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Firm Size, Competition, Financing and Innovation

Abstract

This paper investigates the effects of firm size, competition and access to finance on the innovation performance of that firm. After a review of the relevant literature, three logit models are proposed and tested. The empirical analysis is based on the business environment and enterprise performance survey (BEEPS) for 1053 enterprises from twenty-six countries in years 2002 and 2005. Our results suggest a positive and statistically significant relationship between firm size and innovation. We also find a positive relationship between both competition and access to finance with innovation.

Keywords*:* access to financing, firm size, innovation and competition
JEL: G21, O31, L25

Introduction

The relationship between a firm's size, financing and market structure is considered a central issue in both industrial organization (IO) and the endogenous growth theory. Schumpeter [1942], who was a pioneer in studying this relationship, argued that large firms, which operate in concentrated markets, are the central drivers of technological progress and, hence, economic growth. He explained why innovation increases disproportionally to, and more than, because large firms can better spread the risks of R&D, have better access to external finance, and have sufficiently large sales to fund the fixed costs of R&D. Taken together, these attributes of size, market structure, and access to financing encourage innovative behavior.

Empirical work has not been conclusive on Schumpter's hypotheses. Some authors point to a positive correlation; others, to a negative one. An inverted U relationship has been reported by Scherer, F.M. [1965a, b] Hence, while the hypotheses are relatively straightforward, but support for them has been less so.

In terms of product market competition (PMC), some of the industrial organization literature predicts a negative correlation between innovation and competition. Schumpeter hypothesizes that innovation is higher in concentrated markets using the following reasoning: firms with market power have more incentive to innovate as they can easily appropriate the returns from innovation (due to little imitation); in addition, since concentrated markets tend to be more profitable, they are more able to finance R&D from their own profits. However, some researchers – such as Blundell, Griffith and Van Reenen [1999] and Maiti [2011] point to a positive correlation between competition and innovation. Other researcher, such as Aghion et al. [2006], assert that the relationship between innovation and competition is non-linear, as there exists an inverted U relationship: innovation increases as competition increases up to a critical level of competition, after which it gradually falls.

Regarding the relationship between innovation and financing, the empirical research by a number of researchers generally point to a positive correlation between financing, size, and innovation. This supports Schumpeter's view.

The present paper is a contribution to understanding the link among innovation, firm size, market structure and access to finance starting from the basic Schumpeterian paradigm. We estimate this link using data concerning a panel of 1,053 enterprises for two years, 2002 and 2005, based on the Business Environment and Enterprise Performance Survey (BEEPS). We run three different models using a pooled time series specification and controlling for country and industry effects. The use of pooled regression was necessary as we do not have data for a sufficient number of years. We then run a cross section analysis for our models. Endogeneity problems are a feature of the equations and are addressed by using lagged values.

The paper starts with a literature review of Schumpeter's specific hypotheses as to how competition, firm size, and financing affects innovative activity. Then we present our data sources and a descriptive analysis of the data. In this same section, we present an explanation of the variables that are used in our empirical model. Later we discuss and analyze the results. Finally, we present a few concluding remarks and suggests directions for future research.

Literature Review

This section presents the literature drawn from industrial organization (IO) and endogenous growth theory on the link between innovation and a variety of firm-specific, industry-specific, and institutional characteristics. The section covers both empirical and theoretical contributions in three areas: the link between competition and innovation, firm size and innovation, and financing and innovation.

Competition and Innovation

The relationship between product market competition (PMC) and innovation has received much attention from economists. Both the theory of IO and endogenous growth theory have grappled with this issue. In the Schumpeterian paradigm of growth theory innovation, which plays an essential role in sustaining economic growth, is motivated by the expected monopoly rents from resulting patents or licenses that guarantee successful the innovator monopoly power over its inventions [Tirole, 1988]. Empirical work by Blundell, Griffith and Van Reenen [1999] has found a positive correlation between PMC and innovation, i.e., more competition and more innovation are correlated. Several analytical approaches have also augmented the Schumpeterian growth model by demonstrating the convergence between theory and evidence[1].

One such attempt was made by Aghion, Dewatripont and Rey [1999], which introduced Hart's [1983] framework[2] into a Schumpeterian growth model, considering competition as an incentive to innovate. In this approach, the relationship between product market competition and innovation is monotonic with a positive correlation if firms are administrated by managers who care about the firm's survival. In other words, competition (and the concomitant threat of liquidation) are disciplinary devices that reduce managerial slack and foster technological adaptation and, therefore, growth. The inverse relationship holds when most of the firms are value-maximizing due to a Schumpeterian effect in their model.

This expansion of the basic Schumpeterian model allows all firms to innovate in order to reduce production costs. Both the technological leader and followers in this model invest in R&D. "Step-by-step" innovation means that the laggard firm must innovate (once) to catch up with the leader before it can innovate (again) to become a (cost) leader in the future. This structure is known as a quality ladder or a vertical innovation model, which states that growth is generated by a sequence of quality improving innovations that result from research activities by firms, which (if successful) will grant them monopoly power. New innovations make the prior technology obsolete.

