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REGULAR ARTICLE

Employment effects of R&D and process innovation: evidence from small and medium-sized firms in emerging markets

Rajeev K. Goel[1,2] · Michael A. Nelson[3]

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Abstract
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 process 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

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✉ Michael A. Nelson
nelson2@uakron.edu

Rajeev K. Goel
rkgoel@ilstu.edu

1 Department of Economics, Illinois State University, Normal, IL 61790, USA

2 Innovation and International Competition, Kiel Institute for the World Economy, Kiel, Germany

3 Department of Economics, University of Akron, Akron, OH 44325, USA

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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 saving 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.

Along another channel of influence, employment in innovating firms can increase at the expense of non-innovating firms via a business-stealing effect, whereby the market share of innovating firms increases at the expense of other firms (Dachs et al., 2017; Harrison et al., 2014). Finally, capacity utilization, tied to the demand for labor, might be different in innovating and non-innovating firms (Goel & Nelson, 2021). All this points to the possibility that the employment effects of research and innovation are unclear a priori and likely a matter of empirical investigation of specific regions and industries (also see Dosi et al., 2021).

Broadly speaking, this research can be viewed as examining the impact of firm-level conduct (research and innovation) on the employment of small and medium-sized firms across a data set consisting of mostly emerging markets. Specific contributions on the impact of firm-level structure on employment growth, including size, age, ownership are also addressed. 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

[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).

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 & 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).

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 (Goel, 1990), 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 & 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 stand-alone form (see Cohen & 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]

[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).

[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 explana-

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 technological change have been noted in the literature (Calvino & Virgillito, 2018; Piva & 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, and the empirical model in the next section. This is followed by data and estimation, results, and conclusions.

2 Related literature, 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 & 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 tends to be uncertain/

Footnote 5 (continued)

tory 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.

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; Goel & Ram, 1994 for an early study).

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. (2014), 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 or 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.

Employment in innovating firms can increase at the expense of non-innovating via a business-stealing effect, whereby the market share of innovating firms increases at the expense of other firms. Several factors might influence the prevalence and intensity of the business-stealing effect. For instance, the size and age of firms might matter in dictating how aggressive they are in stealing business from rivals, the type of technological change (embodied or disembodied) and innovation type (product or process innovation), and the type of industry where the firms are located might make a difference (see, for examples, Dosi et al., 2021; Pellegrino et al., 2012, 2019; Piva & Vivarelli, 2018). In our analysis, we control for industry effects, firm characteristics, and consider process and product innovations.

Within the spectrum of this 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 ensure 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).

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

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 & 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 (also see Coad et al., 2016 and Pellegrino et al., 2012). They report a positive impact of process innovation on productivity growth.

The recent growth of digital technologies and computerization has led to automation in many industries and this trend seems to be continuing. Many of these technologies are labor-saving and, at the very least, they shift the capital-labor ratios across different industries. This move toward automation and robotization has been an active area in recent studies (Acemoglu & Restrepo, 2019, 2020; Acemoglu et al., 2020; Borland & Coelli, 2017; Frey & Osborne, 2017; Graetz & Michaels, 2018; Staccioli & Virgillito, 2021; Van Roy et al., 2018). A related aspect, distinguishing across high-, medium-, and low-tech industries in Europe has been considered by Piva and Vivarelli (2018) and the employment effects of technological change have been shown to be sensitive to tech-intensity of industries.

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 & Enste, 2000). Workers in the informal sector can complement or substitute for employment in the formal sector, depending upon whether the informal sector workers are subcontractors or direct competitors. In some cases, labor quality in the informal sector is hard to ascertain as such workers lack official certifications (education degrees or trade licenses). The level of worker education or labor quality also ties to disembodied technical change.

