Is innovation activity persistent among small firms in developing countries? Evidence from Vietnam

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Abstract

Using firm-level panel data collected in Vietnam bi-annually from 2005 to 2013, this paper examines whether innovation is persistent among small firms in Vietnam. The empirical results obtained from dynamic random effect probit and dynamic random effect ordered probit show that the innovation activity is persistent among these small firms. Our estimation results also show slightly different roles of human capital of firm's owner and employees in innovation activities. While the owner's human capital is associated with creating a new product, employees' human capital is positively correlated with upgrading the existing products or production procedure. However, we do not find evidence on the roles of unobserved heterogeneity in explaining this persistence. Our results are consistent with results found in the literature for firms in developed economies.

Key words: Innovation, Persistence of Innovation, Unobserved heterogeneity, Dynamic Random Effect Probit Model, Dynamic Random Effect Ordered Probit Model, Small and Medium Enterprises, Vietnam

JEL Code: O31, O33, C23, C25, L20

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1. Introduction

Recent literature suggests that observed persistent heterogeneity in firm productivity is partly attributed to the persistent differences in innovation among firms across countries and across firms (Klenow and Rodriguez-Clare, 1997; Hall and Jones, 1999; Parisi et al., 2006). Theoretically, however, there is an opposite view on whether innovation activity is persistent or not. While Romer (1990) supports the view that innovation is persistent at the firm level, Aghion and Howitt (1992) take the view that technological change can be attributed to the process of creative destruction. Empirically, little is known about the dynamics in firms' innovation activity, especially among small firms in developing countries. This paper aims to fill this gap.

In particular, we will examine whether innovation activity is persistent and which factors drive this phenomenon among small firms in a developing country. Using micro-, small- and medium- (MSM) enterprise panel data collected biannually from 2005 to 2013 in Vietnam, and adopting the 'new-to-firm' approach to measure innovation, we find that the innovation activity is persistent among these small firms. This result is consistent with results found in the literature using firm-level data in developed economies. Furthermore, using a dynamic random effects (RE) discrete choice model and a new estimator recently proposed by Wooldridge (2005), we find that unobserved heterogeneity plays a small role in explaining persistence of innovation, but it has a strong association with initial innovation activity conditions. We also find the extent of persistence is slightly lower for firms in low technology industries.

The paper extends the literature by providing empirical evidence on the persistence in innovation among MSM enterprises in developing countries. While there are a rather large number of empirical studies that explore the determinants of innovation activities, only a few look at the permanence of the innovation activities (Peters, 2009). Moreover, all these studies are conducted in developed country context. Meanwhile, current studies relating to innovation in developing countries either explore the determinants of engaging in innovation activities (Almeida and Fernandes, 2008; Gorodnichenko et al., 2010; Ayyagari et al., 2011) or the effect of innovation activities on firm performance. Yet, there are not any studies that aim to find out whether innovation is persistent in these economies or not. To our knowledge, our paper is the first paper to try to study the persistence of innovation activity in developing countries. Furthermore, the dynamic RE approach proposed by Wooldridge (2005), allows us to control for individual heterogeneity in determining the persistence of innovation.

The paper is organized as follows. Section 2 gives a brief of theoretical foundation and related literature on persistence of innovation. The data and variable construction approach are discussed in Section 3. Sections 4 and 5 present our empirical strategy and some stylized facts, respectively. Econometric results are shown in Section 6, followed by some concluding remarks in Section 7.

2. Theoretical foundation and empirical evidence

Theoretically, there are various explanations for the potential state of dependence over time of innovation factors (Peters, 2009). First, successful innovation in the past could help firms to have an advantage over other firms, thus stimulate firms to innovate in the subsequent periods. The advantages could be permanent market power (Phillips, 1971) or improved technological opportunities (Mansfields, 1968) or increased internal funds (Himmelberg and Petersen, 1994). These advantages will further encourage firms to innovate. Second, as argued by Nelson and Winter (1982), knowledge accumulates over time. Past innovation will help firms to increase their knowledge stocks and thus technological capacities, which in turn will allow firms to efficiently accumulate knowledge in subsequent periods (Cohen and Levinthal, 1990). Third, innovation incurs sunk costs, which will act as a barrier to both entry into and exit from innovation (Sutton, 1991 and Peters, 2009). However, there are also some counter arguments for the persistence in innovation (Schmookler, 1966; Reinganum, 1983). Firms may stop innovation since they find that previous innovation is sufficient and the customers do not require anything further. Or, stagnation of demand also prevents firms from carrying out innovation activities.