In this framework, competition has two different effects: a Schumpeterian effect and an escaping competition effect. The former implies that a leader gets "monopoly" rents from the innovation if it pulls ahead. The latter; that a laggard firm gets nothing (where the firms are Bertrand competitors), and therefore, innovates in order to "escape" symmetric competition. This suggests an inverted-U relationship between PMC and innovation, which relies on step-by-step innovation to dampen excessive incentives to innovate for extreme industry structures: as the leader innovates, the follower will automatically copy the leader's technology and a one step gap remains. Hence, the leader will have no more incentive to innovate once it has pulled ahead "once," as profits depend on a gap between the leader and the follower that can only be so large. Similarly, the follower can only be so far behind, so it does not get "discouraged" and can instead always maintain a realistic hope of pulling ahead through some new innovation.

An important feature of the Aghion et al., framework is that innovation incentives hinges on the difference between post-innovation and pre-innovation rents, while in the basic Schumpeterian model incentives to innovate depend only on the post-innovation rents. The increase of PMC may, then, promote innovation because PMC reduces pre-innovation rents more than it reduces post-innovation rents. Innovation progresses along a quality ladder[3] on which successful innovation raises quality, and short-term monopoly power compensates for the fixed costs of that innovation. In this case, the escape competition effect is stronger when firms compete neck-and-neck. An example of neck-and-neck competition is the homogeneous product – Bertrand Industries- where the firm's profit is zero. By contrast, in asymmetric industries where there is a leader and a follower, increased competition might reduce innovation because of a possible decrease in the laggard's reward for catching up. In other words, the Schumpeterian effect dominates.

This model has been investigated empirically by Aghion, Bloom, Blundell, Griffith and Howitt [2002]. They confirm the existence of an inverted U-shaped relationship between PMC and innovation.[4] For lower levels of competition, the escape competition effect dominates. Accordingly, innovation rises with competition, while under the Schumpeterian innovation falls as competition rises. This result has been confirmed in related work by Polder and Veldhuizen [2012], who empirically investigate the relationship between competition and innovation using industry-level data from the Dutch National accounts. They find an inverted U-shaped relationship when using Profit Elasticity as a measure of competition; however, this U-shaped relationship is not found when they use one minus PCM.

Firm Size and Innovation

A substantial body of literature has focused on the relationship between innovation and firm size.[5] The most important hypothesis is that firm size has a positive correlation with innovation [Symeonidis, 1996]. Empirically speaking, Schumpeter [1942] has found that large firms, which operate in a concentrated market, are the essential engines of technological progress. As a variety of measures of innovation have been used in the literature, this part of our review will be divided according to the classification of innovation measurements. First, we consider innovation inputs such as R&D. We then consider innovation outputs, such as the number of significant innovations and the number of patents.

Considering R&D investment and firm size, previous studies such as Fisher and Temin [1973] described a positive relationship between firm size and R&D investment activities that enhance innovation. By contrast, Shefer and Frenkel [2005] encountered a negative and significant correlation between firm size and R&D investment rate in a large number of small firms investing in R&D activities. Hence, there is little certainty whether larger firms invest more (or less) on R&D. However, Tether et al. [1997] found a non-linear relationship between size and innovation, as both small and large firms might reflect high innovation propensities. Additionally, Scherer's [1965a, b] regressions show an inverted U-relationship between R&D investment and firm size.

Regarding innovation output, Rothwell and Dogson [1994] found the early stages of an industry's life cycle is more favorable for small firm innovation, whereas during more mature stages the situation favors larger firms. Acs and Audretsch [1987] found that small firms are more innovative in competitive markets while large firms do better in more monopolistic markets.

Zona et al. [2013] use the total number of directors as a measure of size. Their regression analysis using Italian firms identifies a positive and statistically significant relationship between firm size and innovation.

In brief, Schumpeter's hypothesis says that larger firms innovate more because of their ability to access to funds and spread R&D risk. However, the empirical evidence is mixed. Firm size is just one factor that influences innovation, and how salient that size is in a given case overall depends on other factors. Those other factors, in turn, include industry life cycle and, as we have seen above, product market competition. Accordingly, the finding of a size-innovation relationship will depend heavily on what controls are included in the equation. Moreover, innovation measures also matter to the findings. For example, if small firms tend to be more successful at innovating even though they spend less, one measure of innovation could generate the opposite results to the other measure in empirical work.

Financing and Innovation

Innovation is considered an expensive process, as significant resources must be invested in R&D until the innovation process is complete, while the outcome and the returns of this process are uncertain [Mowery, Nelson, 2006].[6] The availability of financial resources therefore determines whether a firm can undertake R&D activities.

