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ABSTRACT

EMPLOYMENT EFFECTS OF R&D AND INNOVATION: EVIDENCE FROM SMALL AND MEDIUM-SIZED FIRMS IN EMERGING MARKETS

Rajeev K. Goel, and Michael A. Nelson

This paper studies the impact of research and development (R&D) and innovation on employment growth, focusing on small and medium-sized firms. Employment effects of R&D and innovation are unclear a priori as process innovation may be labor-saving or labor might have complementarities with other inputs. Employing firm-level data from 125 nations, results show that both R&D and innovation increased employment growth, suggesting that innovation was either capital-saving or labor had strong complementarities with other inputs. Upon splitting the sample into growing and contracting firms showed that contracting firms benefit from innovation but not from R&D. In other findings, sole proprietorships, larger firms, firms with relatively more experienced managers, firms with females as top managers, and firms facing the threat of informal competition had lower employment growth, while foreign-owned and government-owned enterprises have positive influences on employment growth. Finally, employment growth in shrinking firms was boosted in nations with greater economic freedom, but this growth is undermined by informal sector competition.

Keywords: R&D; innovation; employment growth; managerial experience; foreign ownership; government ownership; economic freedom; emerging markets

JEL classification: L2; O3; O5

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1 Introduction

Payoffs from innovative activities in terms of impacts on firms' performance are the prime inducements for firms to undertake the expensive and sometimes risky pursuit of new technologies. However, payoffs from innovation come in various forms, differing in scope and timing (i.e., some payoffs are more immediate than others – see Bowen et al. (2010)). For example, innovations might improve efficiency, performance, profitability, market share, licensing royalties, reputation, etc., while deterring rival entry (or even inducing rival exit). All these dimensions qualitatively and quantitatively differ across the two innovation categories – process innovation and product innovation.

Research and innovation, especially process innovation, are generally taken to lower production costs via savings resources, labor, and capital. However, in practice, this might not happen given the nature of the production process and related complementarities between inputs, employment could very well increase. Furthermore, although research and development (R&D) is paramount to innovation, not all R&D might yield successful innovation. Yet, R&D might improve productivity and synergies among inputs, and R&D might substitute for learning by doing, some of which might come from firm longevity.

Broadly speaking, this research can be viewed as examining the impact of structure and conduct on performance (employment growth). Specific contributions in this regard to the literature include the inclusion of firm-level elements of firms' structure (size, age, ownership) and conduct (research and innovation) on the employment of small and medium-sized firms across a data set consisting of mostly emerging markets. Information at this scale and depth has generally not been analyzed in the literature. [1] Furthermore, the innovation response of small and medium firms is not clear in general as information about such firms is not readily available until recently. Plus, smaller firms generally do not have large marketing departments that are able to publicize or market their innovations. The insights from survey data provide useful insights in this regard. Another novelty is that we can compare the employment effects of growing and contracting firms and assess the influence of informal sector competition on firm R&D investment and process innovation. Both represent useful new contributions to the literature on this general topic.

Whereas the theoretical literature on the causes and effects of innovation has made tremendous strides in recent decades, arguably up to a somewhat saturation point, the empirical literature has lagged behind, due to the general unavailability of relevant data (for a review of the related empirical literature, see Cohen and Levin (1989)). These issues gain somewhat special importance in developing or emerging nations that are generally labor abundant and capital scarce.

A meta-analysis of the literature by Bowen et al. (2010) concludes that the relation between innovation and firm performance is uncertain.[2] Along a related dimension, the employment effects of innovation have been noted to be unclear – both theoretically and empirically (see Vivarelli (2007)).

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[1] *Some other studies, however, have used firm-level data in different contexts – see Avenyo et al. (2019), Baffour et al. (2020), Barbieri et al. (2019), Goel and Nelson (2018).*

[2] *Insightful surveys of the literature on the innovation-employment nexus can be found in Calvino and Virgillito (2018) and Vivarelli (1995, 2012). Also, see a recent compilation of the literature on this topic by Dosi and Mohnen (2019)).*

This paper adds to the empirical literature on the effects of innovation by studying the effects of R&D and innovation on employment growth, using firm-level data for 125 nations.[3] Does the introduction of process innovation enhance firms' performance as measured by employment growth? Depending upon the nature of technology and the substitution-complementarity between inputs, R&D and process innovation might or might not enhance employment.

The payoffs from innovation can also be undermined by the informal sector - business enterprises that do not pay taxes, nor adhere to costly regulations (Schneider and Enste (2000)). The presence of such informal or shadow competition can diminish the potential payoffs from innovation and the availability of inputs for formal sector firms, impacting employment growth.

This paper focuses on process innovation, while product innovation could arguably be equally, if not more, important. However, due to a lack of comparable data across countries, we restrict our focus to process innovation. Unlike product innovations, process innovations are less saleable in a disembodied or standalone form (see Cohen and Klepper (1996)). Furthermore, the timing of relative payoffs might be different – returns to process R&D are more concurrent with the firm's output when R&D is being performed; on the other hand, returns to product innovation are in the future as new markets are created and they mature (diffuse).[4]

This paper studies the impact of R&D and innovation on firms' employment, focusing on small and medium-sized firms. Following the World Bank's Enterprise Analysis Unit, we define firm size levels as 5-19 employees (small) and 20-99 (medium). They point out that firms in these size categories constitute the majority of firms in most economies (https://www.enterprisesurveys.org/methodology).[5]

The following key questions are addressed in this research:

- How do R&D and innovation by small and medium-sized firms affect their employment growth?
- How does the presence of the informal sector competition impact employment growth in innovating firms?
- Are there differences in the impact of R&D and innovation on employment growth by growing and contracting firms?

A better understanding of the impact of innovation would help firms make informed decisions about allocating resources for research and assist policymakers in deciding on research subsidies to promote such activity and spur economic growth. The differing labor-using and labor-saving impacts of

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[3] *This work can be viewed as complementary to research that studies the causes of innovation (Goel and Nelson (2018))*

[4] *The importance of another dimension – organizational innovation – is slowly dawning on economists (Polder et al. (2010)).*

[5] *Given appropriate data, some scholars have been able to consider both process and product innovation (Antonucci and Pianta (2002), Mantovani (2006)). In preliminary analysis, we included firms of all size levels (available upon request) with generally similar results, although with lower overall model explanatory power because of the wide variation in firm size in the 100+ employee size category. Approximately 83% of the total number of firms in our data set had 100 or fewer full-time employees at the start of the period under analysis.*

technological change have been noted in the literature (Calvino and Virgillito (2018), Piva and Vivarelli (2018), Vivarelli (2013)). Furthermore, as noted above innovation by small- and medium-sized firms often gets overlooked because of a lack of their ability to market or diffuse such innovations. Small firms also face higher borrowing costs and are often unable to realize scale economies in innovation production. Large enterprises, on the other hand, have extensive marketing and distribution networks. This relative handicap of smaller enterprises also makes obtaining data on such firms more challenging, limiting formal analyses. Yet, in many nations, small- and medium-sized firms generate a substantial portion of employment. This study has the benefit of focusing on these firms by employing self-reported data on innovation and employment.

Results show that both R&D and innovation improved firms' performance. Splitting the sample into growing and contracting firms showed that contracting firms benefit from innovation but not from R&D. Competition from the informal sector, however, undermines employment gains in innovating firms. This focus has obvious policy implications related to the survival of firms.

The structure of the rest of the paper includes related literature, theoretical background, and the empirical model in the next section. This is followed by data and estimation, results, and conclusions.