Some authors have been able to consider the distinction between embodied and disembodied technical change (Barbieri et al., 2019; Dosi et al., 2021; Pellegrino et al., 2012, 2019). In general, the results show that the employment effects of technological change (i.e., whether technical change is labor-friendly or not) is dependent on (i) embodied versus disembodied technological change; (ii) the type of sector/industry considered; and (iii) the type of innovation (product or process) considered. At a broader level, the ambiguity in the innovation-employment relation has been

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

noted in surveys of the related literature (see Calvino & Virgillito, 2018; Ugur et al., 2018; Vivarelli, 2007, 2014).

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 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 is the following:

$$\begin{aligned}\text{Employment growth} = {} & f\big(\text{INNOVATION, R\&D, Ownership}_{\text{m}},\ \text{Firm characteristics}_{\text{g}},\\ & \text{Management attributes}_{\text{j}},\ \text{Informal sector (Informal)},\\ & \text{Macroeconomic influences}_{\text{k}}\big)\end{aligned} \tag{1}$$

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.[8] 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.[9] 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 193% 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 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

[8] The employment growth period is constrained by the questions asked in the World Bank Enterprise Surveys instrument that is the primary source of the data used in this analysis.

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

Table 1 Variable definitions, summary statistics and data sources

Variable	Mean (std. dev.)	Maximum value	Minimum value
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)	− 1.134	1.933
Establishment introduced a new or improved process in last three years, (1 = yes, 0 = no), [*INNOVATION*]	0.396 (0.489)	0	1
Establishment spent on R&D (excl. market research) during last fiscal year, (1 = yes, 0 = no), [*R&D*]	0.180 (0.384)	0	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)	0	1
Top manager is female, (1 = yes, 0 = no), [*female_manager*]	0.157 (0.364)	0	1
Age of the establishment (years), [*FIRMage*]	21.018 (13.071)	1	212
Establishment size category measured by full-time equivalent workers at the beginning of period under analysis (in logs), [*FIRMsize*]	2.721 (0.926)	0	4.595
Establishment legal status is sole proprietorship, (1 = yes, 0 = no), [*SOLEprop*]	0.400 (0.490)	0	1
Top manager's years of experience working in sector, [*MANexp*]	17.878 (11.031)	1	72
Ten percent or more of firm owned by private foreign individuals, companies or organizations, (1 = yes, 0 = no), [*FOREIGNown*]	0.064 (0.245)	0	1
Ten percent or more of firm owned by the government/state, (1 = yes, 0 = no), [*GOVTown*]	0.010 (0.101)	0	1
Average annual growth rate in GDP per capita in PPP, (constant 2011 international $), over preceding three years, [*GDPgr*]	0.032 (0.027)	− 0.065	0.122
Economic Freedom Index, (0 – 100, higher values imply more freedom), [*EF*]	57.287 (7.755)	22.1	78.0

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

Sources: All firm-level data: Enterprise Surveys (http://www.enterprisesurveys.org), The World Bank. Data were taken for all available years between 2006 and 2018 where the survey was conducted using the Enterprise Surveys Global Methodology (accessed August 2018). The list of countries included in the data set and survey years can be found in Appendix A

GDP: World Development Indicators, The World Bank (accessed June 2019)

Economic Freedom: 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

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

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.[10,11]

Three dimensions of firms' ownership structure are considered—sole proprietorships (SOLEprop), partially government-owned firms (GOVTown), and foreign-owned firms (FOREIGNown).[12] 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 & Audretsch, 1987a, 1987b; Cohen & 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. Coad et al. (2016), Huego and Jaumandreu (2004), and Pellegrino et al. (2012) consider the impacts of firms' age. Coad et al. (2016) study

[10] Note that, as Table 1 details, the available quantitative measures of R&D and INNOVATION are dichotomous in our dataset.

[11] More generally, in a multi-input production function, the impact of R&D would also depend upon labor's relation with other inputs. Goel (1990) 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.