Schumpeter assumed that available resources are completely utilized in a stationary circular flow, and that the creation of new products and new processes requires reallocation of these resources, as the entrepreneur cannot be financed by the returns of established activities. He noticed that entrepreneurs introduce innovations financed through bank credit (creation of credit) rather than savings or the existing stock of money or goods [Schumpeter, 1934]. He pointed out the role of commercial banks in producing new purchasing power that is used as a demand driver, a situation that creates the preconditions for innovation by entrepreneurs. He also characterized the role of large companies, which have the resources and the capital to invest in R&D, as agents that drive innovation.

Hall [1992] found that more R&D-intensive firms have relatively less debt in their capital structure than less R&D-intensive ones. Further, she found that financial constraints hinder R&D activities. Her results show a positive relationship between cash flow and R&D investment, suggesting that R&D is financed out of free cash flow.

Of course, acquiring external resources may be costly. One reason, according to Myers and Majluf [1984] is asymmetric information between lenders and borrowers, which might lead firms to prefer financing risky projects using debt. On the other hand, moral hazard concerns may cause banks to not finance innovation using debt. That reticence could be reflected in the financing of innovation out of retained earnings, or other non-debt sources, which suggests using cash flow as the main financing for R&D, in line with some of the regressions cited above. Another issue is the agency problem. Jensen and Meckling [1976] pointed out that this issue arises when the managers do not pursue shareholder interests, leading firms to pay a premium for external financing. Agency issues are generally not fully present in Schumpeter's work and can drive a wedge between empirical results and Schumpeter's theory.

In sum, our literature review indicates that while Schumpeter's theory yields relatively straightforward predictions, the empirical implementation has revealed a wide variety of results. This motivates our work, which revisits the issue with a data set that is useful for studying Schumpeterian hypotheses. We now turn to this data set and our methods of exploiting it.

Data Description

The paper is based on the Business Environment and Enterprise Performance Survey (BEEPS), which is a joint work of the European Bank for Reconstruction and Development (EBRD) and the World Bank Group.

The survey is based on a stratified random sampling procedure using the size of the economy and sector as strata. This survey consists of firm level data collected in five rounds (1999, 2002, 2005, 2009 and 2013). The survey provides information about innovation behavior of enterprises through data on whether the firm has introduced new or significantly improved products or processes. This allows a distinction to be made between product and process innovation. In addition to that, the survey includes information about the number of competitors, firm age, firm size, ownership, exports, legal status, education of work force, corruption, obstacles faced by the enterprise and financing obstacles. As such, it is a rich and unique data for investigating innovation correlations, specifically those suggested by Schumpeter. Information is, however, self-reported, so that items like "number of competitors" represents the firm's view and is not an externally-validated figure.

Due to data shortages for 2003 and 2004, we assess a balanced panel of 1,053 enterprises in two years only – 2002 and 2005.

Descriptive Analysis of Data

Table 1 shows that most innovative firms face a high number of competitors but, to a similar degree, do most of non-innovative firms. As previously noted, Aghion et al. [2006] argued that innovation can be driven by escaping competition, as well as by the Schumpeterian effect. The first result reported here can be explained by Aghion's work and the Hart model (in which competition works as an incentive to innovate). The second result is consistent with Schumpeter's hypothesis, according to which firms innovate optimally in concentrated markets. Considering all size categories in our data, innovation is higher when facing a higher number of competitors, which suggests that the "escape innovation" effect may dominate.

Tables 1,2 and 3 are based on cross tabulation and three-way tabulation.

TABLE 1. Different innovation activities according to size and number of competitors

Innovation behaviour	Number of competitors		
	None	1 to 3	4 or more
No innovation	15	110	704
Product innovation	15	172	689
Process innovation	19	223	958
Both	21	251	1,082
Innovation/Size	Number of competitors		
	None	1 to 3	4 to more
Small			
No innovation	8	70	564
Product innovation	5	88	425
Process innovation	6	122	593
Both	7	136	689
Medium			
No innovation	3	25	91
Product innovation	4	45	161
Process innovation	6	57	228
Both	7	64	245
Large			
No innovation	4	15	49
Product innovation	6	39	103
Process innovation	7	44	137
Both	7	51	148

Source: own elaboration.

TABLE 2. Proportions of firms involved in different innovation activities according to age and size

Innovation/Size	AGE[7]			
	Young N=2344	Middle N=303	Old N=213	Very Old N=32
Small				
No innovation	26.87	33.65	22.73	0.00
Product innovation	18.07	16.83	14.77	33.33
Process innovation	25.30	23.08	29.55	33.33
Both innovations	29.76	26.44	32.95	33.33
Total	100.00	100.00	100.00	100.00
Medium				
No innovation	12.02	26.60	14.08	7.14
Product innovation	22.03	15.43	25.35	28.57
Process innovation	31.54	27.66	29.58	28.57
Both innovations	34.42	30.32	30.99	35.71
Total	100.00	100.00	100.00	100.00
Large				
No innovation	13.33	13.51	9.05	5.56
Product innovation	24.56	19.59	24.57	25.93
Process innovation	29.12	32.43	32.33	33.33
Both innovations	32.98	34.46	34.05	35.19
Total	100.00	100.00	100.00	100.00

Source: own elaboration.