2 Related literature, theoretical background, and empirical model

2.1 Related literature

The positive link between innovation and firms' growth is noted by Audretsch et al. (2014), while suggesting caution in considering the multidimensional natures of R&D, innovation, and growth modes (see Birley and Westhead (1990), Karabulut (2015)). Due to this variation, the meta-analysis by Bowen et al. (2010) concludes that the relation between innovation and firm performance to be uncertain/ unclear. They recommend a better accounting of the temporal sequence of the relation between innovation and performance.[6] Reviews of the literature in firm-level innovation models can be found in Hobday (2005), Mowery and Rosenberg (1979), and Vivarelli (2014). At a broader level, the present research can be viewed as being complementary to models studying the effect of R&D on economic growth at the aggregate level (see Jones (1995) for a related review).

Related more directly to the focus of the current research, the impact of technological change on employment has been noted by many scholars; for example, by Antonucci and Pianta (2002), Baffour et al. (2020), Barbieri et al. (2019), Benavente and Lauterbach (2008), Cirera and Sabetti (2019), Harrison et al. (2008), Katsoulacos (1984), Lachenmaier and Rottmann (2011), Peters (2004), Piva and Vivarelli (2018); with broader overviews of the literature in Calvino and Virgillito (2018), Dosi and Mohnen (2019) and Pianta and Vivarelli (2000). These studies vary in the size and scope of the samples used. Further, their focus is on either process and product innovations, or both, constrained by the availability of related data. The main conclusion that one can draw from this literature is that the employment effects of innovation vary and are not uni-directional. Using data on Greek firms, Hatzikian (2015) finds the relationship between innovation and firm performance to be U-shaped. Within the spectrum of this

[6] *Also see Li and Hou (2019) regarding the lags between and R&D and its payoffs.*

literature, perhaps Cirera and Sabetto (2019) is relatively closest to the current work in their use of the same underlying data source (i.e., Enterprise Surveys from The World Bank). However, their coverage of nations is more limited, and, more significantly, their consideration of the factors impacting employment growth is quite different. For example, they do not consider the role of the informal sector or various ownership structures. The authors find that process innovation does not impact additional employment.

In the innovation-employment nexus, there is the compensation theory that states that market forces should assure a complete compensation (or reverse-accounting), through various channels, of the initial labor-saving impact of process innovations. However, as noted by Vivarelli (2007) in his influential survey, the compensation theory is prone to criticism and the theoretical and empirical support for the positive spillovers from innovation to employment is mixed (also see Vivarelli (2012, 2014)).

A strand of the literature examines the nexus between firm size and innovation, arguing that larger firms might be at an innovative advantage, especially in capital-intensive industries, while small firms might have advantages in other cases (Acs and Audretsch (1987a)). Using data on small and micro firms in the Netherlands, de Jong and Marsili (2006) found the pattern of innovation by small firms to be quite diverse (also see Nooteboom (1994)), whereas Martínez-Ros and Labeaga's (2002) study of Spanish firms finds the relationship between firm size and innovative activity to be non-linear.[7] The presence of contradictory results between size and innovation in the literature has been noted by Camisón-Zornoza et al. (2004). Related to this, firm size might also affect the allocation of R&D outlays. Cohen and Klepper (1996) note the influence of size on the allocation of R&D funds between process and product innovation (also see Fritsch and Meschede (2001)). The impact of firm size on innovation is not necessarily uni-directional, and it is possible that innovation could impact size. Accordingly, some studies have taken account of the related endogeneity aspects (Koeller (1995)). Focusing on a related yet different aspect, Huergo and Jaumandreu (2004) consider the impact of firms' age and process innovation on productivity growth. They report a positive impact of process innovation on productivity growth.

Finally, our focus on the role of informal markets in the innovation-employment relation ties to the broader literature on the effects of the shadow economy (Schneider and Enste (2000)).

Overall, the present research will add to the literature by including firm-specific elements across a large sample of mostly emerging economies. Analysis of innovation-performance nexus at such a scale seems missing in the literature, as is the consideration of a number of specific influences (such as the impact of the informal sector).

2.2 Theoretical background

To place the empirical model on a somewhat solid theoretical footing, we sketch a formal model, borrowing from the work on Dasgupta and Stiglitz (1980).[8,9] Let the representative firm have a single

[7] *Roper (1997) provides related comparisons of firms in Germany, Ireland and the U.K.*

[8] *See Goel (1990b) and Tandon (1984) for related modeling extensions.*

[9] *Another well recognized theoretical model of process innovation is due to d'Aspremont and Jacquemin (1988), albeit with research spillovers.*

input, labor (L), with Q denoting output, such that $Q = f(L)$, and $f' > 0$, $f'' < 0$. The linear demand for the firm's product is given by $P = a - b(NQ)$,[10] where N denotes the number of firms in the industry, and a can be interpreted as market size.[11] Constant cost production technology is assumed as is represented by $c(x)$, where x represents spending on R&D. Spending x on R&D (the price of a unit of R&D is assumed to be numeraire) reduces production costs, such that $c'(x) < 0$, and $c''(x) > 0$. The cost-reduction (B) associated with R&D (x) can be denoted in a constant elasticity framework, such that $B \equiv (a - c) = \beta x^{\alpha}$; where $\beta > 0$, and $0 < \alpha < 1$. Here β can be interpreted as the productivity of research and α as the technological opportunity.

Given this framework, the representative firm chooses its production (Q) and research (x) to maximize profits that are denoted by

$$\max_{Q,\,x} \pi = PQ - cQ - x \quad = (a - bNQ)Q - cQ - x = (B - bNQ)Q \qquad \ldots(1)$$

The optimal R&D, output and profits in this stylized framework is solved recursively across different market structures that also enable one to do welfare comparisons.[12] Besides yielding a closed-form solution, the introduction of the cost-reduction $(a - c) = \beta x^{\alpha}$ enables the introduction of parameters α and β that have intuitive economic interpretation and that can be readily incorporated in the empirical analysis below. Specifically, the recursive system yields parameters: a = market size; $-b$ = slope of demand (related to demand elasticity); N = number of firms or market participants/competitiveness; α = technological opportunity; and β = productivity of research.

Having solved for L^* and Q^*, one could see how employment and Q^* would grow with R&D (x) and innovation (i.e., via cost reduction $(a - c)$). However, given diminishing returns to cost reduction, i.e., $c'' > 0$, and given the relation of labor with the other inputs, cost reduction could lead to a decline in employment (or in employment growing more slowly). Thus, the quantitative impacts would be less clear a priori and we will have our formal empirical analysis inform us in this regard.

While we do not have information on some market specifics like the nature of the demand curve or the market structure across the 125 nations and more than 50,000 firms in our analysis, we are able to account for a number of aspects. For instance, the technological opportunity (α) can be approximated by the GDP growth and the degree of economic freedom. Firm size, firm age, and managerial experience can approximate for the productivity of research (β). Furthermore, industry dummies, ownership type (whether a firm is a sole proprietorship, partially government-owned or foreign-owned) capture elements of the market structure. Details about how these measures figure in the empirical model are discussed next, with Table 1 providing specifics on the variables.

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[10] See Mowery and Rosenberg (1979) on the link between demand and innovation.

[11] Kamien and Schwartz (1982) is an authoritative work on models linking market structure and innovation.

[12] The specific details are beyond the scope of this paper and the interested reader is referred to Dasgupta and Stiglitz (1980), Goel (1990b) and Tandon (1984) for details.

Based on the above discussion, we formulate two testable hypotheses:

H1: Firms introducing process innovation will see employment grow (contract) depending upon whether innovation is labor-using or labor-saving, ceteris paribus.

H2: Firms engaging in R&D will see employment grow (contract) depending upon whether R&D is labor-using or labor-saving, ceteris paribus.

Next, we formulate an empirical model to test these hypotheses.

