGFs' growth is *not* persistent. For example, Daunfeldt & Halvarsson (2015) 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. Although the conclusions regarding persistence depend on how growth is measured (Hölzl, 2014), it seems that HGFs cannot be identified 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 firms manage to sustain high growth over longer periods of time.

Most of the discussion on HGFs is based on evidence from OECD countries, which are significantly different from less developed ones regarding their economic structure, levels of innovation, distance to the technological frontier, nature of entrepreneurship, etc. It is thus important to expand our understanding of HGFs in non-OECD countries. In the specific case of Ecuador, there is no study available on 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. Likewise, firms that spend

more on R&D per employee are significantly more likely to become employment HGFs. However, the size of the firms does not have an effect on either of these variables. We also find that 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. Smaller firms have higher sales growth, as well as those with a *lower* share of exports on sales and those that invest *less* on fixed capital per employee, although the last result is only marginally significant.

Our results show how our conclusions on HGFs can vary significantly depending on the chosen growth variable, and these differences can have important consequences for policy.

LITERATURE REVIEW

A large amount of literature on HGFs and their determinants emerged following the work of Birch (1979). Despite the large number of theoretical and empirical analyses, there is no common definition of what exactly constitutes a HGF. Therefore, it is hardly surprising that there is no consensus about which factors contribute to their creation. In this section we briefly discuss five dimensions that make the definition of HGFs problematic.[1] Considering 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 effects on HGFs, emphasizing the role of expenditure on R&D. In this context, we discuss the decisions made regarding the chosen variables.

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, market value, and asset growth have also been used.[2] This lack of consistency is problematic because different indicators lead to different sets of HGFs, making it difficult to set policy recommendations.[3] 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 in absolute terms (e.g. employment growth of 25% or

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

[2] See Daunfeldt, Elert & Johansson, (2010) and Daunfeldt, Elert & Johansson (2014) for a discussion of the implications of using different indicators to measure firms' growth.

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

more per year as in Haltiwanger, Jarmin & Miranda, 2013) or with respect to the relative performance of the firms (e.g. the 5% of firms with the highest employment growth as in Coad, Daunfeldt, Hölzl, Johansson & Nightingale 2014). As a response to this problem, several authors have used the Birch index, which combines relative and absolute growth.[4] Alternatively, to deal with the bias in favor of small firms when using relative growth, OECD/Eurostat (2008) proposes to use a relative measure of growth, but to only include firms with 10 or more employees among HGFs.

Third, because growth implies a change in quantity over time, either one of these dimensions can be emphasized. As a consequence, some authors have focused on quantity (high-growth firms)[5] while others have focused on time (fast-growth firms or similar definitions).[6] 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, Carsrud & Kiviluoto, (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 to be firms that grow more than 20% per year for a period of three or four consecutive 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, Davidsson & Gartner, 2003). Conceptually, this distinction is clear, and OECD/Eurostat (2008) recommends not considering a firm as 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, Daunfeldt, Johansson & Wennberg, 2014). In our sample we do not include firms that have experienced a merger or an acquisition over the period of analysis.

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

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

[6] Birch (1981) uses the term "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.[7]

We measure growth in terms of employment and sales. These variables are the most commonly used in the literature, and thus provide a natural starting point to allow for comparisons with previous studies. Also, as discussed by Coad (2009), there is a key distinction between sales and employment in that while the former is an output, the latter is an input. As a consequence, because of the productivity enhancements brought about by innovation, there is reason to believe that the effect of innovation on firms' growth may differ depending on whether we look at employment or sales.

In spite of the methodological challenges, there is extensive literature that explores the potential factors that contribute to firms' high growth (see Coad, 2009, for a review). 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.),[8] 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 regarding each of these factors.

First, consider a firm's age. A robust finding is that a firm's age and high growth are inversely related (Coad, 2009; Henrekson & Johansson, 2010). Among developed countries, Schreyer (2000) finds this result for Italy, Germany, Netherlands, Spain, Sweden, and Quebec, Canada. Similar results are also confirmed in developing countries. For instance, Burki & Terrell (1998) find that a firm's average

[7] OECD/Eurostat (2008) explicitly identifies gazelles as the subset of HGFs that are less than five years old.

