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Innovative firms or innovative owners? Determinants of innovation in micro, small, and medium enterprises

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Small, and Medium Enterprises**

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ABSTRACT

Innovative Firms or Innovative Owners? Determinants of Innovation in Micro, Small, and Medium Enterprises*

Innovation is key to technology adoption and creation, and to explaining the vast differences in productivity across and within countries. Despite the central role of the entrepreneur in the innovation process, data limitations have restricted standard analysis of the determinants of innovation to consideration of the role of firm characteristics. We develop a model of innovation which incorporates the role of both owner and firm characteristics, and use this to determine how product, process, marketing and organizational innovations should vary with firm size and competition. We then use a new large representative survey from Sri Lanka to test this model and to examine whether and how owner characteristics matter for innovation. The survey also allows analysis of the incidence of innovation in micro and small firms, which have traditionally been overlooked in the study of innovation, despite these firms comprising the majority of firms in developing countries. More than one quarter of microenterprises are found to be engaging in innovation, with marketing innovations the most common. As predicted by our model, firm size is found to have a stronger positive effect, and competition a stronger negative effect, on process and organizational innovations than on product innovations. Owner ability, personality traits, and ethnicity are found to have a significant and substantial impact on the likelihood of a firm innovating, confirming the importance of the entrepreneur in the innovation process.

JEL Classification: O31, O33, L26

Keywords: innovation, microenterprises, SMEs, development

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1. Introduction

Differences in total factor productivity account for roughly half the differences in income across countries and are generally associated with differences in technological progress (e.g. Hall and Jones, 1999). These differences are also large between firms within a single country (Hsieh and Klenow, 2007). Innovation is a key to technology adoption and creation and studying the determinants of innovation is a crucial first step in understanding how firms catch up to the technology frontier, and for designing policies to enhance growth and development. However, the existing empirical literature on innovation has two main gaps. The first is that data limitations have largely restricted analysis to the role of firm characteristics in innovation, leaving out any role for the characteristics of the firm owner. Given the central role of the entrepreneur in the innovation process, it is important to understand whether firm characteristics alone are sufficient to capture the role of the owner. The second limitation is that existing studies of innovation have not examined innovation in microenterprises and small firms. Such firms account for the overwhelmingly majority of firms in developing countries, and it thus of great interest to see whether and how such firms are innovating.

This paper uses a new representative survey of over 2800 firms in Sri Lanka to empirically examine the determinants of innovation in micro, small, and medium firms. The survey contains detailed measures of innovation, allowing us to consider the four main types of innovation identified by the OECD's Oslo Manual (OECD, 2005): product, process, marketing and organizational innovations. The survey collected detailed information on the socioeconomic background, ability levels and personality traits of the enterprise owner, enabling us to examine the role the owner plays in innovation.

We develop a parsimonious model of firm innovation which combines the idea in Klette and Kortum (2004), where innovation allows firms to produce new products, with that in Cohen and Klepper (1996a), where innovation lowers the unit costs of production. Both firm and owner characteristics are allowed to influence the efficiency of innovation in this model. The model then delivers predictions for the interplay between the different types of innovation, firm size, competition, and firm and owner characteristics, which we can take to the data.

Our data show innovation to be important for micro and small firms, with 26 percent of firms with no employees and 40 percent of firms with 1 to 9 employees engaging in some form of innovation in the last three years. The most common innovations in smaller firms are marketing and product innovations, and for the majority, are only innovations new to the firm, not to the country. The types of innovations reported by firms in our survey are similar to innovations undertaken by firms in developed economies. The most common are related to product design and packaging, pricing, or adoption of new processes through adoption of technology. In accordance with our model, we find firm size to play a larger role in process and organizational innovations than product and marketing innovations. The model also predicts a negative effect of competition on the likelihood of innovating, which is born out in our data. Innovation is positively correlated with exporting and access to finance, in common with other studies in the literature, but is not found to have any relationship to whether or not the firm is formally registered.

We find very strong evidence that the characteristics of the owner do matter for innovation. More educated individuals, those with higher digitspan recalls, and those scoring higher on a raven test are more likely to innovate. Individuals of Tamil ethnicity are much less likely to innovate, which may be explained by the instability in the areas where they reside arising from the civil conflict in Sri Lanka. Owners of more innovative firms are also found to be more optimistic, and have had more prior jobs. The impact of owner characteristics is sizeable, with the predicted probability of innovation in a firm with no employees and typical firm characteristics ranging from 0.08 to 0.58 according to the characteristics of the owner. While owner characteristics have a lower relative impact on the likelihood of innovation in firms with 25 or more employees, the effects are still sizeable. Innovative firms therefore are those with innovative owners.

The findings contribute to the literature on innovation by filling in information on innovation among very small firms which are typically left out of analyses of innovation. Importantly in this regard, we find that process innovation increases with firm size at a steeper rate than product innovation, a finding consistent with Cohen and Kleper (1996). Second, the data also help us identify characteristics of owners associated with microenterprises which are likely to be more dynamic. Individual owner characteristics

are likely to have a particularly important association with innovation in small firms. Given the prevalence of small firms in low income countries, the analysis has important implications for policies aimed at encouraging innovation and entrepreneurship in the low income country context.

2. Data

We use data from the baseline of the Sri Lanka Longitudinal Survey of Enterprises (SLLSE), a survey designed by the authors and collected between January and May 2008.¹ The survey was designed to obtain a representative sample of micro, small and medium enterprises in urban Sri Lanka, irrespective of their registration status. Firms were restricted to be privately owned with a Sri Lankan owner, since much of our analysis is interested in the characteristics of the enterprise owner. There are 20 districts in Sri Lanka, excluding the Northern province (which is inaccessible due to civil conflict). Among those 20 districts, the 31 largest cities and towns were chosen, and in each city or town, 5 GN divisions (the smallest administrative unit, of approximately 300 households) were randomly selected. A listing exercise was then carried out on approximately 70-100 households per GN division, to list households with a male or female self-employed worker, and also households with male and female wage workers (the wage worker sample is not used in this paper). Altogether the listing exercise covered 12,736 households, which was used to select a sample of approximately 1500 male self-employed and 800 female self-employed.

This door-to-door survey placed no limits on the size of the enterprise owned. However, 55 percent of the 2,255 enterprises surveyed had no employees other than the owner, and 94.6 percent had 4 or fewer employees, leaving only 121 firms with 5 to 50 workers. We had anticipated that a representative survey of firm owners will not yield many owners of large firms, and so also designed a booster sample of 610 small and medium enterprises with 5 to 250 employees. The sample frame for this dataset came from two sources. 400 enterprises were selected from a recent census of firms carried out by AC Nielsen, Lanka. The Nielsen census covered only part of the geographic area of our survey. Therefore we supplemented this sample by asking wage workers in the

¹ The survey was undertaken by the Nielsen Company Lanka (Pvts) Ltd.

representative listing for the name and size of the firms where they are employed. From this list, we selected an additional 210 firms with 5 to 250 workers.

The survey took an average of one hour and a half to complete, and collected rich data on the characteristics of the firm, and of the firm owner. In addition to standard operating data, the survey had detailed modules on the education and employment background of the owner, the owner's ability and personality traits, members of the owner's household, use of finance and loans, informality, the competitive environment facing the firm, and most importantly for this study, a detailed module on innovation. Tables 1 and 2 summarize the key variables used in our study. These variables will be introduced and explained in later sections of the paper.

3. Innovation in Micro, Small and Medium Firms

3.1 Defining Innovation

Our survey follows the recommendations of the Oslo and Bogota Manuals for measuring innovation (OAS, 2001, OECD, 2005). The OECD's Oslo Manual defines an *innovation* as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" (OECD, 2005, p.46). It notes that the minimum requirement for an innovation is that the product, process, marketing method, or organizational method must be new or significantly improved to the firm. This includes both innovations that the firm in question is the first to develop, as well as those adopted from other firms or organizations. In developing countries incremental changes, acquisition of embodied technology, and applications or adaptations of existing products or processes are thought to be the most frequent forms of innovation.