2.3 Empirical model

With the unit of observation being a small or a medium-sized firm's response to the survey questionnaire in a given year (firms in some nations were surveyed in multiple years – see the Appendix), the general form of the estimated equation to test the above hypotheses is the following:

Employment growth= f(INNOVATION, R&D, Ownership_m, Firm characteristics_g, Management attributes_j, Informal sector (Informal), Macroeconomic influences_k) …(2)

m = SOLEprop, FOREIGNown, GOVTown
g = FIRMsize, FIRMage
j = MANexp, female_manager
k = GDPgr, EF

Firms' performance is measured via average annual employment growth (EMPgr) over a three-year period. Employment growth may be seen as a relatively forward-looking measure of performance relative to sales growth – firms hire more workers with a view to future expansion. Audretsch et al. (2014), Bowen et al. (2010) and Roper (1997) focus on the link between innovation and firms' growth.[13] In our data set, the average annual employment growth rate was 0.031 or 3.1%. Perhaps not surprising given that the focus was on small and medium-sized firms, the range in growth rates was quite large, with the poorest performing firm experiencing an annual negative growth rate of 113%. In contrast, employment grew at the annual rate of 248% for the firm reporting the strongest growth in our data set.

The main explanatory variables of interest are process innovation and R&D. In our sample, about 40% of the firms had introduced a new or improved production process in the past three years, and nearly 18 percent spent resources on R&D. Although R&D and invention are generally sequential stages in the process of innovation, some inventions can occur in firms without formal R&D spending – e.g., via free-riding on others' ideas or reverse engineering. Due to this, and given that the correlation between R&D and INNOVATION in Table 2 is somewhat modest, we consider R&D and INNOVATION both separately and jointly in the estimated models presented below.

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[13] *See Barkham et al. (1996) and Birley and Westhead (1990) for a more general discussion, while Vivarelli (2014) considers employment growth.*

Tying to the theoretical model above, the influence of R&D on employment growth, would capture $(\partial(d(L)/L)/\partial x)$).[14] A positive and statistically significant coefficient on each of these relations in different model formulations will signify a satisfaction of Hypotheses 1 and 2 outlined above.

Three dimensions of firms' ownership structure are considered – sole proprietorships (SOLEprop), partially government-owned firms (GOVTown), and foreign-owned firms (FOREIGNown).[15] Sole proprietors might be agile in decision making and they might grow more rapidly. The limitations of resources involving firms with some government ownership may be less relevant as they often face captive markets – e.g., sole suppliers to defense markets. Thus, such firms might perform differently, especially to the extent they have non-profit maximizing objectives (see Goel (2004)). Finally, foreign-owned firms usually have lower transaction costs in accessing foreign markets, greater access to foreign technology, and bring international experience and expertise. Thus, they might perform differently than other firms. These considerations will be instructive for nations that have a heightened presence of government and/or foreign firms.

Two firm characteristics, the age of the firm (FIRMage) and its size (FIRMsize), account for agility and experience (with age), and scale/scope economies (with size). In our sample, the average age of firms was 21 years. The size of firms in relation to their innovative behavior has been the subject of considerable attention in the literature (see Acs and Audretsch (1987a, b), Cohen and Klepper (1996), Koeller (1995), Martinez-Ros and Labeaga (2002); and Camisón-Zornoza et al. (2004) for a related meta-analysis), whereas Beck et al. (2005) highlight the role of firm size in the growth of firms. Huego and Jaumandreu (2004) consider the impacts of firms' age. In all this, the focus on innovation by small firms is somewhat limited, with de Jong and Marsili (2006) and Nooteboom (1994) being two notable exceptions. Thus, the present study will contribute in this respect. Firm size is tied to the variable Q in equation (1), although size could also impact the productivity of research (β). Furthermore, the consideration of firm size can be seen as addressing the validity of the Gibrat's law, which states that the proportional rate of firm growth is independent of its absolute size (https://en.wikipedia.org/wiki/Gibrat%27s_law).

Besides firms' age, we account for experience by including the years of experience of the top manager. Experienced managers likely have different discount rates and propensities regarding how they would like their firms to grow. In our sample, the average experience of the top manager was about 18 years. Another managerial dimension is incorporated via the inclusion of the variable, female_manager, to capture firms with top female managers (see Dohse et al. (2019)). Do firms with top female managers grow differently from other firms?

A somewhat novel angle to the innovation-employment literature is added by including the threat firms perceive from their informal sector competitors (Informal).[16] Informal sector firms might increase the

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[14] More generally, in multi-input production function, the impact of R&D would also depend upon labor's relation with other inputs. Goel (1990a) showed that, for the United States, the relationship of R&D with other inputs (i.e., whether inputs are substitutes or complements) varies across industries. In our context, if R&D is complementary to labor, then employment growth-based performance would improve.

[15] Firms with 100% government/state ownership were not surveyed by the World Enterprise Surveys.

[16] A survey of the literature on the role of informal markets can be found in Schneider and Enste (2000); also see Schneider (2012).

competition for securing resources and impact the potential payoffs from innovation. This is especially relevant in studying employment growth since formal sector firms looking to grow might lose some employees to the informal sector. The informal sector also reduces potential payoffs, inducing firms to grow more slowly.

Finally, some economy-wide influences likely have significant bearings on firms' employment, and we consider GDP growth (GDPgr) and the extent of economic freedom (EF). Faster growing economies raise firms' and consumers' expectations, inducing them to hire more workers and increase sales. Greater economic freedom, signifying less intrusive regulations and less burdensome taxation, would boost employment, ceteris paribus. The average economic freedom in sample nations was 57.3 on a 0-100 scale, with higher values signifying greater economic freedom. Together, EF and GDPgr capture technological opportunity (α) in equation (1) above – the logic being that greater technological opportunity increases innovation, which in turn boosts employment.

All estimated equations included survey year fixed effects and industry fixed effects to capture influences that were not otherwise captured in variables considered in equation (1).

3 Data and estimation

3.1 Data

The main source of data is the Enterprise Surveys dataset from the World Bank (www.enterprisesurveys.org). These data are a compilation of surveys of business owners and top managers in mostly-emerging nations.[17] Our analysis is restricted to the surveys conducted between the years 2006 and 2018, a period where the survey was conducted using the Enterprise Surveys Global Methodology.[18] In all, the number of countries included in our data set totaled 125, and 69 of these countries were surveyed more than once over the period considered.
The Enterprise Survey website reports that the number of interviews conducted range from 1,200-1,800 in larger countries to around 360 in smaller economies. Survey questions address characteristics of a country's business environment in a wide variety of areas including access to finance, corruption, infrastructure, crime, competition, and performance measures. Respondents are also asked to identify the major obstacles to the growth and performance faced by their firm. Most of the firms surveyed are in the manufacturing and service sectors, enterprises fully owned by the government are excluded. The total number of observations in the data set exceeded 40 thousand. Details about the countries and the years covered can be found in the Appendix.

The other variables used in the analysis are drawn from reputed international sources that are routinely used in the literature. Details about the data, including variable definitions, summary statistics, and sources are in Table 1.

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[17] *The Enterprise Survey Group states on their website that "[e]merging economies are the primary focus and a few developed economies have been surveyed for comparative purposes." (https://www.enterprisesurveys.org/about-us/frequently-asked-questions.) In our data set (see Appendix A), 19% are classified as "low income", 32% as "low middle income", 35% as "upper middle income", and 13% as "high income" using the 2019 World Bank classifications.*

[18] *http://www.enterprisesurveys.org/methodology*

Table 2 provides pairwise correlations between the key variables in the analysis. As expected, both R&D and INNOVATION are positively correlated with employment growth, with the correlation of INNOVATION being greater in magnitude. Finally, the correlation between INNOVATION and R&D is 0.36, consistent with the notion that R&D leads to process innovation, but also allowing for the possibility that some firms might be able to process innovate via alternative avenues – e.g., spillovers from others' research, learning-by-doing, and serendipity, etc. Next, we outline our estimation strategy.

3.2 Estimation

We estimate different versions of equation (2) in Tables 3-5 using OLS and report t-statistics based on country-level clustered standard errors. As stated earlier, all models include industry dummies to account for the possibility that the pace of technological change might be higher in certain industries (e.g., information technology, etc.) and low in others (e.g., pulp and paper, etc.). [19] We also include year fixed-effect variables to account for the fact that the survey year in some nations might be associated with some other event – e.g., significant natural disaster, an election year, etc. This consideration addresses the different survey years across nations noted in the Appendix.