[8] 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 a firm's characteristics. In other words, we deem it more appropriate to consider it a feature of the firm and not of the aggregate context.

growth rate decreases with age in the case of Pakistan. Mead & Liedholm (1998) find a similar result among micro and small enterprises (MSEs) in five African countries and the Dominican Republic.

Regarding the effect of a 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, Jarmin & Miranda, (2013) find that, in the case of the United States, a firm's size ceases to have a significant effect on growth once age is controlled for.

There is less evidence on the effect of fixed capital investment, participation in a business group, and exports. Oliveira & Fortunato (2017) find that investment in physical capital has a positive effect on the growth of Portuguese manufacturing firms. Almeida, Kim & Kim (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 recent interest on the effect of innovation on high growth. Despite the natural prior that high-growth firms should be innovative, there is conflicting evidence on the effect of innovation [see e.g. the revision in Del Monte & Papagni, 2003). At the theoretical level, based on the idea of creative destruction, Schumpeter (1942) and Nelson & Winter (1982) argue that innovation is a key driver of firm growth. As mentioned above, however, how we measure growth matters: while we expect innovation to have a positive effect on sales growth, its effect on employment growth is uncertain because innovation should lead to a more efficient use of inputs (Coad, 2009). More specifically, in the case of employment growth, product and process innovation may have different effects (Coad & Rao, 2011). Thus, while Hölzl & Friesenbichler (2007) find that *product* innovation has a positive effect on employment growth, Coad & Rao (2008) and Hall, Lotti & Mairesse (2008) find that *process* innovation leads to employment decline. These results are confirmed by Goedhuys & Sleuwaegen (2010) in the case of 11 African countries.

One key issue is the measure used to capture innovation. The most common include patent counts and R&D expenditure. Patents are infrequent and also highly skewed in value (Coad, 2009). R&D statistics are smoothed but are an innovative input, which does not necessarily reflect innovative output. We prefer the later because: i) in the case of Ecuador, patents are very scarce, and ii) we would like to capture the effects of innovative *effort*, which is a firm's choice not affected by uncertainty.

More generally, innovation is a highly uncertain process that can be seen as a high-risk high-gain strategy (Hölzl, 2009). Indeed, Coad & Rao (2010b) find that innovation is positively related to the *variance* of US manufacturing firms' growth, while Oliveira & Fortunato (2017) find that R&D expenditure has no effect on Portuguese manufacturing firms' growth and Demirel & Mazzucato (2012) find that it can actually have a *negative* effect on the growth of large US pharmaceutical firms. Oliveira & Fortunato (2017) argue that a possible reason for their result is that Portuguese firms have low R&D expenditure, which is consistent with the evidence that there are important differences between countries. For instance, Hölzl (2009) finds that HGFs in countries far from the technological frontier require less R&D investment. Another possible reason for their result is that innovative efforts may appear only after a lag. Some papers have emphasized the role of persistence in innovation as a determinant of a positive effect on firms' growth (Deschryvere, 2014; Triguero, Córcoles & Cuerva, 2014). Indeed, in their analysis of Spanish manufacturing firms, Triguero et al. (2014) find that the positive effect of innovation on employment growth is *larger* after one or two years.

Another important dimension regarding the effect of innovation on firm growth is its heterogeneity across firms' distribution, both between and within industries. 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, Elert & Johansson, (2016) find that HGFs are less frequent in sectors with high levels of R&D investment and Del Monte & Papagni (2003) find that the effect of R&D investment on Italian firms' growth is greater in traditional sectors than in sectors with high research intensity. Likewise, Coad & Rao (2008) find that innovation has no effect on the mean of the growth distribution of US firms, but its effect is significant at the upper quantiles.

Finally, more recent research argues that firm growth is a multidimensional process in which various forms of growth (sales, employment, profit and labor productivity/R&D investment) co-evolve (Coad, 2010; Coad & Rao, 2010a). This analysis is important because it highlights that causality may run in the opposite direction. In particular, using a VAR model, Coad & Rao (2010a) find that employment and sales growth *lead* to growth in R&D expenditure, but not the other way around. Consistent with this result, as explained below, in order to mitigate the issue of reverse causality we conduct an econometric model with lagged regressors.