Although there is extensive theoretical literature that explains the persistence in innovation activities, the empirical evidence is thin. Malerba and Orsenigo (1999) find that only a small fraction of firms were able to persist in patent activities. Similarly, Cefis and Orsenigo (2001) and Cefis (2003) also find a low degree of persistence. They also find that the degree of persistence differs from industry to industry. However, patent activities are only a narrow definition of innovation, since not all inventions are patented. Therefore, Manez Castillejo et al. (2004) extend the definition of innovation by examining R&D activities of Spanish manufacturing firms between 1990 and 2000. They show that past R&D experience had affected the current decision to engage in R&D. Peters (2009) examines the persistence in innovation among manufacturing and service firms and also finds that there exists a state dependence in both groups of firms, and that the state dependency effect is stronger for the firms in the manufacturing sector. Although R&D activities are important, they cannot capture innovation in small firms. Thus, some studies define innovation as new-to-firm innovation such as introducing new products or processes (for example, Konig et al., 1994; Flaig and Stadler, 1994; Duguet and Monjon, 2004; Rogers, 2004; Geroski et al., 1997; Raymond et al. 2006). However, the empirical results are inconclusive.

To our knowledge, all studies so far on the persistence of innovation activities have been carried out in the context of developed countries. Even the literature on factors that determine innovation activities in developing countries is scare. Almeida and Fernandes (2008) examine the relationship between international technology transfer and technological innovation in developing countries. They find that firms that import intermediate inputs are more likely to acquire new technology from their suppliers. Gorodnichenko et al. (2010) look at the impact of foreign market competition on innovation and find a robust evidence of foreign competition and innovation. Ayyagari et al. (2011) analyze the impact of access to finance, competition, and governance. They find that access to external financing and exposure to foreign competition are associated with greater firm innovation. However, data availability does not allow previous studies to investigate the persistence of innovation activity in developing countries.

3. Data sources and variable construction

The data were jointly collected by the University of Copenhagen and two Vietnamese research institutes (Central Institute for Economic Management and Institute for Labor Studies and Social Affairs) in 2005, 2007, 2009, 2011 and 2013. The surveys were conducted in 10 provinces in Vietnam. In each province, the sample was stratified by the form of ownership to ensure that all types of non-state enterprises, including formal and informal firms, were represented. Subsequently, stratified random samples were drawn from a consolidated list of formal enterprises and an on-site random selection of informal firms was made. After each survey round, to replace exit firms or a small number of firms which declined to continue the survey, some firms were randomly selected from a list of formal firms compiled by the Government Statistics Office in the previous year and an on-site selection of informal firms. The sample size for each survey was around 2,500 firms.

Although the sample has been slightly adjusted over time, the questionnaires are nearly the same. Information collected includes the firm's and owner/managers' production, sales and markets, and some other characteristics. The questionnaires also contain questions about innovation activities that the firms have undertaken in the last two years, between surveys.

Measuring innovation

Previously, longitudinal data on innovation activities at the firm level usually covered activities of firms in the form of patent registration and R&D expenditure in developed economies (Ayyagary et al., 2011). Although original innovations (that is, new-to-world innovations) are crucial, imitation in the form of adopting new production technology, or improving quality of the products or introducing some new products are more relevant to firms in developing countries, where most firms are engaged in activities far from the technological frontier (UNCTAD, 2007). We follow Ayyagary et al. (2011) and other literature on innovation in the context of developing economies in adopting the definition of "new-to-firm" innovation. We use three indicators to measure the innovation carried out by firms: (i) introducing a new product, (ii) upgrading existing products, and (iii) upgrading existing production procedure. Furthermore, we also follow Ayyagary et al. (2011) in analyzing two aggregate indices. *Aggregate innovation index 1* is a dummy variable, which takes the value of one if the firm has at least an innovation activities and zero otherwise. *Aggregate innovation index 2* is an aggregate index obtained by summing firm responses to introducing new product, upgrading an existing products and upgrading the production procedure.