Furthermore, Table 4 provides a robustness check of Table 3 results by also including country fixed-effects variables. The introduction of country dummies enables us to account for country-specific factors (e.g., whether a land-locked nation, etc.) that might have an impact the innovation-employment nexus. The results section follows.

4 Results

4.1 R&D, process innovation, and employment growth

The baseline results are in Table 3. The overall fit of both models is decent, as shown by the statistically-significant F-values. The relatively low R^2s are generally in line with what is found in studies with micro-data that have wide variations in survey responses such as we have here for annualized employment growth at the firm level.

The results summarized in the table show that both process innovation and R&D are associated with stronger firm performance as measured by employment growth. Both variables are consistently statistically significant across all six models presented.[20] These findings are in line with the classical compensation theory (Vivarelli (2007)), whereby, through different compensation mechanisms, innovation spurs employment growth. Moreover, the estimated impact of each conduct indicator on employment growth is quite similar and economically meaningful. For example, the results indicate that

[19] *Specifically, based on the number of observations for each industry in the data set and our own judgment of industry groupings that made sense, we included fixed-effect variables for the following eight industry classifications in our models: food, beverages, and tobacco; textiles, weaving, and tanning; wood and paper; chemicals; rubber/plastics; basic metals and fabricated metals; other non-metallic; machinery and electrical machinery; motor vehicles and other transport; and furniture. "All other" industry classifications became the omitted category in our analysis.*

[20] *Tying to the theoretical model above, the empirical findings support a positive sign on* $(\partial(d(L)/L)/\partial(a\text{-}c))$ *and* $(\partial(d(L)/L)/\partial x)$*, respectively.*

firms that introduced a new or improved process innovation in the past three years enjoyed 2.0% higher annual employment growth over that period, other things equal, a figure that is quite substantial given that the average annual employment growth for all firms in our data set was 3.1% (see Table 1). The estimated impact is very similar for firms that allocated resources to R&D initiatives. In a political economy context, these findings suggest that politicians looking to garner votes via employment generation may want to more enthusiastically support R&D and innovation promoting initiatives. The significant impact of process innovation supports earlier findings for Germany (Lachenmaier and Rottmann (2011)), but is in contrast to studies using the same underlying data, albeit with limited scope and with a somewhat different emphasis (Cirera and Sabetti (2019)). Further, with respect to the positive employment effect of R&D, the findings are in line with those of Piva and Vivarelli (2018). In particular, the authors use data for 11 European nations over 1998-2011 and find a significant labor-friendly impact of R&D expenditures. However, this positive impact is sensitive to the tech-intensity of the underlying sectors where firms operate. These positive employment effects of innovation are also supported with Italian data by Barbieri et al. (2019). Baffour et al. (2020) find that the type of innovation (i.e., product innovation or process innovation) might matter, especially for Ghanaian firms that they consider. We address this issue further in Section 2.4 below.

Other results show that firms' characteristics, including size and age or vintage, have opposite effects on employment. Older firms and larger firms, ceteris paribus, exhibited lower employment growth.[21] Even when innovating or conducting R&D, larger and older firms might be somewhat lethargic in decision making or locked into long term employment/union contracts that might limit their abilities to boost employment.

The threat of informal market competition resulted in lower employment growth (Models 2.3 and 2.6). This result is consistent with the argument that the informal sector undermines employment via crowding-out (i.e., via greater competition of resources) and lower expected returns. For both models, the results indicate that firms that viewed the practices of competitors in the informal sector as either a major or a severe obstacle to current operations of their establishment faced a 1.0% lower annual employment growth over that period, other things equal. Whereas the literature has considered various causes and effects of informal markets (see Schneider (2012), Schneider and Enste (2000)), the insight about how the informal competition might impact the innovation-employment relation appears novel.

Firms with more experienced managers, somewhat paradoxically, experienced lower employment growth. It could be the case that experienced managers were less receptive to suggestions and less agile, making them less likely to act on performance-improving initiatives or suggestions. On the other hand, the planning horizons/discount rates of experienced managers might differ from less experienced managers. As an alternative consideration of management and focusing on gender aspects, when an account is taken of firms with top managers being female (Models 2.2 and 2.5), a negative impact on

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[21] Recall firm size is measured in natural logs. The finding about the impact of firm size can be seen as consistent with Beck et al. (2005) where, using a sample of 54 nations, they find that small firms benefit the most from financial and institutional developments.

As an alternative test of the firm size dimensions, we re-estimated the baseline models in Table 3 all firms (large and small) and the main results about the positive employment effects of R&D and innovation remained robust. An abridged version of Table 3 is produced in the Appendix B as Table 3A. Additional details are available upon request.

employment growth is found. This is consistent with greater challenges faced by female managers in recruiting new workers, due partly to a relative lack of networking (see Dohse et al. (2019)).

With respect to the three ownership dimensions, sole proprietors experience lower employment growth, while foreign-owned and firms with partial government ownership had higher employment growth. The latter effect may be due to greater stability and resources firms with such ownership structure made recruiting workers easier for them.[22] Furthermore, firms with significant government ownership might not necessarily have profit-maximization as their overriding objective, and likely situated in mixed markets with different competitive implications (see, for example, Haruna and Goel (2015)).

As expected, employment grew in nations experiencing higher economic growth, whereas the general index of economic freedom (EF) failed to show statistically significant results. In other words, firms in faster-growing nations are inclined to hire more workers, but this is not necessarily the case in more economically free nations. Finally, both year – and industry dummies, each viewed collectively, are statistically significant. The industry dummies account for industry differences that might be crucial in ascertaining the substitution-complementarity between R&D and other inputs, as has been found for the United States (Goel (1990a)).

Overall, the baseline results support the employment-enhancing aspects of R&D and process innovation noted in Hypotheses H1 and H2. Having discussed the baseline results, we turn a robustness check by including country dummies.

4.2 R&D, process innovation, and employment growth: Robustness analysis with panel data and country fixed-effects

Eighteen countries in the dataset had observations for multiple years as the surveys were conducted more than once in these cases.[23] To make use of this additional information and to address concerns of unobserved heterogeneity among we performed a panel data analysis with country fixed effects as a robustness check of our earlier findings. The corresponding results are presented in Table 4 (replicating the basic format of Table 3).

The main results are again supported. Notably, consistent with capital-saving research and innovation, both R&D and INNOVATION have a positive impact on performance or employment growth. Thus, the main findings with regard to the (positive) impact of R&D and process innovation on employment growth hold when time-series data for available nations are used.[24] With the exception of the government ownership variable, the results for most of the other firm-level control variables are qualitatively quite similar to what was reported earlier.[25]

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[22] *In a theoretical model, Goel (2004) has shown that the research spending by nonprofit enterprises exceeds the profit-maximizing levels.*

[23] *These countries include Argentina, Bolivia, Chile, Columbia, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Guatemala, Honduras, Mexico, Myanmar, Panama, Paraguay, Peru, Uruguay, and Zimbabwe.*

[24] *This robustness of the impact of process innovation is noteworthy, given that studies using similar data in a more limited fashion did not find a significant impact of process innovation on employment (Cirera and Sabetti (2019)).*

[25] *One plausible explanation for the lack of significance of the GOVTown variable might be that profit-maximization is not the prime objective of firms with significant government ownership and hence they are relatively less*

4.3 Robustness check: Using robust regression

The baseline results in Table 3 are based on OLS regression, which could be sensitive to outlying observations. A small set of nations or firms in the sample with abnormally high (low) innovation or employment growth might be driving the results. To address this aspect and as a robustness check, we employed robust regression to all the models in Table 3. We follow STATA's rreg command which drops any observation with Cook's distance is greater than one and then uses Huber weighting of the residuals.