HIGH-GROWTH FIRMS IN ECUADOR

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

Datasets

We use the two rounds of the Ecuadorian National Innovation Activities Survey of 2012 and 2015, implemented by the National Institute of Statistics and Censuses

(INEC).[9] 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 sources of financing, R&D expenditures, patents and licenses, constraints of innovation, etc.

The 2012 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, and has a sample of 6,275 firms. The surveys display 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 is the initial sample used in our analysis. We restrict this 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% in any given year. Our final sample comprises 993 firms. From this total, 91 firms (9.16%) are employment-based HGFs and 180 firms (18.13%) are sales-based HGFs.

Descriptive Statistics of Ecuadorian HGFs

To reduce the problem of reverse causality and capture the lagged effect of R&D expenditure, we focus on firm growth during the period 2011-2014, and look at its determinants during the period 2009-2011. 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).[10] Several interesting results follow immediately.

First, during this period and for the full sample, employment grew by 20.37%, 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, Grijalva, Ponce & Rodríguez, 2017; forthcoming). Second, there is large variation across deciles, consistent with a strong process of creative destruction. Regarding employment, among firms in the lowest decile, the number of employees falls by 60.04% but it increases by 184.33% in the highest one. Regarding sales, in the lowest decile they fall by an average of 78.48%, while they increase by an impressive 687.62% in decile ten. Third, the table also shows that labor productivity growth is very high in the *lower*

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

[10] Our measure of productivity is the ratio of sales to the number of employees and thus corresponds to labor productivity only.

deciles of employment growth, but it tends to fall as we move towards the upper deciles. Except for deciles two and four, the opposite occurs with sales deciles, where in general productivity growth is low or negative in the lower deciles, increasing thereafter.

Table 1.
Firms' Employment, Sales and Productivity by Deciles, 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).

Table 2.
Characteristics of High Growth Firms (HGFs) by Employment and Sales. 2011-2014

	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 (2011-2014, %)	194.33	116.79	2.82	3.92	71.29	29.29	9.09	4.01
Growth rate of sales (2011-2014, %)	225.49	84.76	60.79	8.61	429.25	194.80	-2.35	2.58
Growth rate of productivity (2011-2014, %)	14.85	-20.78	113.46	6.56	342.87	134.82	51.64	-2.89
Firms with R+D activities (2009-2011, %)	27.47	-	31.04	-	28.89	-	31.12	-
R+D expend. per employee (2009-2011, US$ of 2016)	446.75	0.05	378.26	0.04	269.42	0.05	410.02	0.04
Fixed capital expenditure per employee (2009-2011, 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	-	11.70	-	9.60	-	12.40	-
Firms that are public (2011, %)	1.10	-	2.99	-	2.22	-	2.95	-

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

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, which is not necessarily permanent, firms should modify the variable labor factor of production (i.e. hours per worker). In this case, we would observe an increase in sales without an increase in employment. Only when firms expect the shift in demand to be permanent, should they modify the fixed labor factor of production (i.e. number of workers). Second, Ecuadorian HGFs 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: seven years in the case of employment and four years 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 30 times that of non-HGFs. In the case of sales, the median rate of sales growth among HGFs is almost 76 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 labor productivity among sales-HGFs is almost seven times the average growth among their counterparts, average productivity growth among employment-HGFs is around one-eighth of their counterparts average growth rate. In fact, the median growth rate of productivity among HGFs by employment is -20.78%.