As firm age and size tend to coincide, we follow the approach of some authors – such as Maiti and Singh [2011] – in controlling for age in order to study the effect of size. Table 2, illustrates that very old firms and large firms are the most innovative in all size categories. Process innovation is weakly dominant over product innovation in all size and age categories. The highest proportion of non-innovative firms is found in small and middle age and young firms.

Table 3 shows that the number of firms innovating (considering all innovation categories) is higher when access to finance does not form an obstacle. Considering the case of product innovation, 39.49 percent of product innovative firms face no such obstacle. This percentage is 40.06 when considering process innovation alone and 40.41 when considering both product and process innovation.

In conclusion, our data review generally supports Schumpeter's view in the sense that innovation is optimal in concentrated markets (the Schumpeterian effect). However, there was also a noticeable escape competition effect; a situation explained by Aghion's work [2006]. In regards to firm size, the findings coincide with Schumpeter's hypothesis that large firms innovate more than smaller ones. In addition, financial resources seem to play a vital role in innovation.

TABLE 3. Proportions of firms under different innovation behavior facing access to financing obstacle

Innovation	Obstacle: Access to Financing			
	No	Minor	Moderate	Major
No innovation	40.89	19.01	20.49	19.62
Product innovation	39.49	18.66	20.34	21.52
Process innovation	41.06	18.16	20.57	20.21
Both innovations	40.41	18.56	20.36	20.67

Source: own elaboration.

The Dependent Variable

Our dependent variable is a measure of innovation. The BEEPS classifies a firm as an innovator if the firm has either introduced a significantly new product, or a significantly new process.

In order to capture innovation, we construct a set of binary variables based on Schumpeter's innovation categories [1934]. Maiti and Singh [2011] [8] also maintain this dissection of innovation as a dependent variable in a similar analysis of innovation sources.

We will run our regression so that "any" type of innovation on the left hand side is included. Hence, the dependent variable would be 1 if either process or product innovation or both innovations types occur, and zero if no innovation of any type occurs.

Explanatory Variables

Size

The previous literature review indicate that larger firms are more likely to be more innovative than smaller firms, using a variety of measures such as R&D expenditure, sales revenue and employees as a proxy of size. Therefore, for robustness purposes we will do two different runs; the first using the number of employees and the second using R&D expenditure in the previous year.

Competition

A main hypothesis of the Schumpeterian model is that firms operating in concentrated industries tend to be more innovative. As we saw in the literature review, this has been empirically controversial, with some finding the reverse correlation and more recent literature finding a non-linear relationship in the form of an inverted U. Accordingly, we construct a measure of competition to test the relation between product market competition and innovation.

Access to Financing

We introduced a dummy variable to measure access to financing constructs as obstacle for the firms. In Schumpeter's work, financial resources and firm size influence innovation. The more access a firm has to financial capital the more innovative it would be, and the bigger the firm the higher the propensity to innovate.

Control Variables

We will include the following variables into our regression to see the contribution of each of them to the results.

Ownership and Age

Following Maiti and Singh [2011], we added an ownership dummy variable and log of age. Their results suggest that private and large firms are more innovative than others. We have already commented that agency issues may be of concern and so ownership controls are appropriate. Concerning age, the log of age does not have a consistent sign in Maiti and Singh's results, but empirically large and old firms tend to coincide. Looking at the probability of innovation after including the age of the firms into our regressions helps us to understand the dynamics of the industries. Some researchers, such as Huergo and Jaumandre [2004], confirm econometrically that the evolution of innovation behavior across ages is complex in the sense that two opposite results always show up. On one side, entrant firms on average present a high probability of innovating. On the other side, old firms tend to show a lower probability of introducing an innovation than entrant firms in their first year. Theoretically, the effect of age on innovation has two opposite forces. On one hand, knowledge accumulation positively affects a firm's ability to catch up and improve its innovation rate because current technological achievements depend on the previous work [Nelson, 1991]. On the other hand, aging might lead to rigidities in communication flows within the boundaries of the firm, and rivalry might lead to more advances in the surrounding environment; therefore, firms will produce less innovations as they age [Sorensen, Stuart, 2000], and age should be controlled for in a study of the effect of firm size on innovation.

Legal System

We introduced a dummy variable indicating whether the legal system is able to uphold contracts and property rights. This variable was constructed according to each firm's survey response.

Exports

According to Maiti and Singh [2011], exports create an incentive to innovate. Or it might be the case that more able innovators tend to export more. To capture these effects, we included a continuous variable that indicates exports as a percentage of the total sales in the previous year.

Industry

Cohen and Levin [1989] argued that the importance of controlling for industry effects arises from the fact that size is likely correlated with industry-level variables such as technological opportunity,[9] which affects innovation positively. Therefore, controlling for industry-specific characteristics prevents bias in the estimation.