The findings with respect to the main variables of interest (i.e., INNOVATION in Models 2.1-2.3, and R&D in Models 2.4-2.6, respectively) remained robust – both process innovation and R&D positively and significantly impacted employment growth. Complete details are available upon request.[26]

4.4 Additional consideration: Considering product innovation

Product innovation might occur equally frequently (or even more frequently) than process innovation, although process innovation might be less frequently patented (and hence less observable). Accordingly, we considered the influence of product innovations to their employment impacts. The correlation between product and process innovation in our sample was 0.16, signifying that most firms in are sample were not undertaking these two innovations simultaneously. Some scholars, more recently Avenyo et al. (2019), have considered the role of product innovation and their impact on employment. Baffour et al. (2020), using Ghanaian data, find that the positive employment effect of innovation is sensitive to whether process or innovation is considered.

Employing product innovation (whether the firm introduced a new product/service to the market) as the main explanatory variable in place of process innovation, we reran the baseline Models 2.1-2.3 from Table 3. The sample size in these models shrunk to about 18,000 observations. The resulting coefficient on the product innovation variable was positive but statistically insignificant in all cases.[27] Thus, employment growth in firms introducing product innovation was no different from other firms, at least based on the relatively limited sample of data we had to work with. These findings contrast with those on the sub-sample of firms in sub-Saharan Africa, where a positive impact of product innovation on employment was found (Avenyo et al. (2019)). Furthermore, when both process and product innovations were considered together as explanatory variables, the impact of process innovation was quite similar to what is reported in Table 3 and that of product innovation remained insignificant.

4.5 R&D, process innovation, and employment growth: Growing versus contracting firms

It is quite possible the employment of growing and contracting firms is different in response to research and innovation. This is especially relevant given the forward-looking nature of innovation. To address this aspect, we split the sample between growth (positive employment growth) and shrinking (negative

responsive to market conditions, with the result that their employment does not significantly grow over time even when innovating or conducting R&D.

[26] *We also tried a Huber M-estimator which yielded very similar results (Verardi and Croux (2009)).*

[27] *Additional details are available upon request.*

employment growth) firms.[28] Do growing and contracting firms respond similarly (in terms of employment growth) to R&D and innovation?

The subsample of contracting firms was less than half that of growing firms. The corresponding estimation results, following the general format of Tables 3 and 4, are in Table 5 (with Tables 5a and 5b, respectively, considering the impact of INNOVATION and R&D).

Turning first to the impact of innovation in Table 5a, we see that both growing and contracting firms that introduced a process innovation experienced positive employment growth. Interestingly, and as one would expect, the magnitude of the impact of innovation is larger in growing firms than in contracting firms.

Employment growth in larger firms and sole proprietorships was lower, with again some differences in the magnitudes between growing and shrinking firms. On the other hand, the negative employment growth in older firms was experienced by both growing and shrinking firms. Employment growth was lower in female managed growing firms, but not necessarily in shrinking firms. These negative impacts on growing firms were countered somewhat by foreign-owned firms. On the other hand, the negative effects of the informal sector competition were felt by shrinking firms only. This may be due to a relative lack of resources with shrinking firms to devote to fighting informal sector competition.

Finally, firms with partial government ownership boosted employment in both cases (although the evidence is statistically weaker for shrinking firms in Model 2.3), while greater economic freedom (EF) benefitted shrinking firms, and GDP growth had no significant impact. Thus, while less government intrusion the economy did not significantly impact employment growth in the full sample in Table 3, shrinking firms in nations with greater economic freedom see positive impacts on employment growth. This finding is potentially useful for policy formulation.

Turning to the effects of R&D in Table 5b, we see that, contrary to Tables 3 and 4, R&D boosts employment growth only in growing firms and has no impact on shrinking firms. Given that our measure of R&D captures research participation rather than research intensity (see Table 1), it could be the case that R&D in shrinking firms might be quite minimal – e.g., maintain research facilities, rather than pursuing new inventions. The findings for the other determinants are like those in Table 5a.

Overall, splitting the sample between growth and shrinking firms provides some new insights, both in terms of the effectiveness of the drivers of employment growth and their magnitudes. Most significantly, we see that growing and shrinking firms do not uniformly benefit from R&D and innovation. In fact, employment growth in shrinking firms does not benefit from R&D. This novel finding has important policy implications – firms in distress need more direct measures than R&D subsidies to boost employment.

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[28] *Approximately one-third of the firms in our sample reported no change in employment over the period analyzed and hence are excluded from the data set used in this subsection.*

4.6 Impact of R&D and process innovation across the prevalence of employment growth: Quantile regression

As an alternative to the focus on growing and shirking firms, we employed the quantile regression (see Koenker and Hallock (2001) for details) to see whether the impact of process innovation on employment growth differed across the prevalence of employment growth across nations in the sample. It is possible that firms with employment growth rates at the tails of the distribution (i.e., with very high or low employment growth rates) respond differently to innovation than other firms (i.e., firms closer to the median in terms of employment growth rates). The use of quantile regression also enables us to address possible nonlinearities in the relation between innovation and employment (see Hatzikian (2015)). To conserve space, the findings of this exercise are only briefly summarized here.

Using the 25th and 75th quantiles, we found the impact of both R&D and process innovation activity to be positive and statistically significant in both cases. However, the magnitude of the estimated coefficients on both was much larger at the 75th quantile. In particular, R&D activity was associated with 0.4% employment growth at the 25th quantile while it was estimated to be 1.9% at the 75th. The corresponding figures for the introduction of process innovations were 0.3% and 1.9%, respectively. In other words, process innovation and R&D had more pronounced employment growth effects in nations with a higher employment growth. These findings can be seen qualitatively supporting what was reported in Tables 5a and 5b. A plausible explanation for the higher impact of innovation in nations with higher employment growth is that higher employment growth rates are better able to exploit synergies and demands of new innovation (compared to when employment is stagnant of not growing very rapidly). The concluding section follows.

5 Conclusions

Contributing to the empirical literature on the economic effects of innovation, this paper studies the impact of process innovation introductions and R&D activity on firms' employment, focusing on small and medium-sized firm-level data drawn for 125 mostly-emerging nations. The diversity in innovation in small enterprises has been noted in the studies of individual nations (Forsman (2011)).

The consideration of firms in these size categories, the focus on process innovations and R&D expenditures, the large sample of firms and nations, the consideration of the influence of the informal sector in innovation-employment growth nexus, and comparison of growing and contracting firms are the main contributions to the related literature. Small and medium-sized firms are generally viewed as consumers/imitators/followers of technologies produced by other firms and this study provides insights into their innovative behaviors and their impacts. The extant literature has generally found some evidence of a linkage from innovation/R&D to employment (generally positive), this association is shown to be sensitive to innovation type (Baffour et al. (2020)) and industry/sector type. In this paper we control for these aspects in our analysis and ground our empirics through the introduction of a short formal theoretical on firm R&D expenditure. Finally, while the consideration of employment effects of innovation or R&D is not entirely new in the literature, with studies considering data from individual nations (Baffour et al. (2020), Barbieri et al. (2019), Lachenmaier and Rottmann (2011)), or a handful of nations Piva and Vivarelli (2018), this appears to be the first study considering a large sample of more than 100 nations in this context.

Regarding the first question posed at the Introduction of this paper and drawing on a basic theoretical model to set up the empirical analysis, results show that both innovation and R&D enhanced firms' employment. These results are consistent with technical change being capital-saving and labor-using rather than the other way around and reinforce what one would expect in capital-scarce, labor-abundant emerging nations that are mostly represented in this study. The results also support the traditional compensation theory linking innovation and employment (Vivarelli (2007)). Furthermore, in terms of magnitude, the estimated impact of each conduct indicator (i.e., R&D and innovation) on employment growth is quite similar and economically meaningful. In contrast, single nation studies on the impact of process innovation on employment find mixed results, with some finding complementarity (e.g., Lachenmaier and Rottmann (2011) for Germany; Baffour et al. (2020) for Ghana, Barbieri et al. (2019) for Italy) and others no effect (e.g., Benavente and Lauterbach (2008 for Chile), Cirera and Sabetti (2019)).