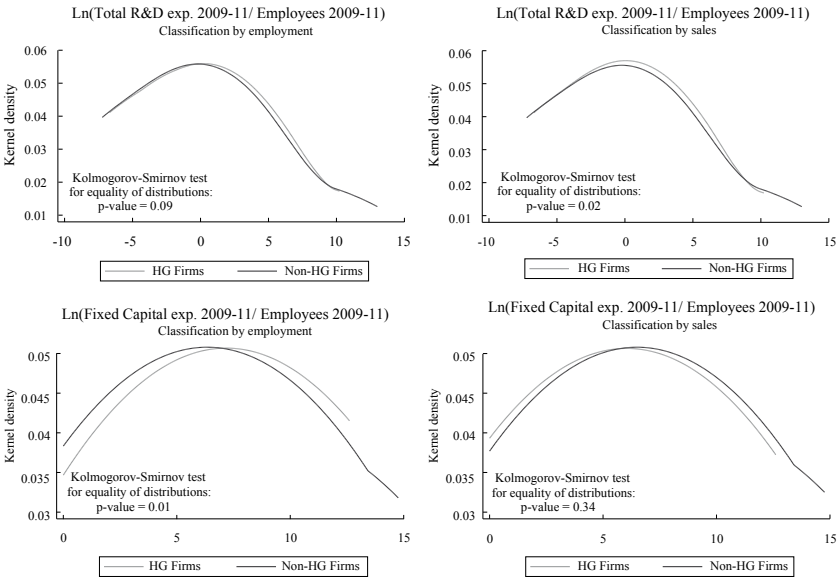
Regarding the relationship between R&D expenditure and HGFs in particular, Table 2 shows two interesting results. On the one hand, a smaller share of HGFs choose to perform innovation activities compared to non-HGFs, both for employment and sales-HGFs. On the other hand, there is a clear difference in the amount spent among HGFs, depending on whether we look at employment or sales. Employment-HGFs spend on average 18% more on R&D per employee than their counterparts, while sales-HGFs spend over 34% *less* on R&D per employee than their counterparts.[11]

Finally, regarding fixed capital expenditure per employee, on average employment-HGFs invest almost 26% more than their counterparts. Sales-HGFs, on the contrary, invest less than 60% of their counterparts' average.

To further look at the relationship between firms' R&D and capital expenditure per employee, and their classification as HGFs, Figure 1 presents a comparison of these variables' distribution among HGFs and non-HGFs based on employment and sales for the period 2009-2011. The figure also reports Kolmogorov-Smirnov tests for the equality of the distributions. As can be seen, there exist non-HGFs that have particularly high levels of R&D and capital expenditure, which affect the means reported in Table 2. Still, the Kolmogorov-Smirnov test rejects equality of distributions in three of the four panels (p-value < 0.1) showing that the distribution of R&D expenditure in all cases and capital expenditure in the case of employment-HGFs is different compared to their counterparts.

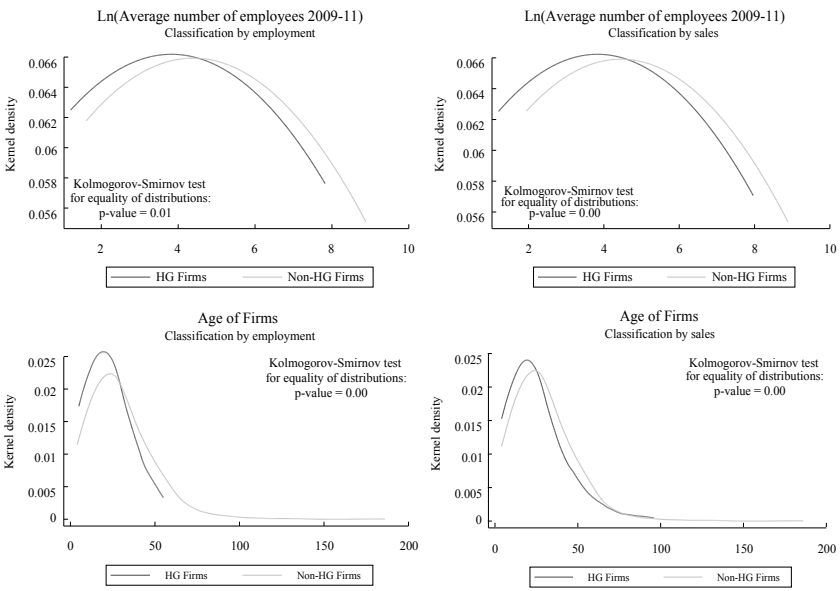
[11] In this case, medians are not informative due to the large number of firms with zero investment in R&D.