All the variables used are detailed in the appendix.

The Empirical Model

Our research goal is to investigate the effect of firm size, competition and the access to financial sources on innovation. Since our dependent variable is a binary variable, we employ a logit model. Our estimation procedure involves three different models. Model 1 examines the effect of size on innovation. Model 2 examines the effect of competition on innovation and Model 3 examines the effect of access to finance on innovation. In order to capture non-linearity in PMC and size in models 1 and 3, we used a categorical competition variable. Hence, the non-linearity we wish to uncover is included by using dummy variables for each category.

First we estimate the following models using a pooled time series specification. The estimates are carried out including control variables such as for country and sector effects. The use of a pooled regression was necessary as we do not have sufficient history of data over the years. We can get more precise estimates and test statistics with more power by pooling samples from the same population but at a different point of time.

Model 1.

$$\begin{aligned}\text{Innovation} = \alpha_1 + \beta_1\text{LogofAge} + \beta_2\text{ Exports} + \beta_3\text{Legalsystem} + \beta_4\text{ Ownership} + \\ + \beta_5\text{SizeDummy} + \beta_6\text{CountryDummy} + \beta_7\text{SectorDummy} + \varepsilon\end{aligned} \tag{1}$$

Model 2.

$$\begin{aligned}\text{Innovation} = \alpha_2 + \beta_8\text{LogofAge} + \beta_9\text{ Exports} + \beta_{10}\text{Legalsystem} + \beta_{11}\text{ Ownership} + \\ + \beta_{12}\text{CompetitionDummy} + \beta_{13}\text{CountryDummy} + \beta_{14}\text{ SectorDummy} + \varepsilon\end{aligned} \tag{2}$$

Model 3.

$$\begin{aligned}\text{Innovation} = \alpha_3 + \beta_{15}\text{ LogofAge} + \beta_{16}\text{ Exports} + \beta_{17}\text{Legalsystem} + \beta_{18}\text{ Ownership} + \\ + \beta_{19}\text{FinancingDummy} + \beta_{20}\text{CountryDummy} + \beta_{21}\text{ SectorDummy} + \varepsilon\end{aligned} \tag{3}$$

Endogeneity problems, which are a feature of the previous equations, are dealt with later in this paper.

Results

This section reports the results of the regressions for the three models using both the pooled time series analysis and the cross section analysis.

Pooled Time Series Analysis

Table 4 presents our analysis with innovation as a dependent variable, which takes a value of one if either process and/or product occur, and zero if no innovation of any type occurs.[10] We run three different regressions using the pooled time series estimate. In particular, column 1 is the estimation of the equation (1) above which considers the size dummies.[11] Small size is the omitted category in the regression. Both medium and large firms have a positive and statistically significant effect at the 1 percent level. The odds of a firm being innovative rather than not increase by a factor of 3.480 when the firm is large rather than small. The relative probability of innovating rather than not is 2.102 higher when a firm is medium rather than small sized. This finding is consistent with Schumpeter's theory that larger firms will be more innovative. Considering the second size measure, we included R&D expenditure instead of size categories. The results indicate robustness, as we found a statistically positive effect.[12]

The second column focuses on the degree of competition. We find a negative marginal effect when the number of competitors is 4 or more. When the number of competitors is between 1 and 3, the odds of innovating rather than not is greater by 1.519. This relative probability of innovation rather than not is also positive when the number of competitors is 4 or more, and greater than no competitors at all by 1.242. However, both degrees of competition are not significant at any level. This might result from the lack of the data in our estimate. The middle category seems to have the greatest innovative potential with less difference between low and high levels of concentration. Indeed, since the coefficient of the high competition dummy is less than the middle level, this is evidence of non-linearities in the relationship between competition and innovation. Aghion's [2006] model of macroeconomic growth and innovation specifies that the escaping competition effect dominates for some industries and he Schumpeterian effect dominates for others where the optimal innovation rate happens at intermediate levels of concentration.

The third column captures firm access to the financial resources. It was expected that the probability of innovating is higher when the firm does not face a problem in accessing finance. However, the results were not significant in our regression. This insignificant result may reflect a lack of data used in our research or, perhaps, financing issues are so tied to the controls that they do not stand out as an independent effect.

The effects of the control variables bear mention. In all three models, the probability of innovation is higher in firms that export. This can be explained by the fact that exports create the profit incentive to innovate. On the other hand it could be a selection effect in the sense that more able innovators tend to be more likely to innovate. This result is consistent with Maitiand Singh's [2011] findings. The probability of innovation is at least 0.26 percent higher when the legal system is able to uphold property rights, as we might expect. Privately-owned firms are more likely to innovate than state-owned ones with a positive and statistically significant coefficient. Evidence generated by Lerner et al. [2011] supports our result that private firms are more innovative than public ones. Ferreira et al. [2012] suggest that public firms normally exploit existing ideas while private firms take more risk in exploring new ideas, explaining that situation private firms are less transparent to outside investors as compared to public ones. Therefore, insiders in private firms are more able to deal with failure, and are hence more willing to invest in innovation than public firms because they can choose an early existing strategy if they receive bad news. For example, in public firms the price of securities react to both good and news, which leads insiders to invest (or refrain from investing) in conventional projects.