This general definition of innovation, can be split into four subcomponents of innovation, defined in the Bogota and Oslo manuals as:

- 1) *Product innovation*: the introduction of a good or service that is new or substantially improved.
- 2) *Process innovation*: the introduction of a new or significantly improved production or delivery method.

- 3) *Marketing innovation*: the implementation of a new marketing method involving significant changes in product design or packaging, product promotion or pricing.
- 4) *Organizational innovation*: involves the creation or alteration of business practices, workplace organization, or external relations.

Economic models of innovation have typically focused on product innovation, and distinguish further two distinct types (Gancia and Zilibotti, 2005). The first type is *horizontal innovation*, which consists of producing a new product that does not displace existing products, thereby expanding the variety of products produced. This form of innovation features in the growth model of Romer (1990). The second type is *vertical innovation*, where the introduction of one product makes an existing product obsolete. This form of innovation captures the process of creative destruction emphasized by Schumpeter, and underlies the growth model of Aghion and Howitt (1992).

Finally we will also consider the more traditional proxies for innovation often used in developed country studies: whether or not the firm has spent money on research and development (R&D) in the last three years, and whether or not the firm has ever been granted a patent. Such measures are likely to be very uncommon among micro, small and medium enterprises, making them much less useful for understanding innovation in developing countries.

3.2 The Incidence and Type of Innovation in Micro, Small and Medium Firms

Much of the existing literature on innovation in developing countries has concentrated on innovation in formally registered firms (e.g. Ayygari et al. 2007). As a result, little is known about the incidence of innovation in microenterprises, and how this compares to all small and medium enterprises, regardless of their legal status. We therefore begin by examining the incidence of innovation among Sri Lankan firms, and the types of innovation which are taking place.

Table 2 summarizes the incidence of each type of innovation for our full sample, by firm size, and for the two largest industry sectors: wholesale and retail trade and manufacturing. A sizeable minority of micro and small firms are carrying out some form of innovation – 26 percent of firms with no employees, 38 percent of firms with 1 to 4

employees, and 44 percent of firms with 5 to 9 employees engaged in some form of innovation. Innovation is more common among medium sized firms, with 48 percent of firms with 10 to 24 employees and 59 percent of firms with 25 or more employees engaging in some form of innovation over the past three years. Innovation is slightly more prevalent in the manufacturing sector than in wholesale and retail trade.

The most common form of innovation for small firms is marketing innovation, measured by whether the firm has implemented a new design or product packaging, significantly changed the way merchandise is displayed, introduced a new channel for selling goods and services, or introduced a new method of pricing products. Almost 19 percent of firms with no employees (apart from the owner) have carried out such an innovation in the past year. Product innovation is the next most common, with 13 percent of firms with no employees either introducing a new product or significantly improving an existing product over the past three years. Process and organizational innovations are much less common among microenterprises, with 5 percent or fewer firms with zero employees having carried out each of these forms of innovation. Product innovation occurs as both horizontal and vertical innovation, with horizontal innovation being slightly more prevalent. Spending money on research and development and obtaining patents are even less common among microenterprises.

The nature of product innovation varies by industry sector and firm size. Larger firms are more likely to have introduced a product innovation. Moreover, the products introduced by microenterprises are typically only new for the firm. Table 3 shows only 1.7 percent of firms with zero employees introducing a new product had a product which is new to Sri Lanka, compared to 16.7 percent of innovating firms with 10 to 24 workers and 28.6 percent of innovating firms with 25 or more workers. Manufacturing firms are more likely than retail firms to introduce products which are new to Sri Lanka. Examples include manufacturing a new design of toy animal, manufacturing a couch with a specific design, and manufacturing a new jewelry design. An example in retail is starting to sell plants from Australia not previously available in Sri Lanka. For the most part the innovations are new to the firm, rather than to the country as a whole, and in approximately half of the cases, are invented by the firm from their own ideas. Direct acquisition of new products from suppliers is a less common form of product innovation.

For the firms which do innovate, these new products constitute a significant share of their revenues. Among firms which introduced at least one new product in the previous three years, new products accounted for an average of 46 percent of revenues in 2007.

Firms were asked to rate the importance of different reasons for introducing the new product or service. The two most important reasons were to open up new markets and increase market share, which 41 percent of product innovating firms gave as a very important reason for their product innovation; and to deal with new competitors, which 38 percent gave as a very important reason. Replacing old products and fulfilling regulations or standards were not viewed as important reasons.

Process innovations were less common, especially among microenterprises. Examples of process innovations undertaken by firms with no employees include introducing a new method to dry fish, starting to keep formal business accounts, using machines to do construction tasks previously carried out by hand, using a computer instead of a typewriter for typing, and other changes in the manufacturing process. These types of improvements are similar to those undertaken by the small and medium firms that undertook process innovations, they are just less common among microenterprises. When asked the importance of different reasons for carrying out process innovations, improving product quality was viewed as the most important reason. Only one-third of businesses engaging in process innovation gave lowering production costs as an important or very important reason.

4. A model of innovation

This section sets out a simple model of an individual firm's decision of whether or not to innovate that we use to guide our empirical work. We begin with a similar set-up to Klette and Kortum (2004), in which innovation increases demand for a firm's products. We modify this model to incorporate the concept of innovation embedded in Cohen and Klepper (1996a), in which innovation increases profits by lowering the unit costs of production, and to incorporate a role for the characteristics of the firm and the firm owner to affect the decision to innovate. For simplicity of exposition we consider myopic risk-neutral firm owners who are concerned with maximizing current expected profits. Of course risk-aversion and high discount rates are both reasons why a firm owner may not

undertake risky innovative activities with payoffs in the future, and our empirical work will also incorporate this element.

We assume that the economy consists of a unit continuum of differentiated goods, and that consumers have symmetric Cobb-Douglas preferences across these goods so that the same amount, one unit, is spent on each good. A firm is defined by the characteristics of its owner, θ , the industry sector s , and the portfolio of goods which it produces. Firms compete through product quality improvements, which come from innovation activities. This results in each good being produced by a single firm, the one that currently has highest quality for this good, with the profit flow from each good equal to π , where $0 < \pi < 1$. A firm with n goods then has revenues equal to n and profits of $n\pi$.

The firm owner then has to decide whether or not to engage in innovative effort. A key feature of innovation is that it involves a costly investment, with uncertainty over the outcome. The cost of engaging in innovative effort is D , and the likelihood that it succeeds is $\lambda = \lambda(\theta, s)$, depending on the characteristics of the owner and the sector in which the firm operates. If the innovation succeeds, it has two benefits to the firm. First, as in Klette and Kortum (2004), product innovation allows the firm to successfully produce a new product at higher quality than the incumbent producer, taking over the market for this good. Second, as in Cohen and Klepper (1996a), innovation enables the firm to reduce the unit cost of producing each good produced, allowing it to gain an additional profit of x per unit sold.

Regardless of whether or not it chooses to engage in innovation, firms face the possibility that another firm will innovate on a good it is currently producing. If this occurs, the firm will lose this good from its portfolio. The probability that such competition causes the firm to lose a good is μ . The firm will thus produce $n+1$ goods at profit $\pi+x$ per unit if it succeeds in innovating and no competitors innovate on a good the firm currently produces, n goods at profit $\pi+x$ per unit if it succeeds in innovating and a competitor also innovates on one of its goods, n goods at profit π per unit if it doesn't succeed in innovating and there is no loss of a product to a competitor, and profit π per unit on $n-1$ goods if innovation fails and a competitor innovates on one of its goods. The expected profit to the firm if it chooses to innovate is then:

$$\lambda(1-\mu)(\pi+x)(n+1) + \lambda\mu(\pi+x)n + (1-\lambda)(1-\mu)\pi n + (1-\lambda)\mu\pi(n-1) - D \quad (1)$$

If the firm chooses not to innovate, the expected profit is:

$$(1 - \mu)\pi n + \mu\pi(n - 1) \quad (2)$$

Comparing (1) and (2), we see the net expected gain in profits to a firm from innovating is:

$$\lambda(\pi + x(n + 1 - \mu)) - D \quad (3)$$

A credit-constrained firm with resources (assets and available credit) of W will then innovate if:

$$\pi + x(n + 1 - \mu) > \frac{D}{\lambda}$$

and (4)

$$D \leq W$$

Equation (4) allows us to summarize many of the empirical associations found in the existing literature, derive several testable implications, and set out a role for owner characteristics.