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).

Figure 2.
Kernel Densities of Size and Age (HGFs vs. non-HGFs)



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

Figure 2 provides similar information to Figure 1 for firm's size and age. It shows that Ecuadorian HGFs (based both on employment and sales) are both smaller and younger than non-HGFs. Interestingly, as shown below, the age effect dominates when analyzing the case of employment HGFs (Table 6), while the size effect dominates in the case of sales HGFs (Table 8).

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 this is not the case with sales-HGFs.

ECONOMETRIC ANALYSIS

Our main purpose is to estimate the effects of innovation expenditure on firms' employment and sales growth, and on the likelihood of them becoming HGFs. There are two econometric issues that need to be addressed. First, our model can be affected by selection bias because a firm's decision to invest in innovation is not random. As a consequence, inference based on an OLS analysis would be biased. Second, simultaneity should be taken into account because 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 on innovation.

To correct for selection bias, we divide our analysis into two main stages. In the first one we analyze the determinants of innovation expenditure, correcting them based on selection bias. We use the Heckman two-step method (Heckman, 1979). 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, again including the inverse Mills ratio. When we analyze the likelihood of becoming a HGF, we use a probit model.

To (partially) correct for simultaneity we specify our dependent variables in the second stage forwarded with a period in regard to the regressors. In particular, all growth variables are defined for the period 2011-2014 (i.e. three growth years), while all regressors are defined for the period 2009-2011. Hence, although our database is a panel of firms, our analysis is actually cross-sectional.

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

$$Pr(y_1 = 1 \mid \mathrm{x}_1) = \Phi(\mathrm{x}'_1\beta_1) = \int_{-\infty}^{\mathrm{x}'_1\beta_1} \varphi(z)dz, \tag{1}$$

where $\Phi(\cdot)$ is the cumulative distribution function (CDF) of the standard normal distribution, and x_1 is a vector of explanatory variables, including 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,[12] 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 the ratio of the probability density function (pdf) to the cumulative distribution function (cdf) of the standard normal distribution:

$$\lambda(\mathrm{x}'_1\hat{\beta}_1) = \frac{\varphi(\mathrm{x}'_1\hat{\beta}_1)}{\Phi(\mathrm{x}'_1\hat{\beta}_1)} \tag{2}$$

In the second step, we estimate the firms' R&D expenditure per employee y_2[13] using an OLS regression of the form:

$$y_2 = \mathbf{x}'_2\beta_2 + \sigma_2\lambda(\mathbf{x}'_1\hat{\beta}_1) + v_i, \tag{3}$$

where $\lambda(\cdot)$ is the inverse Mills ratio obtained in the first step. The vector of covariates 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.[14]

For the second stage, in the case of continuous growth we use an OLS model for growth y_3 in the period 2011-2014 as follows:

$$y_3 = \mathbf{x}'_3\beta_3 + \sigma_3\lambda(\mathbf{x}'_1\hat{\beta}_1) + u_i, \tag{4}$$

where again $\lambda(\cdot)$ is the inverse Mills ratio from the first stage. The vector of explanatory variables x_3 includes 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 per employee from 2009 to 2011, a dummy variable to show if the firm is part of a business group, the share of exports on sales, and the percentage of employees with a higher education degree.

[12]Capital expenditure is measured in real terms using US$ of 2016.

[13]R&D expenditure is measured in real terms using US$ of 2016.

[14]The estimation is conducted in Stata using the command heckman with the option twostep. This option estimates the standard errors as in Heckman (1979).

In the case of HGFs, we use a regular probit model of the form:

$$Pr(y_3 = 1 \mid \mathbf{x}_3) = \Phi(\mathbf{x}_3 \beta_3 + \lambda(\mathbf{x}_1' \hat{\beta}_1)) \tag{5}$$

where y_3 takes a value of one when the firm is a high growth firm for each case (employment or sales) in the period 2011-2014.