In most of the regressions, we see that age is not significant in explaining innovation. However, in the first logit model, the probability of innovation appears to decrease as the firms get older with a 10-percent level of significance. Some authors, such as Sorensen and Stuart [2000], explain that aging leads to rigidities in the flow of communication within the boundaries of the firm, and to rivalry towards technical advances in the surrounding environment, so that firms will produce less innovation as they get older.

TABLE 4. Logit model of innovation activity (Pooled time series analysis)

Dep.Var: Innovation	(1)	(2)	(3)
LOG of Age	–0.173*	–0.0118	–0.0176
	[0.0942]	[0.0659]	[0.0878]
Exports	0.0141***	0.0157***	0.0175***
	[0.0041]	[0.00325]	[0.00407]
Legal system	0.230*	0.227**	0.265**
	[0.128]	[0.101]	[0.128]
Private	0.591**	0.25	0.354
	[0.238]	[0.173]	[0.231]
Large	1.247***		
	[0.289]		
Medium	0.743***		
	[0.191]		

Dep.Var: Innovation	(1)	(2)	(3)
Competition 3		0.18	
		[0.295]	
Competition 2		0.378	
		[0.308]	
Access to finance			–0.116
			[0.129]
Country F.E	Yes	Yes	Yes
Sector F.E	Yes	Yes	Yes
Observations	2,084	2,084	2,084

Standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1
Model 1 examines the effect of size on innovation, model 2 examines the effect of competition on innovation, and model 3 examines the effect of access to finance on innovation.

Source: own elaboration.

Cross Section Analysis

In this section we re-run the previous regressions, considering each year separately. Table 5 replicates the same regressions using a cross section analysis for the year 2005, while Table 6 considers cross section analysis for year the 2002. In the first model large firms appear to have a slightly higher probability to innovate as compared to medium and small sized firms. This finding coincides with our finding in the pooled time series regression and with Schumpeter's hypothesis. The second model indicates that the probability of innovation is higher when a firm faces low or no competition, which is more in line with the Schumpeterian effect than the escaping competition effect. In addition to that, the results show that the intermediate level of competition is the most conductive for innovation, which is consistent with Baldwin et al.'s [2000] empirical finding. The third model focuses on the effect of financial resources on innovation. It is expected that the probability of innovating is higher when a firm does not face a problem in accessing finance. We capture this positive relationship only in year 2002, meaning the probability of undertaking innovative efforts in 2002 is higher in firms that do not face an obstacle in accessing finance. This fits with the Schumpeterian hypothesis in which financing and size interact to generate innovation.

Observed impacts of the legal system are consistent with what we found in the pooled time series regression. Moreover, firms that export are more likely to be innovative in all of the regressions. Private firms seem to be more innovative than public firms, which also mirrors the results observed in our pooled time series regression.

Overall, the results seem to be consistent with Schumpeter's hypothesis that bigger size firms with greater access to finance enhance innovation. The competition results indicate that firms facing lower competition are more likely to innovate, which is also consistent with Schumpeter's view.

TABLE 5. Logit model of innovation activity (Cross section analysis 2005)

Dep.Var: Innovation	(1)	(2)	(3)
LOG of Age	–0.102	0.049	0.0525
	[0.104]	[0.0949]	[0.0927]
Exports	0.0106*	0.0142**	0.0144***
	[0.00569]	[0.00562]	[0.00473]
Legal system	0.269*	0.326**	0.376**
	[0.148]	[0.146]	[0.148]
Private	0.533*	0.229	0.249
	[0.275]	[0.263]	[0.258]
Large	1.520***		
	[0.347]		
Medium	0.689***		
	[0.207]		
Competition 3		0.163	
		[0.322]	
Competition 2		0.363	
		[0.339]	
Access to finance			–0.375**
			[0.154]
Country F.E	Yes	Yes	Yes
Sector F.E	Yes	Yes	Yes
Observations	1,044	1,044	1,044

Standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1
Model 1 examines the effect of size on innovation, model 2 examines the effect of competition on innovation, and model 3 examines the effect of access to finance on innovation.

Source: own elaboration.

In order to compare the coefficients within the two cross-section models, we conduct a Chi-square test. The Chi-Square test for the equality of the medium and large size coefficients across the two years are equal to 16.89 and 24.22, respectively at two degrees of freedom; hence we reject the hypothesis of the equality of the two coefficients at p value 0.05. Conducting a Chi-square test for the equality of the competition variables provides us with values of 1.15 for competition 2 and 0.28 for competition 3 at two degrees of freedom. Hence there is no statistical difference in the two models of different years considering competition variables. Chi-square value is 2.89 when testing the equality of the two models at one degree of freedom. Hence, there is no statistical difference in the two models.