First consider the implications of (4) for the relationship between firm size and innovation. Dating back to Schumpeter, it has long been argued that larger firms have an advantage in innovation, and a positive relationship between firm size and innovation has been found within each of a number of countries (Ayyagari et al., 2007). Cohen and Levin (1989) summarize several arguments for such an effect occurring: larger firms may have an advantage in securing finance for risky projects, and there may be scale economies in the technology of research and development. In our model, this would lead to W being increasing in n , and D , the cost of innovation, falling with n . A further factor, seen directly in our model, is that larger firms have more output and products over which to achieve cost savings (Cohen and Klepper, 1996b). Such cost savings on all products produced are more likely to result from process innovation than product innovation, leading Cohen and Klepper (1996a) to predict that process innovation should depend more on firm size than product innovation. From the model, we can see that product innovations proportional to size measured by the number of products in a linear manner. Process innovation increases in firm size in an increasing manner, since the cost of innovation is fixed.

Organizational innovations such as the use of new business process, better supply chain management, new quality standards for suppliers and the like are also likely to achieve cost savings on all products produced, so we predict firm size will play a larger role in organizational innovation than product innovation. Marketing innovations are harder to classify. Some marketing innovations will be tailored towards promoting or advertising a particular product, in which case we would expect them to have a similar relationship to firm size as product innovation. Other marketing innovations may increase demand for all products, yielding additional profit on all products sold, in which case marketing innovations will depend more on firm size than product innovation.

Hypothesis 1: Firm size will play a larger role in process and organizational innovations than in product innovations; firm size will play the same or a larger role in marketing innovations than in product innovations.

Second, consider the role of competition. The traditional view has been that innovation should decline with competition, as more competition reduces the monopoly rents that reward entry by new successful innovators (Aghion and Howitt, 1992). This effect is captured in our model. More intense competition can be viewed as a higher μ , that is, a greater likelihood that a competitor will innovate and take over one of your products. Equation (4) shows that the additional profit per unit from innovation is lower when μ is higher. Note that this competition effect only occurs for innovations which reduce unit costs, not those which just increase products.² This gives rise to our second prediction:

Hypothesis 2: Process and organizational innovations will be more negatively associated with competition than product innovation. Marketing innovations will be at least as negatively associated with competition as product innovation, and possibly more strongly negatively associated.

² Note though that the likelihood that a new product innovation will succeed could also be thought of as depending on the level of competition, in which case there will still be some effect of competition on product innovation.

Third, equation (4) shows that innovation will be less common for firms which are credit-constrained. Empirically there is a strong relationship between access to finance and innovation (Ayygari et al. 2007). Note from (4) that in addition to the wealth and credit W , whether or not a firm is constrained will depend on whether or not innovation is profitable – which in turn depends positively on firm size, negatively on the level of competition, and positively on the likelihood the innovation succeeds, λ . Conditional on these other variables, W should be positively associated with innovation.

Finally, equation (4) clearly links the likelihood of innovating to the efficiency with which a firm can engage in innovative activities, D/λ . Firm or owner characteristics which reduce the costs of innovating, or which increase the likelihood that the innovation succeeds, will make innovation more profitable, increasing the probability that innovation occurs. The literature has found correlations between several firm characteristics which might reasonably be thought to affect the efficiency of innovation. Firm age is often found to be significantly associated with innovation, with younger firms more likely to innovate (Lee, 2004; Ayygari et al. 2007). Firms which export are more likely to innovate (Almeida and Fernandes, 2006). Legal structure has also been found to be associated with innovation (Ayygari et al. 2007), although the focus has typically been on larger firms, with a distinction made between public and private companies, and whether or not the firm has limited liability. Instead we focus on formality, measured as whether or not the firm is registered with the District Secretariat. Formality may directly increase the likelihood of innovation, if informal firms stay small to hide from the law, as well as indirectly increase it through securing better access to finance.

Much of the existing literature on innovation has treated the owners of firms as homogenous. An exception is the literature on adoption of agricultural innovations, where characteristics such as the risk aversion and wealth of the farmer have been long included in empirical models (see Feder et al. (1985) for a survey of such literature). When the owner is risk averse, King and Levine (1993) show that cross-sectional risk diversification can boost innovative activity, as the ability to hold a diversified portfolio of innovative projects reduces risk. It seems likely that this argument would hold for innovations which occur at a product level, such as product and perhaps marketing

innovations, but not apply nearly as strongly for innovations which lower costs or improve operations firmwide, such as process and organizational innovations.

Hypothesis 3: Diversification should be more strongly associated with product and marketing innovations than with process and organizational innovations.

However, to focus exclusively on the characteristics of the firm and the risk-taking propensity of the owner is to abstract from the central role of the entrepreneur in the innovation process. The association of entrepreneurship with innovation dates back to Schumpeter (1934), who defines an entrepreneur as one who implements change in markets through the carrying out of new combinations –that is, who innovates. While some innovations spring from a sudden flash of inspiration, most result from a conscious purposeful search for innovative opportunities (Drucker, 1985). Some business owners will have greater ability to conduct such searches than others, and additionally, the personality traits of the owner may influence their propensity to focus on innovative activities rather than on the day-to-day running of the business. In a prior survey of Sri Lankan firms, we found that owner characteristics do distinguish own account workers (with no employees) from owners of businesses with 5 or more employees (de Mel et al., 2008). We will investigate here whether these owner characteristics also are associated with the likelihood of innovating.

Hypothesis 4: Conditional on firm size and firm characteristics, owner characteristics still have an important role to play in predicting innovative activity, especially for smaller firms.

Which owner characteristics might matter for innovation? Gender and marital status are standard variables to include, although we do not have strong priors on their effect on the likelihood of innovating. Owner's age is another standard demographic variable, and may be negatively correlated with the likelihood of innovation. We expect owner's education to be positively correlated with innovation, as more human capital should increase the efficiency of innovation, lowering D/λ . Risk preferences and

discount rates of the owner should also matter once we introduce risk aversion to the model – we would expect risk seeking individuals to be more likely to innovate, and hyperbolic discounters to be less likely to seek innovations with payoffs in the future. Another owner characteristic which might be likely to effect the motive for innovating in the Sri Lankan context is the ethnicity of the enterprise owner. The ethnic Tamil minority may feel less sure that they will be able to remain in business in their current locations, and therefore less likely to engage in innovation.

We will also consider several ability and personality traits of the owner which are more common to the entrepreneurial psychology literature, but which have not been included in economic studies of innovation to our knowledge. Our survey includes two other measures of ability apart from years of schooling. First, we conducted a forward digitspan recall test. Respondents were shown a four digit number. The card showing the number was then taken away. Ten seconds later, respondents were asked to repeat the number as written on the card. Those responding correctly were shown a five digit number, and so forth up to 11 digits. The median firm owner could recall 6 digits.

The second ability measure comes from a Raven progressive non-verbal reasoning test. We provided 12 printed pages, each of which contained one 3 by 3 pattern with one cell missing. Below the pattern were eight figures, one of which fit the pattern, and the other seven of which did not. The patterns become progressively more difficult from the first to the 12th page. Respondents were given five minutes to complete as many of the patterns as possible. They were instructed to skip as desired, but told that the patterns became progressively more difficult. The median firm owner in our sample completed three of the patterns correctly. Digitspan recall is a proxy for short-term cognitive processing power, whereas the Raven test gets at more abstract logical thinking. We hypothesize therefore that the Raven test should be a stronger predictor of innovation than the Digitspan recall test.