[12] Firms with 100% government/state ownership were not surveyed by the World Enterprise Surveys, the principal data set used in this analysis (Table 1).

is based on data from Spanish firms, while Pellegrino et al. (2012) use data from Italian firms. Our focus on cross-national data is broader (and also considers some different aspects).

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. Furthermore, the consideration of firm size can be seen as addressing the validity of Gibrat's law, which states that the proportional rate of firm growth is independent of its absolute size.[13]

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. The consideration of managerial experience can be seen as tying to the research on job duration (see Castro Silva & Lima, 2017). 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). Of interest here is understanding if managerial leadership by gender impacts employment growth differences among firms. In our sample, females were top managers in approximately 15% of the firms surveyed.

A somewhat novel angle to the innovation-employment literature is added by including the threat firms perceive from their informal sector competitors (Informal).[14] Informal sector firms might increase the 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 about the future economic environment, 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—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 the variables considered in Eq. (1).

[13] https://en.wikipedia.org/wiki/Gibrat%27s_law.

[14] A survey of the literature on the role of informal markets can be found in Schneider and Enste (2000); also see Goel et al. (2022) and Schneider (2012).

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.[15] Our analysis is restricted to the surveys conducted between the years 2006 and 2018, a period where each survey was conducted using the Enterprise Surveys Global Methodology.[16] 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 (Appendix A).

The Enterprise Surveys website reports that the number of interviews of firms conducted range from 1200 to 1800 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.

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 Eq. (1) in Tables 3, 4, 5 and 6 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

[15] The Enterprise Surveys 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% of nations 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.

[16] http://www.enterprisesurveys.org/methodology.

technological change might be higher in certain industries (e.g., information technology, etc.) and low in others (e.g., pulp and paper, etc.).[17] The impact of innovation on firm growth can vary across sectors, and the industry dummies enable us to take that into consideration (Dalgıç & Fazlıoğlu, 2021).

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 on 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 sets of 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. These findings are in line with the classical compensation theory (Vivarelli, 2007), whereby, through different compensation mechanisms, innovation spurs employment growth. Employment can also grow via a "business-stealing effect" where innovating firms displace the output of non-innovating firms.

Moreover, the estimated impact of each conduct indicator on employment growth is quite similar and economically meaningful. The significant impact of process innovation supports earlier findings for Germany (Lachenmaier & Rottmann, 2011), but is in contrast to studies using the same underlying data, albeit with limited scope and with a somewhat different emphasis (Cirera & 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

[17] 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.

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	0.019***	0.019***	0.019***			
[*INNOVATION*]	(7.2)	(7.2)	(7.2)			
Research & Dev.				0.023****	0.023***	0.023***
[*R&D*]				(4.2)	(4.3)	(4.1)
Other firm-level control variables						
Firm size	– 0.040***	– 0.040***	– 0.040***	– 0.040***	– 0.040***	– 0.040***
[FIRMsize]	(7.1)	(6.9)	(7.1)	(7.0)	(6.8)	(6.9)
Firm age	– 0.001***	– 0.001***	– 0.001***	– 0.001***	– 0.001***	– 0.001***
[*FIRMage*]	(5.3)	(6.3)	(5.9)	(5.3)	(6.4)	(6.0)
Legal status	– 0.010***	– 0.010***	– 0.010**	– 0.009**	– 0.009**	– 0.008**
[*SOLEprop*]	(2.7)	(2.6)	(2.5)	(2.5)	(2.4)	(2.3)
Managerial experience	– 0.000***			– 0.000***		
[*MANexp*]	(5.1)			(5.0)		
Top manager female		– 0.014***			– 0.014***	
[*female_manager*]		(4.6)			(4.6)	
Informal sector obstacle			– 0.010***			– 0.010***
[*Informal*]			(4.5)			(4.0)
Foreign owner	0.024***	0.024***	0.025***	0.024***	0.024***	0.026***
[*FOREIGNown*]	(6.5)	(6.5)	(6.8)	(6.7)	(6.7)	(6.9)
Government owner	0.037***	0.037***	0.037***	0.037***	0.038***	0.037***
[*GOVTown*]	(3.2)	(3.4)	(3.4)	(3.2)	(3.4)	(3.3)
Country-level control variables						
GDP per capita growth	0.257**	0.271**	0.257**	0.252**	0.266**	0.252**
[*GDPgr*]	(2.3)	(2.5)	(2.4)	(2.3)	(2.4)	(2.3)
Economic freedom	0.001	0.001	0.001	0.001	0.001	0.001
[*EF*]	(1.4)	(1.5)	(1.3)	(1.3)	(1.5)	(1.3)
Time and industry fixed effects (F-statistic)						
Survey year fixed effects	3.98	3.03	3.97	4.24	2.97	4.19
(p-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Industry fixed effects	3.31	3.10	2.98	3.59	3.34	3.24
(p-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(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