Overall, we find the behavior to be the same in 2002 and 2005 as there is no statistical difference in the coefficients. Hence, we can take the pooled regressions as a "good model" and we can take our conclusions from each individual year seriously.

TABLE 6. Logit model of innovation activity (Cross section analysis 2002)

Dep.Var: Innovation	(1)	(2)	(3)
LOG of Age	–0.184*	–0.085	–0.0806
	[0.103]	[0.0967]	[0.0989]
Exports	0.0151***	0.0170***	0.0172***
	[0.00512]	0.00516]	[0.00466]
Legal System	0.176	0.164	0.139
	[0.148]	[0.147]	[0.148]
Private	0.394	0.298	0.285
	[0.259]	[0.255]	[0.245]
Large	1.520***		
	[0.347]		
Medium	0.644**		
	[0.28]		
Competition 3		– 0.168	
		[1.146]	
Competition 2		0.123	
		[1.153]	
Access to Finance			0.251*
			[0.148]
Country F.E	Yes	Yes	Yes
Sector F.E	Yes	Yes	Yes
Observations	1,044	1,044	1,044

Standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1

Model 1 examines the effect of size on innovation, model 2 examines the effect of competition on innovation, and model 3 examines the effect of access to finance on innovation.

Source: own elaboration.

Addressing Endogeneity

Endogeneity is a serious problem that can arise when we use a single equation model to study the relationship between innovation and market structure, firm size, or financial access because the relation may not be a simple one-way causal relationship. Innovation activity may affect market structure and firm size [Symeonidis, 1996]. At the same time market structure, size and financial access may affect innovation activity. Regarding firm size, Scherer [1992] emphasizes the reverse causation between size and innovation: innovation affects firm growth and hence firm size, so that size in the current year is influenced by innovative activity in the previous year.

Some authors, such as Machin and Van Reenen [1996] argue that the use of instrumental variables could solve this problem, while others, such as Levin and Reiss [1988], have estimated simultaneous equation systems in which both innovation and each of market structure, size or financing are each treated as endogenous.

Since we have data for two years, we could potentially use earlier values (year 2002) for firm size, competition and financial access variables and later values (year 2005) for the dependent variable, which is innovation. The idea would be that the competitive situation, size or financial access for firms in an earlier year might give rise to innovation in later years, but not the reverse. If three years lag is a long enough period to minimize reverse causality, it might give us at least an adequate idea of the magnitude of the effect endogeneity may be having on our results.

Table 7 shows the results of estimating the same three previous models after addressing the endogeneity problem using lagged values.[13] In comparison with the results of the estimation of the pooled time series, we generally see an increase in the coefficient after treating the endogeneity problem. This outcome is expected and suggests that endogeneity is probably an issue; likewise, we would normally expect some bias to arise if endogeneity is present.

In more detail, the first column shows that size generally does not have a large effect and is generally in line with the sort of bias we might expect due to endogeneity. Regarding the other variables, the coefficients increased slightly. Moving to column 2, all the variables have experienced a small increase in their magnitude. After treating for endogeneity, the coefficient of innovation decreases with competition. This change might be due to endogeneity, but we also have to consider the possibility that there is a lag structure to the interaction between competition and innovation. In other words, by using lagged values as instruments we might be instead picking up a different problem with the base model: we might not be capturing lags. If innovation occurs quickly, the instrument strategy might make sense. For innovation that takes longer, it may simply mean that the lag structure of innovation is three years. We cannot separate out these possible explanations with the current choice of instrument. Furthermore, as our data assembles a wide variety of innovation types (process and product) and, as the innovation measure is based on an evaluation process that might, in itself, carry (such that one would only evaluate oneself as innovative some time after having achieved innovation), the lag structure might not be consistent across the data.

TABLE 7. Logit model of innovation activity (Using the lagged values to address the endogeniety problem)

Dep.Var: Innovation	(1)	(2)	(3)
	[9.054]	[8.303]	[8.278]
Exports	0.0176***	0.0188***	0.0190***
	[0.0047]	[0.00465]	[0.00464]
Legal System	0.256*	0.247*	0.247*
	[0.148]	[0.148]	[0.148]
Private	0.456**	0. 335	0.325
	[0.216]	[0.251]	
Large	0.921***		
	[0.313]		
Medium	0.315		
	[0.204]		
Competition 3		0.124	
		[1.051]	
Competition 2		0.271	
		[0.206]	
Access to Finance			0.0449
			[0.149]
Country F. E	Yes	Yes	Yes
Sector F. E	Yes	Yes	Yes
Observations	1,044	1,044	1,044

Standard errors in brackets *** p<0.01, ** p<0.05, * p<0.1
Model 1 examines the effect of size on innovation, model 2 examines the effect of competition on innovation, and model 3 examines the effect of access to finance on innovation

Source: own elaboration.