Finally, we consider several entrepreneurial personality traits which might influence the innovativeness of the owner, using questions developed by industrial psychologists. Responses to all questions are coded on a scale of one to five, with one indicating “strongly disagree” and five “strongly agree.” We rescale these to range between -2 and 2, with 2 indicating strongly agree. The first attitude is *optimism*,

measured as an average over three questions on expectations of good or bad events occurring in life. We hypothesize that more optimistic owners are more likely to think their attempts at innovation will pay off, and thus be more likely to attempt to innovate.

The second attitude is *polychronicity*, which is the willingness to juggle tasks rather than focusing on a single task at a time (Bluedorn et al. 1999). Closely related to this is Lazear's (2005) concept that entrepreneurs should be jacks of all trades. Lazear finds that MBA students who have a broader range of previous job experiences make better entrepreneurs. We examine this by a dummy variable for whether or not the firm owner has worked in three or more previous jobs, which 10 percent of firm owners have done. A tendency to work on many things at once and have broad skills may foster innovation, or it may conversely indicate a lack of an ability to focus on making a particular type of innovative effort work out.

The final attitude is the *tenacity* of the owner (Baum and Locke, 2004), which measures the extent to which the owner perseveres in difficult circumstances, measured as an average over two questions. We expect that more tenacious owners are more likely to make their innovations succeed.

We hypothesize that these owner characteristics will matter more for smaller firms than for larger firms. There are several reasons to think this. The first is that an owner of a smaller firm may be more directly engaged in all production and process decisions, and thus any innovative activities from the firm are more likely to arise from him or her. In contrast, in a larger firm, innovation may also arise from the efforts of other workers in the firm, and be less dependent on the owner. Second, since the likelihood of innovating is predicted to increase with firm size, whether or not equation (4) holds is likely to depend less on D/λ in larger firms.

Finally note that the term D/λ applies for the decision of whether or not it is profitable to engage in each type of innovation. Individual owner characteristics should therefore matter for all types of innovation. Of course the impact of a given owner characteristic on the efficiency of innovating may depend on the type of innovation. For example, formal education might be more beneficial for some types of innovation than others. We will examine this empirically, but do not have any strong theoretical reason to predict that an owner characteristic will matter for one type of innovation but not another.

5. The Empirical Determinants of Innovation

5.1 Innovation, Firm Size, and Competition

We now use equation (4) to motivate probit regressions of the probability of a firm engaging in innovation as a function of firm size, sector, and the level of competition facing the firm. Table 4 reports the marginal effects, first for any form of innovation, and then for the different types of innovation. In accordance with the model and the descriptive statistics in Table 2, column 1 shows that the propensity to innovate increases with firm size, with a firm with 25 or more employees 35 percentage points more likely to innovate than firms with no employees apart from the owner. Column 1 also shows innovation to be more prevalent in manufacturing than in retail and other sectors.

We have two measures of the extent of competition. The first is the number of firms in the same line of business operating in the same G.N. (local government administrative area) as the firm. Thirty one percent of firms don't know how many other firms operate in this area, so we code this as an unknown competitor dummy. We divide the level of competition for the other firms into dummy variables for no competitors (6.6 percent of firms which respond), 1 to 6 competitors (45.4 percent of firms), 7 to 20 competitors (the reference category, with 27 percent of firms), and more than 20 competitors (20 percent of firms). The second measure of competition is based on a question in the survey which asks how long it would take a firm's largest customers to find an alternative supplier of goods if the firm were to close down. Fifty-five percent of firms say a day or less, and so we include a dummy variable for this.

Table 4 then shows that, conditional on firm size, firms facing 20 or more competitors are less likely to innovate, as are firms that don't know how many competitors they face (which is also likely to indicate a large number of competitors). The coefficients on no competitors and on few competitors are positive, but not significant. Firms whose customers can replace the firm's product easily are also less likely to innovate. The results are therefore consistent with the view that competition reduces the incentive to innovate.

Columns 2 through 5 of Table 4 then examine how the effects of firm size and competition vary with the type of innovation. Recall that in our model firm size and low competition act to amplify the effect of innovations which change the profit per unit reduced. We hypothesized this would occur more for process, and organizational innovations than product innovations, with the effects on marketing innovations at least as great as on product innovations. The data provide some support for these hypotheses. The marginal effects of firm size and competition are very similar for product and process innovations. Since product innovations are more prevalent than process innovations, the same size marginal effect thus results in a relatively larger impact for process innovation than it does for product innovation. For example, having more than 20 competitors in the G.N. is associated with a 4.4 percentage point reduction in the likelihood of product innovation, and a 3.8 percentage point reduction in the likelihood of process innovation. Since 18 percent of firms engage in product innovation and only 6.6 percent in process innovation, the effect of lots of competition is thus a 24 percent drop in the likelihood of product innovation, compared to a 58 percent drop in the likelihood of process innovation. Similarly a larger firm size will result in a greater percent increase in the likelihood of process innovation than product innovation.

Organizational innovation is also less prevalent than product innovation, so the same argument means that there is a greater impact of having 20 or more competitors on organizational innovation than product innovation. Moreover, the marginal effects of firm size and of being easily replaced by customers are actually larger in absolute value for organizational innovation than product innovation, so that size and competition matter both absolutely and relatively more for organizational innovation than product innovation, consistent with hypotheses 1 and 2.

Conversely marketing innovation is a more common form of innovation than product innovation, and so although we find larger marginal effects of firm size and competition for marketing innovation, they only equate to similar-sized percent changes in the likelihood of innovation as we find for product innovation. According to our model, this suggests marketing innovations are acting more to promote a particular product than to increase demand for all products. Some suggestive evidence for this is that the most common forms of marketing innovation in our data are introducing a new

method of pricing goods, such as a new type of special offer, and changing the design or packaging of a product. These types of innovations likely apply to one product at a time. In contrast, few firms say they have introduced a new channel for selling their goods and services, which would be a marketing innovation that could increase demand for many products at once.

Columns 6 to 10 of Table 4 introduce a third measure which is also strongly related to the level of competition - the proportion of goods or services which are custom made to meet the specifications of specific customers. It is likely that firms which custom make their products have greater market power and face a lower chance of other firms innovating in their exact line of business. We do find this measure to be positively associated with innovation, with the strongest relationship with product and marketing innovations. This measure appears almost automatically linked to the number of distinct products a firm makes, which explains the stronger relationship with the more product-specific forms of innovation.

5.2 Firm Characteristics and Innovation

Columns 6 to 10 of Table 4 also introduce other characteristics of the firm thought to impact on the cost of innovation or likelihood the innovation will succeed. In common with the existing literature we find a strong positive correlation between exporting (which only 1.9 percent of firms do) and innovation, and between having received a loan from a bank (which 36 percent of firms have ever done) and innovation. This correlation with bank finance is consistent with credit constraints lowering innovation in our model. However, these correlations could also simply reflect unmeasured productivity attributes of the firm which are correlated with both its ability to innovate and its decision to participate in exporting and/or receive a loan. Conditional on these other variables we do not find any significant correlation between innovation and the age of the firm, or the legal status of the firm. Being registered with the district secretariat continues to have no relationship with innovation even if we exclude the bank loan variable, suggesting that the lack of relationship with formality is not because formality impacts innovation through access to finance.

We measure how diversified the firm is by the share of revenue coming from products other than the main product. As in King and Levine (1993), we find that diversification is associated with more innovation. The effect is only present for product and marketing innovations, and not for process and organizational innovations. This is consistent with our fourth hypothesis. Diversification spurs the types of innovations which occur at the product level, since a diversified firm can have a portfolio of these with less risk. However, diversification doesn't help in lowering the risk of innovations which occur at the firm level, as is the case of process and organizational innovations.

5.3 Individual Characteristics and Innovation

In Table 5 we investigate whether the characteristics of the owner help predict innovation after controlling for firm size and firm characteristics, which have been the focus of much of the literature. The first column is the same probit regression specification as in column 6 of Table 4, restricted to the subset of the data with full owner characteristics available, and is included to show the pseudo- R^2 when firm size and firm characteristics are used to predict the probability of innovating. The second column includes the basic set of demographic characteristics, risk attitudes, and discount rates. Columns 3 to 8 add ability and personality traits one by one, while column 9 includes them all together.