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, ** 5% level, *** 1% level (or better)

labor-friendly impact of R&D expenditures. However, this positive impact is sensitive to the tech-intensity of the underlying sectors where the firms operate. These positive employment effects of innovation are also supported with Italian

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	0.018***	0.017***	0.019***			
[*INNOVATION*]	(7.3)	(6.6)	(7.6)			
Research & Dev.				0.031***	0.030***	0.031***
[*R&D*]				(9.6)	(9.3)	(9.6)
Other firm-level control variables						
Firm size	– 0.040***	– 0.038***	– 0.041***	– 0.041***	– 0.039***	– 0.042***
[*FIRMsize*]	(25.8)	(24.7)	(25.6)	(26.1)	(25.0)	(25.9)
Firm age	– 0.001***	– 0.001***	– 0.001***	– 0.001***	– 0.001***	– 0.001***
[*FIRMage*]	(6.0)	(7.7)	(7.7)	(6.0)	(7.7)	(7.7)
Legal status	– 0.024***	– 0.022***	– 0.024***	– 0.023***	– 0.022***	– 0.023***
[*SOLEprop*]	(8.2)	(7.5)	(7.9)	(8.0)	(7.4)	(7.7)
Managerial experience	– 0.001***			– 0.000***		
[*MANexp*]	(4.7)			(4.7)		
Top manager female		– 0.008***			– 0.007**	
[*female_manager*]		(2.6)			(2.4)	
Informal sector obstacle			– 0.010***			– 0.009***
[*Informal*]			(3.9)			(3.7)
Foreign owner	0.030***	0.030***	0.033***	0.030****	0.030***	0.033***
[*FOREIGNown*]	(4.9)	(4.9)	(5.3)	(5.0)	(4.9)	(5.3)
Government owner	0.019	0.018	0.019	0.020	0.019	0.018
[*GOVTown*]	(0.9)	(0.9)	(0.8)	(1.0)	(0.9)	(0.8)
Country-level control variables						
GDP per capita growth	1.167***	1.465***	1.166***	1.142***	1.453***	1.132***
[*GDPgr*]	(5.8)	(6.3)	(5.7)	(5.7)	(6.3)	(5.6)
Economic freedom	0.000	-0.001	0.000	0.000	-0.001	0.000
[*EF*]	(0.2)	(0.3)	(0.1)	(0.2)	(0.4)	(0.1)
Time and industry fixed effects (F-statistic)						
Survey year fixed effects	17.11	18.45	16.73	16.07	17.13	15.63
(p-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Industry fixed effects	7.81	8.24	8.91	6.53	6.98	7.45
(p-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Country fixed effects	18.95	18.71	18.34	18.86	18.70	18.18
(p-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(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

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 Sect. 4.4 below.