Because of the sequential nature of the estimation in the second stage and the inclusion of the inverse Mills ratio ($\lambda(\cdot)$), we estimate the standard errors using the bootstrap method.

RESULTS

We first present results of the two-step Heckman selection model, which is the first stage of all models. Then, we present results for employment growth and HGFs, as well as for sales growth and HGFs. Table 3 summarizes the labels and descriptions of the variables used.

Table 3.
Labels and variable descriptions

Label	Variable description
laemp	Log of average employment
age	Firm's age
lkpe	Log of k expenditure per employee
lrdexp	Log of R&D expenditure per employee
bugr	Business group
asalesexp	Average exports as a percentage of sales
skills	Percentage of employees with a higher education degree
pfk	Percentage of foreign capital
pubcomp	Public company
mills	Inverse Mills ratio

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

Table 4 presents the results from the two-step Heckman model. The first step (selection to innovate) is shown in the upper panel. We conclude that larger 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 (Crépon, Duguet and Mairesse) model performed for Ecuador by Llivichuzhca & Tenesaca (2016). In our case, 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.

Table 4.
Two-step Heckman Model for log of R&D Expenditure per Employee

Probit selection equation	
$laemp_{09\text{-}11}$	0.140***
	(0.036)
age_1	0.003
	(0.003)
$lkpe_{09\text{-}11}$	0.114***
	(0.013)
$asalesexp_{09\text{-}11}$	0.245
	(0.212)
pfk_1	-0.004**
	(0.002)
$skills_1$	0.003
	(0.194)
Constant	-2.059***
	(0.175)
Outcome equation	
$laemp_{09\text{-}11}$	-0.504***
	(0.113)
age_1	-0.004
	(0.007)
$bugr_1$	0.671**
	(0.271)
$pubcomp_1$	-0.497
	(0.582)
pfk_1	0.001
	(0.004)
$skills_1$	0.011**
	(0.533)
Constant	9.796***
	(0.954)

(*Continued*)

Table 4.
Two-step Heckman Model for log of R&D Expenditure per Employee

Error terms	
mills	-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 5.
OLS Model for Employment Growth

	Full sample (1)	**Uncensored (2)**	**Uncensored corrected (3)**
$laemp_{09\text{-}11}$	–7.410***	1.348	–0.582
	(2.463)	(2.707)	(5.202)
age_1	–0.210*	–0.333*	–0.371**
	(0.118)	(0.173)	(0.182)
$lkpe_{09\text{-}11}$	0.622	1.954	0.194
	(0.833)	(1.329)	(3.295)
$lrdexp_{09\text{-}11}$	0.313	4.882***	4.854***
	(0.513)	(1.858)	(1.866)
$bugr_1$	10.132	–21.264***	–20.190***
	(9.538)	(8.006)	(8.043)
$salesexp_{09\text{-}11}$	–4.888	1.943	–1.069
	(13.683)	(30.694)	(29.434)
$skills_1$	0.245**	0.200	0.169
	(10.058)	(13.219)	(0.146)
mills			–21.319
			(39.227)
constant	46.349***	–24.104	23.431
	(13.246)	(18.142)	(91.275)

(*Continued*)

Table 5.
OLS Model for Employment Growth

	Full sample (1)	**Uncensored (2)**	**Uncensored corrected (3)**
Observations	993	305	305
R^2	0.027	0.066	0.067
Adjusted R^2	0.020	0.044	0.042
Residual Std. Error	82.992 (df = 985)	63.666 (df = 297)	63.753 (df = 296)
F Statistic	3.913*** (df = 7; 985)	3.011*** (df = 7; 297)	2.881*** (df = 8; 296)

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

Models (1) and (2) use robust standard errors.

Model (3) uses bootstrapped standard errors based on 1000 repetitions.