Conclusion

In this paper we evaluate the Schumpeterian hypotheses with detailed firm-level data on the relationship between competition, firm size, financial access and innovation behavior. Several findings are of note. First, size is positively related to innovation, which is in line with Schumpeter's hypothesis. Our results suggest that the probability of large firms to innovate is higher than small and medium sized firms. Second, the relationship between competition and size appears to be non-linear. As the number of competitors increases, the probability to innovate first increases, and then decreases. Intermediate levels of competition seem to be the most conductive for innovation. The third finding is that firms with no obstacles to accessing financial resources are more likely to innovate, which also coincides with Schumpeter's predictions.

Our results are robust for different measurements of size and innovation and as to some different divisions of the data, such as year of measurement. We made a first attempt to address the endogeneity problem using lagged values as instruments, which also confirmed our initial results.

Regarding drawbacks of our analysis, our dataset covered only two years as a panel. Hence, this analysis could be extended in two directions. The first would be to examine more carefully competition variables using a larger sample of data. The second would be to address endogeneity using alternative instruments to permit more definitive conclusions concerning innovation policy.

Notes

1 See P.A. Geroski (1995) and S.J. Nickell (1996). Their research also pointed to a positive correlation between competition and innovation.

2 The Hart model (1983) formalized the fact that both competition in the product market and the capital markets play an important role in limiting managerial slack. He proved that managerial slack is lower under competition than for a single "non-profit" maximizing monopolist.

3 Quality ladder here is not an explicit measure of quality but rather a cost ladder where higher quality is equivalent to lower production costs.

4 Other research by P. Aghion et al. (2010), A.R. Hashmi (2013), T. Haruyama (2006) and M. Peneder (2012) also confirm the existence of an inverted U-shaped relationship between innovation and competition.

5 For other research that study the relationship between size and innovation, see M. Corsino et al. (2008), F.M. Scherer and K. Huh (1992), C. Freeman (1982), P. Patel and K. Pavitt (1992), W. Cohen (1995), W.M. Cohen, and S. Klepper (1996), H. Shangqin et al. (2009), J.E. Ettlie, and A.H. Rubenstein, (1987).

6 J. Sutton (1991) provides significant support for this view of R&D as a large sunk cost.

7 Age is categorized into four groups: young, middle, old and very old. A firm is young if it has been operating for less than 20 years, middle if it has been operating between 20 and 50 years, old if it has been operating between 50 and 100 years, and very old if it has been operating for more than 100 years.

8 Our model is based on Maiti and Singh (2011) in the use of the main variables (size, competition and financing). We used some control variables other than those in Maiti and Singh (2011) in order to construct a balanced panel. Maiti and Singh run different regressions considering different types of

innovation. In our case, we only run our regression using one dummy variable indicating 1 when any type of innovation occurs and zero otherwise. Maiti and Singh run a cross section while, in our case, we will run both pooled time series and a cross section. Hence, our paper complements and extends Maiti and Singh's work.

9 Technological opportunities vary across industries as the scientific environment provides more productive grounds for advances in some industries than in others. Hence, technical improvement is higher in some industries than in others (Baldwin et al., 2000).

10 We run three regressions using three different measurement of innovation as explained in the descriptive analysis of the data. The results show robustness across all innovation categories. The results have not been reported.

11 We have not reported the regression table while considering R&D expenditure for abbreviation purposes. We did not find any difference between the two measurements of size.

12 Independent variables were taken from the 2002 data set to be used as instruments to treat the endogeneity bias, whereas the dependent innovation variable is from the 2005 data set.

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Appendix
Description of Dependent and Explanatory Variables for Logit Model

Variable	Description
DEPENDENT	
Innovation	Process with product innovation Product Innovation Process Innovation
EXPLANATORY	
Size Small Medium Large R&D	 Less than 99 employees 100 to 499 500–9999 employees R&D expenditure in the previous year
Competition Competition 1 Competition 2 Competition 3	 No competitors 1 to 3 competitors More than 4 competitors
Access to financial resources	
	Obstacle No Obstacle
Ownership	
	Private-owned State-owned
LOG of Age	Age: number of years that the firm has been operating
Exports	Percentage of exports in sales

Variable	Description
Legal system	
	The legal system able to uphold contracts and property rights. Yes No
Country	Bulgaria, Albania, Croatia, Belarus, Georgia, Tajikistan, Turkey, Ukraine, Uzbekistan, Russia, Poland, Romania, Kazakhstan, Moldova, Azerbaijan, FYR Macedonia, Lithuania, Armenia, Kyrgyz Republic, Estonia, Czech Republic, Latvia, Hungary, Slovak republic, Slovenia, Bosnia and Herzegovina.
Sector	Mining and quarrying, Construction, Manufacturing Transport storage and communication, Wholesale and retail trade, Real estate, renting and business services, Hotels and restaurants, Other services

Source: own elaboration.