Explanatory variables

- Size: The size of the firm is measured as the number of people employed. We also use a dummy variable to indicate whether a firm is a micro-firm or not, that is, firms with fewer than 5 workers. Large firms usually have more advantages in supporting innovation activities.
- Age: Age of the firm is the log of the number of the firm's operation years at the time of the survey. This variable is to capture the learning-by-doing effect on innovation. However, a flat learning curve and being risk averse may hinder firms to innovate.
- Human capital: Percentage of employees with college degree, owners having college degree and owners having technical skills in producing their main products capture human capital of the firms. They reflect the potentials of either employees or owners in innovation activities.

- Sales growth: The sales growth is equal to log of revenue at time *t* minus log of revenue at time *t-1*. The sales growth indicates the firm's market opportunities. Higher growth may boost firms in carrying out innovation to further grasp their current advantage. Higher growth firms may also have a larger pool of internal funds to finance their innovation.
- Capital intensity is the ratio of physical capital to total full-time employees. According to Hall and Ziodonis (2001), firms with large sunk costs would respond strategically by engaging in innovation activity.
- Being an incorporated firm is a dummy variable. It takes the value of one if the firm is either a limited firm or partnership firm or joint stock firm while it is equal to zero if the firm is a household firm or private firm (sole proprietorship). This variable captures the formality of the firm. Incorporated firms tend to serve more competitive market than household firms, which mostly serve on the local customers. Thus, an incorporated firm is more likely to engage in innovation activities than household firms.
- Finally, we also control for firm's location, industry and time dummies.

4. Empirical strategy

In this paper, we use a dynamic RE probit (and dynamic RE ordered probit) model to investigate the persistence of innovation among MSM firms and factors driving this persistence (if any). We will estimate using the following equation:

$$Inn_{it} = \alpha_0 + \alpha_1 Inn_{i,t-1} + \alpha_3 X_{it} + \mu_i + \epsilon_{it} \qquad (1)$$

where Inn_{it} is the innovation indicators of firm i at time t, X_{it} is a vector of firm characteristics, including the firm's age, size, human capital, sales growth, capital intensity, industry and location dummies; μ_i is the unobserved firm characteristics and ϵ_{it} is the error term. In our specification, Inn_{it} can take five values: three binary variables for three individual indicators, one binary variable for our first aggregate innovation index and an ordered variable for our second aggregate innovation index. The estimation equation implies that innovation activity depends on previous innovation $Inn_{i,t-1}$ on observable explanatory variables X_{it} and on unobservable firm characteristics which are assumed to be constant over time and captured by μ_i.

In principle, observed persistence may be attributed to persistence on observable firm characteristics, serial correlation of errors, true dependence or permanent unobserved heterogeneity (Heckman, 1981). One could obtain spurious state dependence rather than true state dependence if permanent unobserved heterogeneity and serial correlation of errors are not well controlled. To deal with this problem, following Wooldridge (2005), we assume the firm heterogeneity (μ_i) to be explained by the following equations:

$$\mu_i = \beta_0 + \beta_1 Inn_{i0} + \overline{X}_\iota \beta_2 + \vartheta_i \quad (2)$$

where Inn_{i0} is the value of the innovation indicator for firm i at time t=0 and $\overline{X}_\iota = \frac{1}{T}\sum_1^t X_{it}$ are vectors of the average over time of the firm characteristics. Substituting equation (2) into equation (1) yields the estimation equations

$$Inn_{it} = (\alpha_0 + \beta_0) + \alpha_1 Inn_{i,t-1} + \alpha_3 X_{it} + \beta_1 Inn_{i0} + \overline{X}_\iota \beta_2 + \vartheta_i + \epsilon_{it} \quad (3)$$

The variables for the average value of firm characteristics are included to control for the unobserved individual effect and their estimated coefficients do not contain meaningful economic implications (Wooldridge, 2005). In this paper, we use the dynamic RE probit to estimate the innovation equation with binary dependent variables (that is three individual innovation indicators and the first aggregate innovation index) while the dynamic RE ordered probit would be used to estimate the equation of ordered dependent variable (that is, the second aggregate innovation indicator.)