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

Model→	[5.1]		[5.2]		[5.3]	
	Shrinking	Growing	Shrinking	Growing	Shrinking	Growing
Process innovation [*INNOVATION*]	0.005* (1.9)	0.013*** (5.2)	0.005* (1.9)	0.012*** (5.0)	0.006** (2.2)	0.013*** (5.2)
Other firm-level control variables						
Firm size [*FIRMsize*]	– 0.004* (1.9)	– 0.053*** (9.1)	– 0.004* (1.7)	– 0.053*** (8.9)	– 0.005** (2.2)	– 0.053*** (9.0)
Firm age [*FIRMage*]	0.000** (2.2)	– 0.000** (2.4)	0.000** (2.1)	– 0.000** (2.3)	0.000*** (2.6)	– 0.000** (2.3)
Legal status [*SOLEprop*]	– 0.009*** (3.0)	– 0.015*** (3.8)	– 0.008*** (2.9)	– 0.015*** (3.7)	– 0.009*** (3.0)	– 0.015*** (3.7)
Managerial experience [*MANexp*]	– 0.000 (0.5)	0.000 (0.0)	– 0.000 (0.5)	0.000 (0.0)	– 0.000 (0.0)	0.000 (0.1)
Top manager female [*female_manager*]			– 0.003 (0.9)	– 0.010*** (2.7)		
Informal sector obstacle [*Informal*]					– 0.010*** (3.7)	0.002 (1.0)
Foreign owner [*FOREIGNown*]	0.004 (0.7)	0.024*** (5.0)	0.004 (0.7)	0.024*** (4.9)	0.005 (0.9)	0.024*** (5.1)
Government owner [*GOVTown*]	0.020* (1.8)	0.049** (2.1)	0.020* (1.9)	0.049** (2.0)	0.017 (1.5)	0.049** (2.1)
Country-level control variables						
GDP per capita growth [*GDPgr*]	0.132 (1.4)	– 0.148 (1.3)	0.130 (1.4)	– 0.142 (1.3)	0.117 (1.2)	– 0.139 (1.3)
Economic freedom [*EF*]	0.001*** (2.9)	– 0.001 (1.5)	0.001*** (3.0)	– 0.001 (1.3)	0.001*** (2.7)	– 0.001 (1.4)
Time and industry fixed effects (F-statistic)						
Survey year fixed effects (p-value)	7.46 (0.00)	3.85 (0.00)	7.24 (0.00)	2.82 (0.00)	7.10 (0.00)	3.49 (0.00)
Industry fixed effects (p-value)	3.40 (0.00)	3.51 (0.00)	3.09 (0.00)	3.11 (0.00)	3.25 (0.00)	3.37 (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

See Table 3

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.[18] Even when innovating or conducting R&D,

[18] 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 (also see Falk and Hagsten (2021)). The negative sign on the size variable is consistent with the notion of a lack of scale economies.
As an alternative test of the firm size dimensions, we re-estimated the baseline models in Table 3 for all

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. On the other hand, there may be a technical reason for this—young and small firms likely show higher employment growth rates due to their small bases (also see Pellegrino et al., 2012).

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. Whereas, the literature has considered various causes and effects of informal markets (see Schneider, 2012; Schneider & 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 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; Goel & Nelson, 2020).

With respect to the three ownership dimensions, firms with 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 available to firms with such ownership structures made recruiting workers easier for them.[19] Furthermore, firms with significant government ownership might not necessarily have profit-maximization as their overriding objective, and are likely situated in mixed markets with different competitive implications (see, for example, Haruna & 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, 1990).

Footnote 18 (continued)

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 Appendix B as Table 8. Additional details are available upon request.

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

Overall, the baseline results support the employment-enhancing aspects of R&D and process innovation. 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.[20] To make use of this additional information and to address concerns of unobserved heterogeneity among countries 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.[21,22] 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.[23]

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 possibility, we employed robust regression to all the models

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

[21] 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).

[22] We also considered the influence of product innovations to their employment impacts (see Avenyo et al. 2019, Baffour et al. 2020). 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 resulting coefficient on the product innovation variable was positive but statistically insignificant in all cases. Focusing on firm age by considering young Italian firms, Pellegrino et al. (2012) study the determinants of product innovation. They found that own R&D increased the introduction of product innovation both in mature and young firms. Also see Piva and Vivarelli (2018).