In regard to the second question raised in the Introduction, we found that a greater perceived threat of informal market competition by a firm manager/owner of contracting firms was associated with lower employment growth by that firm, other factors held constant. This result is consistent with the argument that the presence of informal markets undermines employment in the formal sector via crowding-out and lower expected returns, even in the presence of innovation in the formal sector. This revelation is new to the literature.

In other findings, sole proprietorships, larger firms, and those with relatively less experienced managers and operating in faster-growing economies experienced higher employment growth. Foreign-owned firms and government-owned firms had higher employment growth. On the other hand, older firms had lower employment, but firms with partial government ownership had higher employment, with greater economic freedom showing no influence. However, the threat of informal sector competition undermined growth. Finally, when product innovation was considered, they did not show any appreciable growth effects, although some caution should be exercised regarding this conclusion given the relatively limited data we had regarding such activity.

Upon splitting the sample into growing and contracting firms we see that contracting firms benefit from innovation but not from R&D. Older contracting firms tended to be able to mitigate employment loss, while the opposite is true for older growing firms. These results were qualitatively similar to those with a quantile regression. Thus, with regard to the third question posed in the Introduction ("Are there differences in the impact of R&D and innovation in the performance by growing and contracting firms?"), we find some differences in the impact of R&D and innovation on growing versus contracting firms' employment. Specifically, R&D fails to affect employment growth in shrinking firms. Finally, the macroeconomic impact of greater economic freedom, which failing to have an overall significant influence, positively affected employment growth (slowed employment losses) in shrinking firms. However, such growth in shrinking firms is undermined by the presence of informal sector competition.

Several implications for policy could be noted from our results. First, depending upon the metric considered, the case for government support/subsidy for a given factor could vary. For example, foreign-owned firms have higher employment growth and such firms might not qualify for subsidies Second, given the positive influences of process innovation and R&D, a case for R&D subsidies could be made to boost firms' employment. Third, partially owned government enterprises, in contrast to perceptions, do not necessarily have lower employment growth. Fourth, some policy initiatives might be especially directed to bolster the employment of declining firms. In this respect the positive effects of greater economic freedom on employment growth in shrinking firms are noteworthy. Fifth, the threat of the informal sector and its negative impacts on employment growth add another dimension (besides increasing tax collections) to the need for controlling the underground sector. Sixth, employment-generation policies in emerging nations should consider the positive impact of process innovation over those of product innovation. Finally, policies based on firm size should be cognizant of differences, even within the subset of small and medium-sized firms.

In closing, we try to put our analysis in a broader perspective. While the findings shed some new light on an important area, we are unable to control for some elements of the research process, like market structure (see Cohen and Levin (1989)), research spillovers (see Griliches (1992)), the magnitude of firm-level R&D spending, etc. that might be relevant. It would also be instructive to do a comparison of the relative influences of product and process innovations (see Karabulut (2015), Mantovani (2006), Polder et al. (2010) for studies that focus on both process and product innovations). With appropriate data, future studies could consider these additional dimensions.

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TABLES

Table 1: Variable definitions, summary statistics and data sources

Variable	Mean (standard deviation)	Source
Average annual growth rate in the number of permanent, full-time individuals that worked in the establishment relative to two years prior, [*EMPgr*]	0.031 (0.135)	[1]
Establishment introduced a new or improved process in last three years, (1=yes, 0=no), [*INNOVATION*]	0.396 (0.489)	[1]
Establishment spent on R&D (excl. market research) during last fiscal year, (1=yes, 0=no), [*R&D*]	0.180 (0.384)	[1]
Informal Sector: "To what degree are practices of competitors in the Informal Sector an obstacle to the current operations of this establishment?" (major or severe obstacle: 1=yes, 0=no), [*Informal*]	0.264 (0.441)	[1]
Top manager is female, (1=yes, 0=no), [*female_manager*]	0.157 (0.364)	[1]
Age of the establishment (years), [*FIRMage*]	21.018 (13.071)	[1]
Establishment size category measured by full-time equivalent workers at the beginning of period under analysis (in logs), [*FIRMsize*]	2.721 (0.926)	[1]
Establishment legal status is sole proprietorship, (1=yes, 0=no), [*SOLEprop*]	0.400 (0.490)	[1]
Top manager's years of experience in working in sector, [*MANexp*]	17.878 (11.031)	[1]
Ten percent or more of firm owned by private foreign individuals, companies or organizations, (1=yes, 0=no), [*FOREIGNown*]	0.064 (0.245)	[1]
Ten percent or more of firm owned by the government/state, (1=yes, 0=no), [*GOVTown*]	0.010 (0.101)	[1]
Average annual growth rate in GDP per capita in PPP, (constant 2011 international $), over preceding three years, [*GDPgr*]	0.032 (0.027)	[2]
Economic Freedom Index, (0 – 100, higher values imply more freedom), [*EF*]	57.287 (7.755)	[3]

Notes: Statistics pertain to observations used in the first model that the variable appears.

Sources:
[1]. Enterprise Surveys (http://www.enterprisesurveys.org), The World Bank. Data were taken for all available years between 2006 and 2018 were the survey was conducted the Enterprise Surveys Global Methodology (accessed August 2018). The list of countries included in the data set and survey years can be found in the Appendix.
[2]. World Development Indicators, The World Bank (accessed June 2019).
[3]. Heritage Foundation Index of Economic Freedom, overall score. http://www.heritage.org/index/explore?view=by-region-country-year (accessed January 2018).

Table 2: Correlation matrix of key variables

	Employment Growth [*EMPgr*]	Process Innovation [*INNOVATION*]	Research and Development [*R&D*]
Employment Growth [*EMPgr*]	1.0		
Process Innovation [*INNOVATION*]	0.065 (0.00)	1.0	
Research and Development [*R&D*]	0.054 (0.00)	0.359 (0.00)	1.0

Notes: Pairwise correlation statistics based on maximum available in data set. p-values in parentheses. Observations: 58,922.

Table 3: Employment effects of R&D and process innovation: Baseline models (Dependent variable: *EMPgr*)

Model →	[2.1]	[2.2]	[2.3]	[2.4]	[2.5]	[2.6]
Process innovation [*INNOVATION*]	**0.019**** (**7.2**)	**0.019**** (**7.2**)	**0.019**** (**7.2**)			
Research & dev. [*R&D*]				**0.023**** (**4.2**)	**0.023**** (**4.3**)	**0.023**** (**4.1**)
			Other firm-level control variables			
Firm size [*FIRMsize*]	-0.040** (7.1)	-0.040** (6.9)	-0.040** (7.1)	-0.040** (7.0)	-0.040** (6.8)	-0.040** (6.9)
Firm age [*FIRMage*]	-0.001** (5.3)	-0.001** (6.3)	-0.001** (5.9)	-0.001** (5.3)	-0.001** (6.4)	-0.001** (6.0)
Legal status [*SOLEprop*]	-0.010** (2.7)	-0.010** (2.6)	-0.010** (2.5)	-0.009** (2.5)	-0.009** (2.4)	-0.008** (2.3)
Managerial experience [*MANexp*]	-0.000** (5.1)			-0.000** (5.0)		
Top manager female [*female_manager*]		-0.014** (4.6)			-0.014** (4.6)	
Informal sector obstacle [*Informal*]			-0.010** (4.5)			-0.010** (4.0)
Foreign owner [*FOREIGNown*]	0.024** (6.5)	0.024** (6.5)	0.025** (6.8)	0.024** (6.7)	0.024** (6.7)	0.026** (6.9)
Government owner [*GOVTown*]	0.037** (3.2)	0.037** (3.4)	0.037** (3.4)	0.037** (3.2)	0.038** (3.4)	0.037** (3.3)
			Country-level control variables			
GDP per capita growth [*GDPgr*]	0.257** (2.3)	0.271** (2.5)	0.257** (2.4)	0.252** (2.3)	0.266** (2.4)	0.252** (2.3)
Economic freedom [*EF*]	0.001 (1.4)	0.001 (1.5)	0.001 (1.3)	0.001 (1.3)	0.001 (1.5)	0.001 (1.3)
			Time and industry fixed effects (F-statistic)			
Survey year fixed effects (p-value)	3.98 (0.00)	3.03 (0.00)	3.97 (0.00)	4.24 (0.00)	2.97 (0.00)	4.19 (0.00)
Industry fixed effects (p-value)	3.31 (0.00)	3.10 (0.00)	2.98 (0.00)	3.59 (0.00)	3.34 (0.00)	3.24 (0.00)
			Model summary statistics			
F-statistic	25.4**	22.6**	22.1**	26.3**	24.8**	22.8**
R-squared	0.09	0.09	0.09	0.09	0.09	0.09
Root MSE	0.128	0.128	0.128	0.129	0.128	0.129
Observations	52,049	51,534	49,687	52,437	51,917	50,038