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

Table 6.
Probit Model for Employment HGFs

	Full sample (1)	**Uncensored (2)**	**Uncensored corrected (3)**
$laemp_{09\text{-}11}$	–0.120**	0.082	0.220
	(0.051)	(0.094)	(0.209)
age_1	–0.014***	–0.018**	–0.016
	(0.005)	(0.008)	(0.011)
$lkpe_{09\text{-}11}$	0.035**	–0.002	0.131
	(0.016)	(0.043)	(0.169)
$lrdexp_{09\text{-}11}$	0.001	0.159**	0.160**
	(0.013)	(0.068)	(0.075)
$bugr_1$	0.116	–0.837**	–0.956***
	(0.152)	(0.351)	(0.344)
$salesexp_{09\text{-}11}$	–0.407	–0.106	0.121
	(0.355)	(0.497)	(8.349)
$skills_1$	0.002	–0.000	0.003
	(0.243)	(0.497)	(0.006)
mills			1.554
			(1.943)

(*Continued*)

Table 6.
Probit Model for Employment HGFs

	Full sample (1)	**Uncensored (2)**	**Uncensored corrected (3)**
constant	–0.786***	–2.151***	–5.653
	(0.217)	(0.677)	(4.450)
Observations	993	305	305
Log Likelihood	–287.718	–76.179	–75.736
Akaike Inf. Crit.	591.436	168.359	169.472

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

Model (3) uses bootstrapped standard errors based on 1000 repetitions.

One or more parameters could not be estimated in 136 bootstrap replications.

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

Table 7.
OLS Model for Sales Growth

	Full sample (1)	**Uncensored (2)**	**Uncensored corrected (3)**
$laemp_{09\text{-}11}$	–25.058***	–9.774	–23.054***
	(7.822)	(7.234)	(11.095)
age_1	0.232	–0.704	–0.964
	(0.494)	(0.598)	(0.615)
$lkpe_{09\text{-}11}$	–4.777*	0.050	–12.062*
	(2.750)	(4.910)	(6.963)
$lrdexp_{09\text{-}11}$	–0.533	–11.563	–11.760
	(1.365)	(11.836)	(10.584)
$bugr_1$	–8.722	–24.256	–16.870
	(16.678)	(16.851)	(14.906)
$salesexp_{09\text{-}11}$	–38.903**	–48.265**	–68.988**
	(18.325)	(21.584)	(27.286)
$skills_1$	0.278	0.168	–0.049
	(40.712)	(50.376)	(0.451)
mills			–146.688
			(89.952)
constant	206.368***	200.533***	527.596**
	(41.064)	(77.345)	(206.229)

(*Continued*)

Table 7.
OLS Model for Sales Growth

	Full sample (1)	**Uncensored (2)**	**Uncensored corrected (3)**
Observations	993	305	305
R^2	0.029	0.045	0.048
Adjusted R^2	0.022	0.022	0.022
Residual Std. Error	282.186 (df = 985)	181.117 (df = 297)	181.087 (df = 296)
F Statistic	4.229*** (df = 7; 985)	1.982* (df = 7; 297)	2.313** (df = 8, 296)

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

Models (1) and (2) use robust standard errors.

Model (3) uses bootstrapped standard errors based on 1000 repetitions.

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

Table 8.
Probit Model for Sales HGFs

	Full sample (1)	**Uncensored (2)**	**Uncensored corrected (3)**
$laemp_{09\text{-}11}$	–0.157***	–0.121	–0.328
	(0.041)	(0.075)	(0.213)
age_1	–0.004	–0.007	–0.011
	(0.003)	(0.006)	(0.009)
$lkpe_{09\text{-}11}$	–0.008	0.013	–0.175
	(0.012)	(0.034)	(0.175)
$lrdexp_{09\text{-}11}$	0.007	–0.011	–0.014
	(0.011)	(0.046)	(0.054)
$bugr_1$	–0.004	–0.308	–0.226
	(0.127)	(0.223)	(0.244)
$salesexp_{09\text{-}11}$	–0.045	–0.331	–0.649
	(0.254)	(0.427)	(35.694)
$skills_1$	0.012	0.000	–0.004
	(0.203)	(0.387)	(0.006)
mills			–2.225
			(2.038)

(*Continued*)

Table 8.
Probit Model for Sales HGFs

	Full sample (1)	**Uncensored (2)**	**Uncensored corrected (3)**
Constant	–0.136	–0.130	4.892
	(0.173)	(0.502)	(4.708)
Observations	993	305	305
Log Likelihood	–454.584	–132.104	–130.899
Akaike Inf. Crit.	925.168	280.207	279.798

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

Model (3) uses bootstrapped standard errors based on 1000 repetitions.