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. Product innovation remained insignificant. Further details are available upon request.

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

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.[24]

4.4 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 (Coad & Rao, 2010).[25] 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 employment growth) firms.[26] 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 Table 3, are in Tables 5 and 6 (with Tables 5 and 6, respectively, considering the impact of INNOVATION and R&D).

Turning first to the impact of innovation in Table 5, 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

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

[25] An interesting related angle is studied recently by Dosi et al. (2021), where the authors examine the employment effects of technological change across sectors. The sectors, in the context of vertical integration, refer to upstream and downstream industries. Their results indicate that whether R&D is labor-friendly depends on the type of sector considered (i.e., upstream or downstream industries); also see Piva and Vivarelli (2018) for a related focus on tech sectors.

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

had no significant impact. Thus, while less government intrusion in 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 6, 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 5.

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.

4.5 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 & Hallock, 2001 for details) to see whether the impact of process innovation on employment growth differed throughout 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 relationship between innovation and employment (see Coad et al., 2016; Hatzikian, 2015). The findings of this exercise are summarized in Table 7.

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 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 5 and 6. 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 or not growing very rapidly). The concluding section follows.

Table 6 Employment effects of R&D: Growing versus shrinking firms (Dependent variable: *EMPgr*)

Model→	[6.1]		[6.2]		[6.3]	
	Shrinking	Growing	Shrinking	Growing	Shrinking	Growing
Research & Dev.	0.001	0.021***	0.001	0.021***	0.002	0.020***
[*R&D*]	(0.2)	(5.1)	(0.2)	(5.1)	(0.4)	(5.0)
Other firm-level control variables						
Firm size	– 0.004*	– 0.054***	– 0.004	– 0.054***	– 0.005**	– 0.054***
[*FIRMsize*]	(1.8)	(9.0)	(1.6)	(8.8)	(2.1)	(9.0)
Firm age	0.000**	– 0.000**	0.000**	– 0.000**	0.000***	– 0.000**
[*FIRMage*]	(2.3)	(2.5)	(2.2)	(2.4)	(2.7)	(2.3)
Legal status	– 0.008***	– 0.014***	– 0.008***	– 0.014***	– 0.008***	– 0.014***
[*SOLEprop*]	(2.9)	(3.7)	(2.8)	(3.7)	(2.8)	(3.7)
Managerial experience	– 0.000	0.000	– 0.000	0.000	– 0.000	0.000
[*MANexp*]	(0.5)	(0.0)	(0.4)	(0.0)	(0.1)	(0.1)
Top manager female			– 0.003	– 0.010***		
[*female_manager*]			(0.9)	(2.7)		
Informal sector obstacle					– 0.010***	0.002
[*Informal*]					(3.6)	(1.2)
Foreign owner	0.004	0.024***	0.003	0.023***	0.005	0.024***
[*FOREIGNown*]	(0.7)	(5.0)	(0.7)	(4.9)	(0.9)	(5.0)
Government owner	0.022**	0.049**	0.022**	0.048**	0.017	0.049**
[*GOVTown*]	(2.0)	(2.1)	(2.1)	(2.1)	(1.5)	(2.2)
Country-level control variables						
GDP per capita growth	0.140	– 0.149	0.138	– 0.142	0.126	– 0.139
[*GDPgr*]	(1.5)	(1.4)	(1.5)	(1.3)	(1.3)	(1.3)
Economic freedom	0.001***	– 0.001	0.001***	– 0.001	0.001***	– 0.001
[*EF*]	(2.9)	(1.5)	(3.0)	(1.4)	(2.7)	(1.4)
Time and industry fixed effects (F-statistic)						
Survey year fixed effects	7.81	3.63	7.57	2.58	7.42	3.29
(p-value)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
Industry fixed effects	3.35	3.66	3.05	3.26	3.19	3.50
(p-value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(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