Notes: Variable definitions are provided in Table 1. All models included a constant term (not reported). The numbers in parentheses are t-statistics based on country-level clustered standard errors. * denotes statistical significance at the 10% level, and ** denotes significance at the 5% level (or better).

Table 4: Employment effects of R&D and process innovation: Robustness analysis with panel data and country fixed-effects (Dependent variable: *EMPgr*)

Model →	[2.1b]	[2.2b]	[2.3b]	[2.4b]	[2.5b]	[2.6b]
Process innovation [*INNOVATION*]	**0.018**** **(7.3)**	**0.017**** **(6.6)**	**0.019**** **(7.6)**			
Research & dev. [*R&D*]				**0.031**** **(9.6)**	**0.030**** **(9.3)**	**0.031**** **(9.6)**
	Other firm-level control variables					
Firm size [*FIRMsize*]	-0.040** (25.8)	-0.038** (24.7)	-0.041** (25.6)	-0.041** (26.1)	-0.039** (25.00)	-0.042** (25.9)
Firm age [*FIRMage*]	-0.001** (6.0)	-0.001** (7.7)	-0.001** (7.7)	-0.001** (6.0)	-0.001** (7.7)	-0.001** (7.7)
Legal status [*SOLEprop*]	-0.024** (8.2)	-0.022** (7.5)	-0.024** (7.9)	-0.023** (8.0)	-0.022** (7.4)	-0.023** (7.7)
Managerial experience [*MANexp*]	-0.001** (4.7)			-0.000** (4.7)		
Top manager female [*female_manager*]		-0.008** (2.6)			-0.007** (2.4)	
Informal sector obstacle [*Informal*]			-0.010** (3.9)			-0.009** (3.7)
Foreign owner [*FOREIGNown*]	0.030** (4.9)	0.030** (4.9)	0.033** (5.3)	0.030** (5.0)	0.030** (4.9)	0.033** (5.3)
Government owner [*GOVTown*]	0.019 (0.9)	0.018 (0.9)	0.019 (0.8)	0.020 (1.0)	0.019 (0.9)	0.018 (0.8)
	Country-level control variables					
GDP per capita growth [*GDPgr*]	1.167** (5.8)	1.465** (6.3)	1.166** (5.7)	1.142** (5.7)	1.453** (6.3)	1.132** (5.6)
Economic freedom [*EF*]	0.000 (0.2)	-0.001 (0.3)	0.000 (0.1)	0.000 (0.2)	-0.001 (0.4)	0.000 (0.1)
	Time and industry fixed effects (F-statistic)					
Survey year fixed effects (p-value)	17.11 (0.00)	18.45 (0.00)	16.73 (0.00)	16.07 (0.00)	17.13 (0.00)	15.63 (0.00)
Industry fixed effects (p-value)	7.81 (0.00)	8.24 (0.00)	8.91 (0.00)	6.53 (0.00)	6.98 (0.00)	7.45 (0.00)
Country fixed effects (p-value)	18.95 (0.00)	18.71 (0.00)	18.34 (0.00)	18.86 (0.00)	18.70 (0.00)	18.18 (0.00)
	Model summary statistics					
F-statistic	44.2**	42.3**	40.8**	45.1**	43.1**	41.7**
R-squared	0.14	0.14	0.14	0.15	0.14	0.15
Root MSE	0.132	0.135	0.132	0.132	0.130	0.132
Observations	14,253	13,786	13,435	14,289	13,822	13,466

Notes: See Table 3.

Table 5a: Employment effects of process innovation: Growing versus shrinking firms (Dependent variable: *EMPgr*)

Model →	[5a.1]		[5a.2]		[5a.3]	
	Shrinking	Growing	Shrinking	Growing	Shrinking	Growing
Process innovation [*INNOVATION*]	**0.005***	**0.013****	**0.005***	**0.012****	**0.006****	**0.013****
	(1.9)	**(5.2)**	**(1.9)**	**(5.0)**	**(2.2)**	**(5.2)**
			Other firm-level control variables			
Firm size [*FIRMsize*]	-0.004*	-0.053**	-0.004*	-0.053**	-0.005**	-0.053**
	(1.9)	(9.1)	(1.7)	(8.9)	(2.2)	(9.0)
Firm age [*FIRMage*]	0.000**	-0.000**	0.000**	-0.000**	0.000**	-0.000**
	(2.2)	(2.4)	(2.1)	(2.3)	(2.6)	(2.3)
Legal status [*SOLE*prop]	-0.009**	-0.015**	-0.008**	-0.015**	-0.009**	-0.015**
	(3.0)	(3.8)	(2.9)	(3.7)	(3.0)	(3.7)
Managerial experience [*MANexp*]	-0.000	0.000	-0.000	0.000	-0.000	0.000
	(0.5)	(0.0)	(0.5)	(0.0)	(0.0)	(0.1)
Top manager female [*female_manager*]			-0.003	-0.010**		
			(0.9)	(2.7)		
Informal sector obstacle [*Informal*]					-0.010**	0.002
					(3.7)	(1.0)
Foreign owner [*FOREIGNown*]	0.004	0.024**	0.004	0.024**	0.005	0.024**
	(0.7)	(5.0)	(0.7)	(4.9)	(0.9)	(5.1)
Government owner [*GOVTown*]	0.020*	0.049**	0.020*	0.049**	0.017	0.049**
	(1.8)	(2.1)	(1.9)	(2.0)	(1.5)	(2.1)
			Country-level control variables			
GDP per capita growth [*GDPgr*]	0.132	-0.148	0.130	-0.142	0.117	-0.139
	(1.4)	(1.3)	(1.4)	(1.3)	(1.2)	(1.3)
Economic freedom [*EF*]	0.001**	-0.001	0.001**	-0.001	0.001**	-0.001
	(2.9)	(1.5)	(3.0)	(1.3)	(2.7)	(1.4)
			Time and industry fixed effects (F-statistic)			
Survey year fixed effects	7.46	3.85	7.24	2.82	7.10	3.49
(p-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Industry fixed effects	3.40	3.51	3.09	3.11	3.25	3.37
(p-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
			Model summary statistics			
F-statistic	11.5**	42.0**	11.5**	36.0**	10.6**	43.0**
R-squared	0.03	0.18	0.03	0.17	0.03	0.17
Root MSE	0.105	0.117	0.105	0.117	0.105	0.118
Observations	10,288	22,399	10,189	22,107	9,785	21,459

Notes: See Table 3.