5. Descriptive analysis

One limitation of the estimation methods presented above is that it required a balanced sample. Thus, in this paper, we use only balanced samples, which comprised of firms that participated in all five surveys. We also drop firms whose age is below 2 by the time of the first survey (that is, in 2005) (New firms will surely introduce a new product). The data from the 2005 survey is used as the initial conditions. Ultimately, our sample includes 1,198 firms (thus, sample size is 4792). Furthermore, we divided our sample into two groups based on the industry's level of technology. Firms in food processing, garment and textile, leather and wood processing and waste recycle industries are categorized as the firms in low-tech industry group while firms in chemical, metal process, electronics and means of transportation production industries are categorized as firms in medium and high technology group, We have 778 firms (with sample size of 3112) were in the low technology group and 420 firms (with sample size of 1680) in the medium- and high- technology group.

Table 1 presents some descriptive statistics. About 40% of firms in our sample have at least one innovation. While nearly 36% of firms report that they upgraded an existing product in the studied period, only 3.1% and 12.3% of firms in our data introduced a new product and/or upgraded their production process. Nearly 5% of firms in our data have three innovation activities in a given period (data not shown). We also find that firms in low technology group, on average, have lower innovation activities than firms in medium- and high-technology group. We also observe some differences in other variables among firms in two groups. For example, firms in medium and high technologies have larger size, higher growth rate, and higher level of human capital but slightly are younger than firms in low technology industries.

(Table 1 is about here)

To further shed light on the persistence of innovation among MSM enterprises in Vietnam, Table 2 presents the transition probabilities. About 51% of innovators (that is, firms having at least an innovation activity) in this period will continue to be innovator in the next period. However, the persistence of non-innovator (that is, firms having no innovation activity) is stronger. About 72% of non-innovators will still be non-innovators in the next period. Table 2 also indicates that, the propensity to continue innovating given innovating in the previous period (and to become an innovating firms in the next period given being non-innovator this period) of firms in the medium and high technology group is higher than that among firms in low technology group.

(Table 2 is about here)

(Figure 1a and 1b are about here)

Figure 1a and 1b present the survival rates of innovators and non-innovators cohorts by years. The survival rate is the rate that an innovator (non-innovator) at time t continues innovating (not innovating) at time $t+s$ ($s=1...4$, in our case). We see that 52% of firms that innovated in 2005 continue to innovate in 2007 while 78% of non-innovators were still non-innovator in 2007. Only 7% who innovated in 2005 continue to have one innovation activity in 2013, however. This rate is much lower than the survival rates of non-innovators. This may suggest a small state dependence.

6. Econometric results

Tables 3 and 4 present the marginal effects of the dynamic RE probit model for the whole sample and two groups of firms (Panel A and B), respectively. In both tables, the results for each individual innovation indicators are reported in columns 1, 2 and 3, respectively. Column 4 presents the results for our first aggregate innovation indicators. We find that there is no persistence in two innovation indicators: introducing a new product or upgrading the existing production process while there is a state dependence in indicator relating to upgrading an existing product. The estimated coefficient is positive and statistically significant at 1% level. This result implies that, for firms that carried out upgrading their main existing product in the previous period, their the probability of upgrading an existing product of is 6.6 percentage points higher than that of firms that did not. The persistence of this indicator may be attributed to the persistence in our first aggregate innovation index. The coefficient on the lagged aggregate innovation index is also positive and statistically significant. However, the persistence of innovation among firms in our data is much smaller than that found in studies using data from developed countries[2]

(Table 3 is about here)

The estimation results for two groups of firms as presented in Table 4 show a similar pattern, (that is, only the indicator indicating upgrading existing products and aggregate innovation index 1 show a state dependence effects) although the state dependence effects are stronger among firms in the later group.