See Table 3

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 nations. The diversity in innovation in small enterprises has been noted in the

Table 7 Employment effects of R&D and process innovation: quantile analysis (Dependent variable: *EMPgr*)

Quantile →	q25	q75	q25	q75
Process innovation [*INNOVATION*]	0.003*** (7.6)	0.019*** (14.4)		
Research & Dev. [*R&D*]			0.004**** (7.0)	0.019*** (12.1)
Other firm-level control variables				
Firm size [*FIRMsize*]	– 0.006*** (10.3)	– 0.033*** (6.9)	– 0.006*** (9.7)	– 0.033*** (50.7)
Firm age [*FIRMage*]	– 0.000*** (6.2)	– 0.001*** (15.4)	– 0.000*** (5.8)	– 0.001*** (17.3)
Legal status [*SOLEprop*]	– 0.000 (0.8)	– 0.007*** (4.3)	0.000 (0.0)	– 0.005*** (4.1)
Managerial experience [*MANexp*]	– 0.000*** (5.6)	– 0.001*** (8.4)	– 0.000*** (5.2)	– 0.000*** (7.7)
Foreign owner [*FOREIGNown*]	0.003*** (3.0)	0.020*** (6.9)	0.003*** (3.8)	0.020*** (8.0)
Government owner [*GOVTown*]	0.002 (1.2)	0.016** (2.2)	0.002 (1.2)	0.013** (2.0)
Country-level control variables				
GDP per capita growth [*GDPgr*]	0.162*** (8.4)	0.233*** (8.6)	0.150*** (7.7)	0.228*** (8.7)
Economic freedom [*EF*]	0.000*** (8.1)	0.000*** (2.6)	0.000*** (7.7)	0.000** (2.3)
Model summary statistics				
Pseudo R-squared	0.004	0.057	0.004	0.056
Observations	52,049		52,437	

Variable definitions are provided in Table 1. All models include industry and survey year fixed effects (not reported to conserve space). Absolute values of t-statistics are in parentheses based on bootstrapped standard errors (200 replications). * denotes statistical significance at the 10% level, ** 5% level, *** and 1% level (or better)

studies of individual nations (Forsman, 2011). The analysis of a large sample of small and medium-sized firms operating in primarily emerging markets, the focus on process innovations and R&D expenditures, 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. 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. Finally, while the consideration of employment effects of innovation or R&D is not entirely new in the literature (Baffour et al., 2020; Barbieri et al., 2019; Lachenmaier & Rottmann, 2011; Piva & 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 in the Introduction of this paper, results show that both innovation and R&D enhanced firms' employment. These results are consistent with technical change being capital-saving and labor-using. Another explanation is that innovating firms are able to capture market share from other (non-innovating) firms via a business-stealing effect. 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 regard to the second question raised in the Introduction, we found that a greater perceived threat of informal market competition 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.

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 that R&D fails to affect employment growth in shrinking firms.

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 firm 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 government owned 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. Seventh, in a political economy context, the findings suggest that politicians looking to garner votes via employment generation may want to support more enthusiastically R&D and innovation-promoting initiatives. 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 & Levin, 1989; Goel, 1999; Kamien & Schwartz, 1982), research spillovers (see d'Aspremont & Jacquemin, 1988; Griliches, 1992), the magnitude of firm-level R&D spending, etc. that might be relevant. It would also be instructive to analyze further 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.

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).

125 countries in the data set, 69 countries with multiple surveys (year of survey in parentheses).

Appendix B

See Table 8.

Table 8 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***	0.019***	0.019***			
	(8.1)	(8.2)	(7.9)			
Research & Dev. [*R&D*]				0.022***	0.021***	0.022***
				(4.4)	(4.6)	(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

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, ** 5% level, *** 1% level (or better)

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