We do see a negative correlation between the owner's age and the likelihood of innovating, although the effect size is small and insignificant.³ Likewise gender and marital status are not significantly associated with the likelihood of innovating. As hypothesized, there is a strong and significant negative association between having Tamil ethnicity and innovating: Tamils are 9.6 percentage points less likely to innovate. In 2007 and 2008 there were high profile incidents of the Government forcefully expelling large numbers of Tamils from Colombo, due to security concerns arising from a civil war with the Tamil LTTE movement. In such an environment of uncertainty, it is not surprising that Tamil owners are less likely to be innovating.

We measure the owner's risk seeking attitude by means of a question taken from the German Socioeconomic Panel on how willing people are to take risks in life, scored

³ We also tried adding a quadratic term in owner's age, but this was also insignificant ($p=0.82$).

on a scale of zero to ten, where ten is the most risk seeking. We find no correlation between this measure and the likelihood of engaging in innovation. One might argue that this could just reflect the measure not being a very good measure of risk attitudes. However, in previous work (de Mel et al. 2008) we have found that this measure does help distinguish own account workers from both wage workers and owners of larger firms. An alternative explanation is that the effect of risk attitudes are already being captured by characteristics of the firm, such as firm size, industry, and diversification. Indeed we do find a positive and significant correlation between risk seeking attitudes and innovation when we run a probit of innovation only on risk attitudes, without any other controls.

We measure the owner's subjective discount rate by means of a question which asks the firm owner how much they would be willing to accept today instead of receiving 10,000 rupees in one month's time. The median discount rate is 11 percent, meaning an owner would take 8900 today instead of 10,000 in the future. Some owners would take as low as 1000 or 4000. We therefore use the log of the discount rate to downplay the influence of these outliers. Somewhat surprisingly we find a positive and highly significant relationship between the discount rate and the likelihood of engaging in innovation – more impatient owners are more likely to innovate. One could speculate that impatience might be linked to a tendency for the owner to be dissatisfied with their current business level and with slow growth, and be eager to reach a higher business size more quickly. Firm owner's were also asked a similar discount question about amounts in 5 months compared to 6 months time. Hyperbolic discounters are defined as those who have a higher discount rate when comparing the present to one month, than when comparing 5 months to 6 months. We do find a negative coefficient on this variable, suggesting that extreme impatience is associated with a lower tendency to innovate, but the effect is not significant.

All three measures of human capital are positively and significantly associated with the likelihood of innovating: more educated individuals, those with higher Digitspan recalls, and higher scores on the Raven test are more likely to innovate. When all three measures are put together in column 9, we find the Raven test has a stronger effect than

the Digitspan recall, in accordance with our hypothesis that logical ability rather than short-term cognitive processing ability should matter more for innovation.

We also find some success for the personality traits in predicting innovation. Optimism is significantly positively correlated with innovation. Owners with more than 3 jobs are more likely to innovate, providing some support for a jack-of-all-trades theory. However, there is no relationship between polychronicity and innovation, and while the relationship with tenacity is positive, it is insignificant.

In every specification we can overwhelmingly reject the null hypothesis that the owner characteristics do not help predict innovation, conditional on firm size and firm characteristics. However, this does not tell us how much individual characteristics matter. To examine this, we use the specification in column 9 of Table 5. We fix the characteristics of the firm, and then see how much the predicted probability of innovating varies according to owner characteristics. The results are graphed in Figure 1. The first case we consider is a manufacturing firm with zero workers in Colombo, that is unregistered, does not export or have a bank loan, and which faces the mean level of competition, with the mean diversification and customization of goods levels. The mean predicted probability of innovating for such a firm is 0.28, with a standard deviation of 0.067. The range is 0.08 to 0.58, with a 10-90 percentile range of 0.20 to 0.37. Thus for this type of firm, individual characteristics can double the predicted probability of innovating.

The second case we consider in Figure 1 is a larger firm, with 25 or more workers, again in manufacturing in Colombo, but this time registered, exporting, and with a bank loan. The mean predicted probability of innovating for such a firm is 0.79, with a standard deviation of 0.06. The range is 0.48 to 0.94, with a 10-90 percentile range of 0.70 to 0.85. Thus even for these larger firms, the characteristics of the owner do have a meaningful effect on the predicted likelihood of innovating. Nonetheless, the relative influence of owner characteristics is less than with the smaller firm case.

Finally we note that we did not have strong theoretical reasons to think that owner characteristics should matter more for one type of innovation than another. In appendix 1 we examine empirically whether owner characteristics matter only for some types of innovations but not others. For each type of innovation we can overwhelmingly reject the

null hypothesis that owner characteristics have zero effect. In general the coefficients are of the same sign across types of innovation, and in no case do we find a variable having a significant positive impact on one type of innovation and a significant negative impact on another type.

6. Is this Innovation Associated with Higher Profits?

We have seen that many micro and small firms are engaging in innovation in a way consistent with our simple model, and that owner characteristics as well as firm characteristics help explain this innovation. An open question is whether the types of innovations undertaken by micro and small firms are actually profitable for them, allowing their owners to earn higher incomes. We cannot answer this question with our data, since we do not have an instrument with which to identify the impact of innovation. Nevertheless, we can take a first step towards answering the question, by examining whether it is at least the case that innovation is associated with higher profits for these firms, conditional on firm and owner characteristics. To do this, we estimate the following equation for firm i :

$$\ln(\text{profit}_i) = \zeta + \omega' X_i + \tau' Z_i + \varepsilon_i$$

Where X_i is a vector of firm characteristics and Z_i is a vector of owner characteristics.

Table 6 reports the results. Column 1 shows that firms which innovate earn 15.6 percent higher profits than firms which do not innovate. Conditioning on owner characteristics in column 2, and on log firm assets in column 3 only reduces this slightly, to 14 percent higher profits. Thus innovation is strongly and significantly associated with higher profitability. The remaining columns of the table then examine whether particular forms of innovation are more strongly associated with innovation. All four types are positively associated with profits, but at most weakly significant when examined individually. In column 8, when all four measures are put in together, we can not reject the null hypothesis of an equal effect of each type of innovation (p-value of 0.96 on the test of equality).

7. Conclusions

We have provided a new model of firm innovation, which includes a role for both firm and owner characteristics in the innovation process. The model has several new predictions which we verify in the data. The first is that firm size plays a larger role in process and organizational innovations (which spread cost savings over all products), than in product and marketing innovations (which typically apply to only a single product). In contrast, having a diversified portfolio of products matters more for product and marketing innovations than process and organizational innovations. Third, we confirm the general view in the literature that heavy competition is negatively associated with innovation, and show this is more the case for process and organizational innovations than for product and marketing innovations. Finally, we show that owner characteristics matter a lot for innovation, even conditioning on firm size and a host of firm characteristics.

In related work we have shown that attributes of a firm owner such as his or her socioeconomic background, performance on ability tests, and personality traits, differ in the cross-section between owners of smaller and larger firms. This paper shows that many of these same owner characteristics also predict innovation. Since these are measureable characteristics of the firm owner, it may be possible to use these characteristics to predict which small businesses are likely to innovate and grow, which could be used to help better target policies such as microcredit and business training programs.⁴

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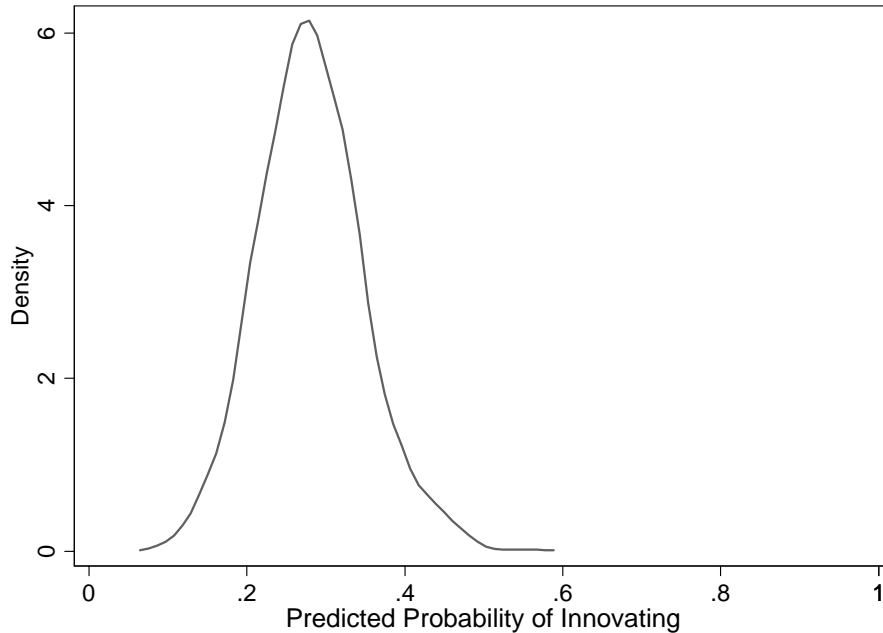
⁴ The Entrepreneurial Finance Lab at Harvard has recently been established to explore such possibilities. See <http://www.cid.harvard.edu/efl/>.