One or more parameters could not be estimated in 4 bootstrap replications.

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

In the second step (expenditure on R&D) we observe the opposite effect of firm size. Together, these results imply that larger firms are more likely to invest in innovation, but larger firms also invest less per employee. In particular, a one per cent increase of average employment is associated with a fall in R&D expenditure per employee of 0.50%. In addition, being part of a business group rises innovation expenditure by 67%. Finally, a one point growth in the percentage of employees with a higher education degree is associated with a 1% rise in the R&D expenditure per employee. Importantly, firms' age does not have a significant effect in either step. 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 us 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 uncensored 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 employment-HGFs are shown in tables 5 and 6. Consider first employment growth in Table 5. The first result is that younger firms are associated with higher employment growth. An additional year of existence is associated with a reduction of 0.37 percentage points 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 around 20 percentage points.

Examining the determinants for the probability of becoming an employment-HGF (Table 6), we observe that a firm's age is no longer significant. 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. Firm size and capital expenditure per employee do not appear to be significant determinants of HGFs. Thus, except for age, the determinants of employment growth are similar to the determinants of a firm becoming a HGF based on employment. Most 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 for becoming a HGF based on employment.

Tables 7 and 8 present the OLS and probit models for sales growth and sales-HGF, respectively. The results for growth show that larger firms tend to grow more slowly than smaller ones: a 1% increase on average employment is associated with a 23 percentage point decrease in sales growth. Likewise, capital investment seems to negatively affect sales growth, and average exports as a percentage of sales reduces sales growth considerably.

From the probit model for high growth we see that a firm's size, age, capital expenditure per employee, being part of a business group, and average exports as a percentage of sales do not affect the likelihood of a firm becoming a sales-HGF. In general, from the models based on sales, we conclude that, in the case of Ecuador, 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, particularly the increased income from oil.

CONCLUSION

In this paper we present the first analysis of HGFs in Ecuador based on the two rounds (2012 and 2015) of the National Survey of Innovation Activities. To reduce the problem of simultaneity, we analyze firms' 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 sales growth are as follows. First, the common regressors used in the literature do not do a very good job in explaining the likelihood of becoming a sales-HGF in Ecuador. Second, regarding our main variable of interest, innovation does not have an effect on either the growth of sales or the likelihood of becoming a sales-HGF. However, size, capital investment, and the share

of exports on sales do have a *negative* effect on sales growth. As we mentioned above, it is possible that because our period of analysis focuses on firms' growth during the peak of the commodities boom (2011-2014), other mechanisms played a more central role in explaining sales growth. For instance, because of the additional income from oil, it is possible that firms were able to increase their sales independently of their innovative efforts. It is unlikely that the same dynamic would apply under a different scenario. Still, these are empirical questions that need to be addressed in future research.

Our main results regarding employment growth are the following. First, innovation plays a key role on a firm's employment growth in terms of continuous growth and the likelihood of becoming a HGF. Second, younger firms tend to create more jobs, although they do not display a larger likelihood of becoming employment-HGFs. 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. Importantly, because size does not seem to affect employment growth, an emphasis on small firms seems unwarranted.

In the case of Ecuador, there is ample space to implement these policies. For instance, according to INEC and SENESCYT (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 0.09% at most) it still lags behind the regional average of around 0.70% (RICYT, 2017). This is particularly worrisome considering that the estimated social return on 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.

In any case, it is important to remember that the promotion of innovation requires a broad set of complementary policies. Previous research shows that effective innovation requires much more than financial resources (Guaipatin & Schwartz, 2014). 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).

There is one important caveat that needs to be considered. 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. In addition to the relatively short period of analysis, the characteristics of the specific period may also affect our results. We are not able to deal with these limitations due to the availability of data. In order to address them our results need to be complemented with other analyses that look specifically at the sustainability of high growth among Ecuadorian firms over longer periods covering different contexts.

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