Table 5b: Employment effects of R&D: Growing versus shrinking firms (Dependent variable: *EMPgr*)

Model →	[5b.1]		[5b.2]		[5b.3]	
	Shrinking	Growing	Shrinking	Growing	Shrinking	Growing
Research & dev. [*R&D*]	**0.001** **(0.2)**	**0.021**** **(5.1)**	**0.001** **(0.2)**	**0.021**** **(5.1)**	**0.002** **(0.4)**	**0.020**** **(5.0)**
			Other firm-level control variables			
Firm size [*FIRMsize*]	-0.004* (1.8)	-0.054** (9.0)	-0.004 (1.6)	-0.054** (8.8)	-0.005** (2.1)	-0.054** (9.0)
Firm age [*FIRMage*]	0.000** (2.3)	-0.000** (2.5)	0.000** (2.2)	-0.000** (2.4)	0.000** (2.7)	-0.000** (2.3)
Legal status [*SOLEprop*]	-0.008** (2.9)	-0.014** (3.7)	-0.008** (2.8)	-0.014** (3.7)	-0.008** (2.8)	-0.014** (3.7)
Managerial experience [*MANexp*]	-0.000 (0.5)	0.000 (0.0)	-0.000 (0.4)	0.000 (0.0)	-0.000 (0.1)	0.000 (0.1)
Top manager female [*female_manager*]			-0.003 (0.9)	-0.010** (2.7)		
Informal sector obstacle [*Informal*]					-0.010** (3.6)	0.002 (1.2)
Foreign owner [*FOREIGNown*]	0.004 (0.7)	0.024** (5.0)	0.003 (0.7)	0.023** (4.9)	0.005 (0.9)	0.024** (5.0)
Government owner [*GOVTown*]	0.022** (2.0)	0.049** (2.1)	0.022** (2.1)	0.048** (2.1)	0.017 (1.5)	0.049** (2.2)
			Country-level control variables			
GDP per capita growth [*GDPgr*]	0.140 (1.5)	-0.149 (1.4)	0.138 (1.5)	-0.142 (1.3)	0.126 (1.3)	-0.139 (1.3)
Economic freedom [*EF*]	0.001** (2.9)	-0.001 (1.5)	0.001** (3.0)	-0.001 (1.4)	0.001** (2.7)	-0.001 (1.4)
			Time and industry fixed effects (F-statistic)			
Survey year fixed effects (p-value)	7.81 (0.00)	3.63 (0.00)	7.57 (0.00)	2.58 (0.01)	7.42 (0.00)	3.29 (0.00)
Industry fixed effects (p-value)	3.35 (0.00)	3.66 (0.00)	3.05 (0.00)	3.26 (0.00)	3.19 (0.00)	3.50 (0.00)
			Model summary statistics			
F-statistic	11.0**	43.9**	10.3**	36.9**	10.4**	46.0**
R-squared	0.03	0.18	0.03	0.18	0.03	0.18
Root MSE	0.105	0.117	0.105	0.117	0.105	0.118
Observations	10,357	22,587	10,257	22,293	9,845	21,639

Notes: See Table 3.

APPENDIX A

Countries in data set

Albania (2007, 2013), Angola (2010), Argentina (2006, 2010, 2017), Armenia (2009, 2013), Azerbaijan (2009, 2013), Bahamas (2010), Bangladesh (2013), Barbados (2010), Belarus (2008, 2013), Belize (2010), Benin (2009, 2016), Bhutan (2009, 2015), Bolivia (2006, 2010, 2017), Bosnia and Herzegovina (2009, 2013), Botswana (2010), Brazil (2009), Bulgaria (2007, 2009, 2013), Burkina Faso (2009), Burundi (2014), Cambodia (2016), Cameroon (2009, 2016), Cape Verde (2009), Central African Republic (2011), Chad (2009, 2018), Chile (2006, 2010), China (2012), Colombia (2006, 2010, 2017), Costa Rica (2010), Croatia (2007, 2013), Czech Republic (2009, 2013), Côte d'Ivoire (2009, 2016), Democratic Republic of Congo (2010, 2013), Dominica (2010), Dominican Republic (2010, 2016), Ecuador (2006, 2010, 2017), Egypt (2013, 2016), El Salvador (2006, 2010, 2016), Eritrea (2009), Estonia (2009, 2013), Eswatini (2016), Ethiopia (2011, 2015), Fiji (2009), FYR Macedonia (2009, 2013), Gambia (2018), Georgia (2008, 2013), Ghana (2007, 2013), Guatemala (2006, 2010, 2017), Guinea (2016), Guyana (2010), Honduras (2006, 2010, 2016), Hungary (2009, 2013), India (2014), Indonesia (2009, 2015), Israel (2013), Jamaica (2010), Jordan (2013), Kazakhstan (2009, 2013), Kenya (2013), Kyrgyz Republic (2009, 2013), Laos PDR (2009, 2012, 2016), Latvia (2009, 2013), Lebanon (2013), Lesotho (2016), Liberia (2017), Lithuania (2009, 2013), Madagascar (2009, 2013), Malawi (2009, 2014), Malaysia (2015), Mali (2007, 2010, 2016), Mauritania (2014), Mauritius (2009), Mexico (2006, 2010), Micronesia (2009), Moldova (2009, 2013), Mongolia (2009, 2013), Montenegro (2009, 2013), Morocco (2013), Mozambique (2007), Myanmar (2014, 2016), Namibia (2014), Nepal (2009, 2013), Nicaragua (2016), Niger (2009, 2017), Nigeria (2014), Pakistan (2013), Panama (2006, 2010), Papua New Guinea (2015), Paraguay (2006, 2010, 2017), Peru (2006, 2010, 2017), Philippines (2009, 2015), Poland (2009, 2013), Romania (2009, 2013), Russia (2009, 2012), Rwanda (2011), Samoa (2009), Senegal (2007, 2014), Serbia (2009, 2013), Sierra Leone (2017), Slovak Republic (2009, 2013), Slovenia (2009, 2013), Solomon Islands (2015), South Africa (2007), Sri Lanka (2011), St. Lucia (2010), St. Vincent and Grenadines (2010), Suriname (2010), Tajikistan (2008, 2013), Tanzania (2013), Thailand 2016), Timor-Leste (2009, 2015), Togo (2009, 2016), Tonga (2009), Trinidad and Tobago (2010), Tunisia (2013), Turkey (2008, 2013), Uganda (2013), Ukraine (2008, 2013), Uruguay (2006, 2010, 2017), Uzbekistan (2008, 2013), Vanuatu (2009), Venezuela (2010), Vietnam (2009, 2015), Yemen (2010, 2013), Zambia (2007, 2013), Zimbabwe (2011, 2016).

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125 countries in the data set, 69 countries with multiple surveys.

APPENDIX B

Table 3A: Employment effects of R&D and process innovation: Baseline models with all firms, large and small (Dependent variable: *EMPgr*)

Model →	[2A.1]	[2A.2]	[2A.3]	[2A.4]	[2A.5]	[2A.6]
Process innovation [*INNOVATION*]	**0.019** (8.1)**	**0.019** (8.2)**	**0.019** (7.9)**			
Research & dev. [*R&D*]				**0.022** (4.4)**	**0.021** (4.6)**	**0.022** (4.4)**
	Other firm-level control variables - included, but not reported here					
	Country-level control variables - included, but not reported here					
	Time and industry fixed effects- included, but not reported here					
F-statistic	24.3**	20.4**	21.6**	25.2**	21.1**	22.1**
R-squared	0.07	0.06	0.06	0.06	0.06	0.06
Root MSE	0.126	0.126	0.126	0.127	0.126	0.126
Observations	63,916	63,345	60,959	64,423	63,844	61,419

Notes: Variable definitions are provided in Table 1. All models included a constant term (not reported). The numbers in parentheses are t-statistics based on country-level clustered standard errors. * denotes statistical significance at the 10% level, and ** denotes significance at the 5% level (or better).