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Figure 1: How Much Do Individual Characteristics Vary the Predicted Probability of Innovating Once Firm Size and Firm Characteristics Are Controlled For?

Case 1: Manufacturing Firm with Zero Workers, in Colombo, facing the mean level of competition, with mean diversification and custom made goods levels, unregistered, not exporting, and not having received a bank loan.



Case 2: Manufacturing Firm with 25+ Workers, in Colombo, facing the mean level of competition, with mean diversification and custom made goods levels, registered, exporting, and having received a bank loan.

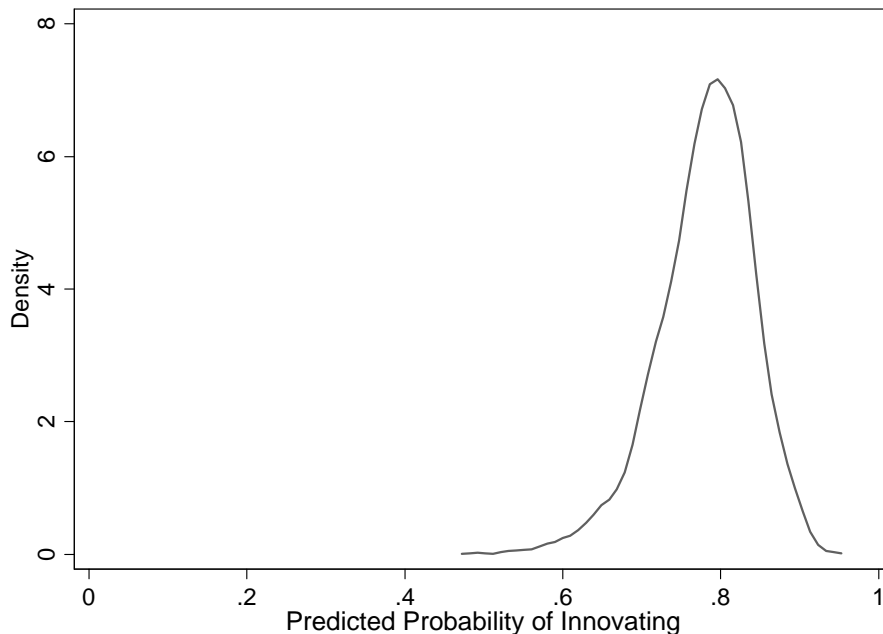


Table 1: Summary Statistics

| <i>Firm Characteristics</i> | # Obs. | Mean | Std Dev. | <i>Individual Characteristics</i> | # Obs. | Mean | Std Dev. |
|---|--------|-------|----------|--|--------|-------|----------|
| Firm Size 0 | 2865 | 0.43 | | Female owner | 2865 | 0.29 | |
| Firm Size 1 to 4 workers | 2865 | 0.34 | | Age | 2863 | 37.1 | 8.8 |
| Firm Size 5 to 9 workers | 2865 | 0.12 | | Married | 2865 | 0.84 | |
| Firm Size 10 to 24 workers | 2865 | 0.06 | | Tamil Ethnicity | 2865 | 0.10 | |
| Firm Size 25 + workers | 2865 | 0.05 | | Years of Education | 2865 | 10.61 | 2.92 |
| Manufacturing dummy | 2865 | 0.33 | | Risk Seeking Score | 2865 | 6.25 | 2.75 |
| Retail dummy | 2865 | 0.35 | | Log Discount rate | 2656 | 2.33 | 1.30 |
| Colombo district dummy | 2865 | 0.35 | | Hyperbolic Discounter | 2569 | 0.38 | |
| Number of competitors | 1841 | 21.8 | 50.0 | Digitspan Recall test score | 2865 | 6.29 | 1.54 |
| Number of competitors unknown | 2865 | 0.31 | | Raven test score | 2865 | 3.59 | 2.52 |
| Customers would take a day or less to replace the firm if it closed | 2865 | 0.55 | | Optimism | 2865 | 0.58 | 0.54 |
| Firm exports | 2865 | 0.02 | | Polychronicity | 2865 | 0.17 | 1.14 |
| Firm is less than 5 years old | 2865 | 0.34 | | Has had 3 or more previous jobs | 2865 | 0.10 | |
| Firm is legally registered | 2865 | 0.33 | | Tenacity | 2865 | 0.74 | 0.39 |
| Firm has received a bank loan | 2865 | 0.37 | | Reverse work centrality | 2865 | -0.20 | 1.09 |
| Diversification (proportion of revenues coming from other than main product) | 2745 | 0.27 | | Plans to leave business in next 5 years | 2865 | 0.06 | |
| Proportion of Goods Custommade | 2865 | 0.14 | | | | | |
| Log Monthly Business Profits (Rupees) | 1699 | 9.40 | 1.31 | | | | |
| Log Business Assets (Rupees) | 2759 | 12.73 | 2.42 | | | | |

Source: Sri Lanka Longitudinal Survey of Enterprises Baseline 2008.

Table 2: Incidence of Innovation in the last three years by Firm Size, and Sector

| Type of Innovation | Full Sample | By Firm Size: Number of Workers (excluding owner) | | | | |
|-----------------------------------|--------------------|--|------------|------------|--------------|------------|
| | | 0 | 1-4 | 5-9 | 10-24 | 25+ |
| <i>All firms</i> | | | | | | |
| Any Innovation | 34.9% | 25.5% | 38.3% | 43.5% | 48.0% | 58.5% |
| Product Innovation | 18.0% | 13.4% | 19.5% | 19.0% | 26.9% | 35.2% |
| Process innovation | 6.6% | 3.0% | 7.7% | 8.6% | 12.9% | 18.3% |
| Marketing innovation | 26.6% | 18.8% | 29.3% | 34.9% | 32.8% | 49.3% |
| Organizational innovation | 10.6% | 4.0% | 9.9% | 18.7% | 22.8% | 38.0% |
| Horizontal innovation | 5.6% | 3.2% | 7.7% | 3.8% | 5.9% | 14.5% |
| Vertical innovation | 3.1% | 1.8% | 3.3% | 4.1% | 8.2% | 4.2% |
| Spent money on R&D | 1.9% | 0.2% | 1.8% | 3.2% | 5.9% | 9.9% |
| Granted a patent ever | 2.5% | 1.4% | 2.0% | 4.6% | 5.9% | 7.0% |
| Number of observations | 2865 | 1244 | 961 | 347 | 171 | 142 |
| <i>Wholesale and Retail Trade</i> | | | | | | |
| Any Innovation | 33.8% | 22.7% | 35.3% | 43.3% | 46.8% | 54.0% |
| Product Innovation | 14.6% | 11.6% | 12.8% | 17.3% | 22.8% | 28.0% |
| Process innovation | 5.4% | 1.9% | 4.2% | 9.3% | 11.4% | 18.0% |
| Marketing innovation | 27.2% | 18.0% | 28.3% | 36.7% | 32.9% | 48.0% |
| Organizational innovation | 10.9% | 3.6% | 7.8% | 19.3% | 24.1% | 40.0% |
| Number of observations | 1000 | 361 | 360 | 150 | 79 | 50 |
| <i>Manufacturing</i> | | | | | | |
| Any Innovation | 39.7% | 30.7% | 42.6% | 51.2% | 56.3% | 74.2% |
| Product Innovation | 23.0% | 18.8% | 24.9% | 26.8% | 31.3% | 35.5% |
| Process innovation | 9.1% | 4.6% | 11.0% | 12.8% | 18.8% | 22.6% |
| Marketing innovation | 29.8% | 22.2% | 32.8% | 38.4% | 40.6% | 58.1% |
| Organizational innovation | 10.5% | 4.9% | 11.3% | 20.9% | 18.8% | 38.7% |
| Number of observations | 949 | 410 | 390 | 86 | 32 | 31 |

Table 3: Characteristics of Product Innovation

| | Full Sample | By Firm Size: Number of Workers (excluding owner) | | | | |
|---|--------------------|--|------------|------------|--------------|------------|
| | | 0 | 1-4 | 5-9 | 10-24 | 25+ |
| <i>All firms</i> | | | | | | |
| New product for Sri Lanka | 11.1% | 1.7% | 12.5% | 3.7% | 16.7% | 28.6% |
| Invented by firm from own ideas | 51.8% | 43.6% | 57.6% | 51.9% | 45.8% | 53.6% |
| Invented by firm, based on ideas seen elsewhere | 18.2% | 19.4% | 14.2% | 25.9% | 29.2% | 14.3% |
| Mean share of 2007 sales from products introduced in last 3 years | 45.9% | 38.9% | 43.0% | 56.6% | 55.6% | 54.4% |

Note: Results are for the 247 firms which introduced a new product in the past three years

Table 4: Innovation, Firm Size, Competition, and Firm Characteristics
Marginal Effects from Probit Estimation

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|--|------------------------|-----------------------|-------------------------|-------------------------|----------------------------|------------------------|------------------------|-------------------------|-------------------------|----------------------------|
| | Any Innovation | Product Innovation | Process Innovation | Marketing Innovation | Organization Innovation | Any Innovation | Product Innovation | Process Innovation | Marketing Innovation | Organization Innovation |
| Firm Size 1 to 4 workers | 0.123*** (0.0217) | 0.0595*** (0.0179) | 0.0497*** (0.0124) | 0.0987*** (0.0205) | 0.0741*** (0.0157) | 0.122*** (0.0226) | 0.0580*** (0.0185) | 0.0459*** (0.0126) | 0.0940*** (0.0212) | 0.0735*** (0.0161) |
| Firm Size 5 to 9 workers | 0.202*** (0.0308) | 0.0769*** (0.0275) | 0.0844*** (0.0230) | 0.181*** (0.0308) | 0.205*** (0.0300) | 0.177*** (0.0354) | 0.0556* (0.0299) | 0.0801*** (0.0262) | 0.154*** (0.0347) | 0.196*** (0.0352) |
| Firm Size 10 to 24 workers | 0.253*** (0.0402) | 0.172*** (0.0405) | 0.153*** (0.0379) | 0.165*** (0.0417) | 0.264*** (0.0426) | 0.213*** (0.0452) | 0.118*** (0.0424) | 0.138*** (0.0415) | 0.127*** (0.0448) | 0.251*** (0.0477) |
| Firm Size 25+ workers | 0.350*** (0.0407) | 0.247*** (0.0452) | 0.235*** (0.0463) | 0.346*** (0.0435) | 0.430*** (0.0475) | 0.265*** (0.0480) | 0.146*** (0.0461) | 0.186*** (0.0472) | 0.285*** (0.0491) | 0.380*** (0.0536) |
| Manufacturing | 0.0785*** (0.0236) | 0.0586*** (0.0191) | 0.0311*** (0.0117) | 0.0672*** (0.0221) | 0.00724 (0.0136) | 0.0508** (0.0244) | 0.0345* (0.0192) | 0.0216* (0.0113) | 0.0494** (0.0226) | -0.00317 (0.0133) |
| Retail | 0.00500 (0.0227) | -0.0267 (0.0176) | -0.00575 (0.0102) | 0.0267 (0.0212) | 0.000943 (0.0128) | -0.0208 (0.0236) | -0.0420** (0.0180) | -0.00953 (0.0102) | 0.00352 (0.0217) | -0.00394 (0.0127) |
| Colombo District | 0.00118 (0.0193) | 0.00920 (0.0153) | -0.0222*** (0.00802) | -0.0289* (0.0175) | -0.00651 (0.0109) | 0.0188 (0.0201) | 0.0221 (0.0159) | -0.0207** (0.00810) | -0.0143 (0.0182) | -0.00545 (0.0111) |
| No Competitors | 0.0408 (0.0471) | 0.0267 (0.0383) | 0.0234 (0.0231) | 0.0187 (0.0421) | 0.0447 (0.0305) | 0.0392 (0.0485) | 0.0314 (0.0390) | 0.0321 (0.0246) | 0.00685 (0.0425) | 0.0306 (0.0287) |
| 1 to 6 Competitors | -0.00109 (0.0255) | 0.0146 (0.0207) | -0.000287 (0.0107) | -0.00108 (0.0230) | -0.000557 (0.0139) | 0.00506 (0.0261) | 0.0195 (0.0211) | 0.000210 (0.0107) | 0.00299 (0.0234) | -0.00127 (0.0137) |
| More than 20 Competitors | -0.0731** (0.0288) | -0.0506** (0.0218) | -0.0400*** (0.00884) | -0.0697*** (0.0253) | -0.0391*** (0.0134) | -0.0924*** (0.0288) | -0.0588*** (0.0217) | -0.0392*** (0.00885) | -0.0834*** (0.0249) | -0.0441*** (0.0127) |
| Number of Competitors Unknown | -0.0904*** (0.0241) | -0.00754 (0.0197) | -0.0200** (0.00975) | -0.0974*** (0.0213) | -0.0314** (0.0127) | -0.0769*** (0.0249) | 0.00637 (0.0204) | -0.0173* (0.00996) | -0.0893*** (0.0217) | -0.0326*** (0.0125) |
| Customers would take a day or less to replace the firm if they closed | -0.0377** (0.0188) | -0.0181 (0.0147) | -0.0125 (0.00850) | -0.0282 (0.0172) | -0.0413*** (0.0112) | -0.0295 (0.0196) | -0.0167 (0.0152) | -0.0116 (0.00862) | -0.0251 (0.0178) | -0.0351*** (0.0114) |
| Firm is less than 5 years old | | | | | | -0.000451 (0.0202) | -0.0178 (0.0156) | -0.00148 (0.00902) | 0.0131 (0.0186) | 0.00426 (0.0117) |
| Firm exports | | | | | | 0.212*** (0.0772) | 0.175** (0.0716) | 0.00900 (0.0275) | 0.0835 (0.0698) | 0.0823* (0.0500) |
| Firm is legally registered | | | | | | 0.0210 (0.0222) | -0.00475 (0.0176) | -0.00485 (0.00974) | 0.0291 (0.0203) | 0.00381 (0.0124) |
| Firm has received a bank loan | | | | | | 0.100*** (0.0200) | 0.0710*** (0.0161) | 0.0297*** (0.00949) | 0.0689*** (0.0183) | 0.0138 (0.0111) |
| Diversification (proportion of revenues coming from other than main product) | | | | | | 0.0935*** (0.0331) | 0.109*** (0.0251) | 0.00757 (0.0136) | 0.0691** (0.0300) | 0.00863 (0.0183) |
| Proportion of Goods Custommade | | | | | | 0.192*** (0.0345) | 0.111*** (0.0250) | 0.0408*** (0.0128) | 0.122*** (0.0305) | 0.0623*** (0.0169) |
| Observations | 2865 | 2865 | 2865 | 2865 | 2865 | 2745 | 2745 | 2745 | 2745 | 2745 |

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 5: Do Owner Characteristics Predict Innovation?

Dependent Variable: Any Form of Innovation, Marginal Effects from Probit Estimation Shown

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|--|--------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| Firm Size Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm Characteristics Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Owner is Female | | 0.0128 (0.0238) | 0.0141 (0.0239) | 0.0135 (0.0239) | 0.0136 (0.0239) | 0.0135 (0.0239) | 0.0198 (0.0242) | 0.0131 (0.0239) | 0.0230 (0.0243) |
| Owner's Age | | -0.00136 (0.00130) | -0.00133 (0.00130) | -0.00114 (0.00131) | -0.00136 (0.00131) | -0.00136 (0.00130) | -0.00164 (0.00132) | -0.00143 (0.00131) | -0.00145 (0.00132) |
| Owner is Married | | 0.00972 (0.0286) | 0.0106 (0.0287) | 0.0113 (0.0287) | 0.00845 (0.0287) | 0.00985 (0.0286) | 0.00779 (0.0288) | 0.00957 (0.0286) | 0.00901 (0.0289) |
| Owner is Tamil | | -0.0963*** (0.0317) | -0.0953*** (0.0319) | -0.0946*** (0.0317) | -0.0967*** (0.0317) | -0.0958*** (0.0318) | -0.0964*** (0.0317) | -0.0967*** (0.0318) | -0.0938*** (0.0318) |
| Owner's Years of Education | | 0.0118*** (0.00379) | 0.0100*** (0.00389) | 0.00979** (0.00384) | 0.0110*** (0.00380) | 0.0118*** (0.00380) | 0.0118*** (0.00379) | 0.0115*** (0.00380) | 0.00797** (0.00393) |
| Risk Seeking Aptitude | | 0.000638 (0.00363) | 0.000404 (0.00363) | 0.000349 (0.00363) | -0.000403 (0.00366) | 0.000596 (0.00363) | 0.000260 (0.00363) | -0.000162 (0.00366) | -0.00155 (0.00369) |
| Log of Owner's Discount Rate | | 0.0318*** (0.00839) | 0.0325*** (0.00841) | 0.0338*** (0.00845) | 0.0334*** (0.00842) | 0.0317*** (0.00839) | 0.0318*** (0.00838) | 0.0318*** (0.00839) | 0.0354*** (0.00849) |
| Hyperbolic Discounter | | -0.0211 (0.0214) | -0.0224 (0.0214) | -0.0194 (0.0214) | -0.0269 (0.0216) | -0.0210 (0.0214) | -0.0222 (0.0214) | -0.0216 (0.0214) | -0.0265 (0.0216) |
| Digitspan Recall of Owner | | | 0.0126* (0.00681) | | | | | | 0.00966 (0.00696) |
| Raven test Score of Owner | | | | 0.0105*** (0.00389) | | | | | 0.00946** (0.00393) |
| Optimism of Owner | | | | | 0.0388** (0.0182) | | | | 0.0314* (0.0190) |
| Polychronicity of Owner | | | | | | -0.00486 (0.00876) | | | -0.00726 (0.00897) |
| Owner has 3 or more previous jobs | | | | | | | 0.0678* (0.0350) | | 0.0664* (0.0352) |
| Tenacity of the Owner | | | | | | | | 0.0375 (0.0261) | 0.0218 (0.0275) |
| Observations | 2461 | 2461 | 2461 | 2461 | 2461 | 2461 | 2461 | 2461 | 2461 |
| Pseudo R ² | 0.0618 | 0.0734 | 0.0745 | 0.0756 | 0.0748 | 0.0735 | 0.0747 | 0.0741 | 0.0791 |
| P-value for test individual characteristics jointly zero | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Notes:

All probits also include the same firm size and firm characteristic controls as column 6 of Table 4.

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 6: Is more Innovation Associated with Higher Profits?

OLS regression, Dependent Variable Log Profits

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|-------------------------------|----------------------|----------------------|----------------------|--------------------|------------------|--------------------|------------------|------------------|
| Firm Size Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm Characteristic Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Owner Characteristic Controls | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm asset controls | No | No | Yes | Yes | Yes | Yes | Yes | Yes |
| Any Form of Innovation | 0.156*** (0.0549) | 0.150*** (0.0544) | 0.140*** (0.0534) | | | | | |
| Product Innovation | | | | 0.0973 (0.0666) | | | | 0.042 (0.075) |
| Process Innovation | | | | | 0.166 (0.113) | | | 0.107 (0.131) |
| Marketing Innovation | | | | | | 0.0987* (0.057) | | 0.066 (0.061) |
| Organizational Innovation | | | | | | | 0.116 (0.102) | 0.005 (0.114) |
| Observations | 1459 | 1459 | 1459 | 1459 | 1459 | 1459 | 1459 | 1459 |
| R-squared | 0.485 | 0.544 | 0.559 | 0.557 | 0.558 | 0.558 | 0.557 | 0.558 |

Notes:

Firm controls are as per Table 4, column 6. Owner characteristic controls as per Table 6, column 9.

Firm asset controls are log of firm total assets.

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Appendix Table 1: Do Owner Characteristics Matter More for Certain Types of Innovation?

| | TYPE OF INNOVATION | | | | |
|-----------------------------------|------------------------|-------------------------|-------------------------|-------------------------|--------------------------|
| | Any (1) | Product (2) | Process (3) | Marketing (4) | Organizational (5) |
| Firm Size Controls | Yes | Yes | Yes | Yes | Yes |
| Firm Characteristics Controls | Yes | Yes | Yes | Yes | Yes |
| Owner is Female | 0.0195 (0.0240) | 0.0139 (0.0182) | 0.0159 (0.0105) | 0.0293 (0.0220) | -0.00833 (0.0132) |
| Owner's Age | -0.00193 (0.00131) | -0.00180* (0.000997) | 0.000152 (0.000534) | -0.00151 (0.00118) | -0.000423 (0.000682) |
| Owner is Married | 0.00814 (0.0283) | 0.00460 (0.0215) | -0.00360 (0.0118) | 0.0150 (0.0252) | -0.0148 (0.0165) |
| Owner is Tamil | -0.0824*** (0.0318) | -0.0325 (0.0237) | -0.00572 (0.0138) | -0.0610** (0.0284) | -0.0151 (0.0166) |
| Owner's Years of Education | 0.0118*** (0.00382) | 0.00936*** (0.00293) | 0.00425*** (0.00158) | 0.00967*** (0.00345) | 0.00504** (0.00206) |
| Risk Seeking Aptitude | -0.00157 (0.00362) | 0.00254 (0.00272) | -0.000552 (0.00138) | -0.000645 (0.00331) | -0.00624*** (0.00192) |
| Log of Owner's Discount Rate | 0.0265*** (0.00775) | 0.0194*** (0.00591) | -0.00192 (0.00333) | 0.0162** (0.00711) | 0.00550 (0.00433) |
| Raven test Score of Owner | 0.00959** (0.00387) | 0.00738*** (0.00286) | 0.00430*** (0.00145) | 0.00839** (0.00346) | 0.00449** (0.00200) |
| Optimism of Owner | 0.0300 (0.0187) | 0.0354** (0.0141) | 0.00507 (0.00696) | 0.00347 (0.0166) | 0.0243*** (0.00933) |
| Polychronicity of Owner | -0.00844 (0.00880) | -0.0121* (0.00664) | -0.00398 (0.00366) | -0.00622 (0.00798) | -0.000378 (0.00479) |
| Owner has 3 or more previous jobs | 0.0658* (0.0347) | -0.00399 (0.0252) | 0.0188 (0.0159) | 0.0759** (0.0329) | 0.0156 (0.0188) |
| Tenacity of the Owner | 0.0275 (0.0273) | 0.0402* (0.0209) | 0.0139 (0.0110) | 0.0169 (0.0249) | 0.0137 (0.0143) |
| Observations | 2545 | 2545 | 2545 | 2545 | 2545 |

Notes:

All probits also include the same firm size and firm characteristic controls as column 6 of Table 4. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1