Our estimation results also show that revenue growth and capital intensity have positive and statistically significant effects on firm's innovation activities and that firms tend not to engage in innovation as they age. These results are consistent with results from Peters (2009) and Ayyagari et al. (2011). While having a college degree has a positive and statistically significant effect on introducing a new product, it does not have any statistically significant effect on other innovation indicators including the first aggregate innovation index. In contrast, the evidence shows that higher percentage of employees with college degree is positively associated with all innovative indicators, except the indicator of introducing a new product. This implies that owner's education matters in introducing new products but the employees' education play an important role in upgrading either existing products or existing production procedure.

(Table 4 is about here)

With regard to the role of unobserved heterogeneity, low values of ρ $\left(=\frac{\sigma_u^2}{1+\sigma_u^2}\right)$ in our estimations indicate that unobserved heterogeneity explains little about the persistence of innovation activities of firms in our data. However, the estimated coefficient on the initial

[2] For example, using German firm-level data, Peters (2009) finds that probability of engaging in an innovation activity in this period, given being an innovator in the last period is 36 percentage points higher than that of non-innovators. Even this figure is much higher for Taiwanese electronic firms at 86 percentage points (Huang, 2009)

condition is positive and statistically significant, implying a substantial relationship between the firm's initial innovation status and the unobserved heterogeneity.

Table 5 reports the marginal effects of the dynamic RE ordered probit model (calculated at the average value of μ_i) at four levels of innovation (outcome 1 indicates that the firm does not have any innovation activities, while outcome 4 means that firm carries out all three innovation activities.) The results further confirm the persistence in innovation activity. The estimated results shows that if the number of innovation activity that firms engaged in the last period increased by 1, the probability that firms will not innovate in the subsequent period is reduced by 3.3 percentage points while probability that firms will engage in one, two and three innovation activities increases by 1.8 percentage points, 1.3 percentage points and 0.2 percentage points, respectively.

(Table 5 is about here)

The estimation results also show a consistency with the results in the previous section. We still find that probability of engaging in innovation activities reduces as firm ages and increases as firm revenue grows. Owner having college degree do not correlate with higher probability of engaging in innovation while the percentage of employees with college degrees will increase firm's probability of carrying out innovation activities

Robustness check

The dynamic RE probit model requires strict exogeneity of explanatory variables, that is, there are no feedback effects from the dependent variables on the future value of the explanatory variables. To assess whether inclusion of variables that potentially violate the strict exogeneity condition, we apply the stepwise procedure. If the marginal effects of lagged dependent variables change significantly as we include potential endogenous variables into the estimation, then the state dependence is spurious. Due to limited space, we only present the results obtained from a specification in which the entire explanatory variables are strictly exogenous such as the firm's age, firm's industry type, location and time (Table 6 for dynamic RE probit and Table 7 for dynamic RE ordered probit). The estimated results show that the marginal effects of lagged dependence variables are changed very slightly. This supports our view of true state dependence of innovation among small firms in our data.

(Table 6 and 7 are about here)

7. Concluding remarks

This paper provides new evidence on the persistence of innovation activity among MSM enterprises in a developing country. Using an estimator of dynamic RE probit and ordered probit models proposed by Wooldridge (2005), the results show that innovations are persistent among the MSM firms. However, not all innovation activities are persistent. While upgrading an existing product in this period will be likely to increase the probability to continue upgrading in the subsequent period, other innovative activities do not show such persistence. We also find the persistence in low-technology industries, as well as medium- and high-technology industries, but the persistence seems to be larger in the later group. However, among the innovation indicators, not all indicators show the persistence. We also do not find a large contribution of unobserved heterogeneity to this persistence since the initial innovation has a strong association with unobserved heterogeneity. Our findings also show that the roles of human capital in the process of innovation are different for owners and employees, although they play a significant role in the whole process of innovation.

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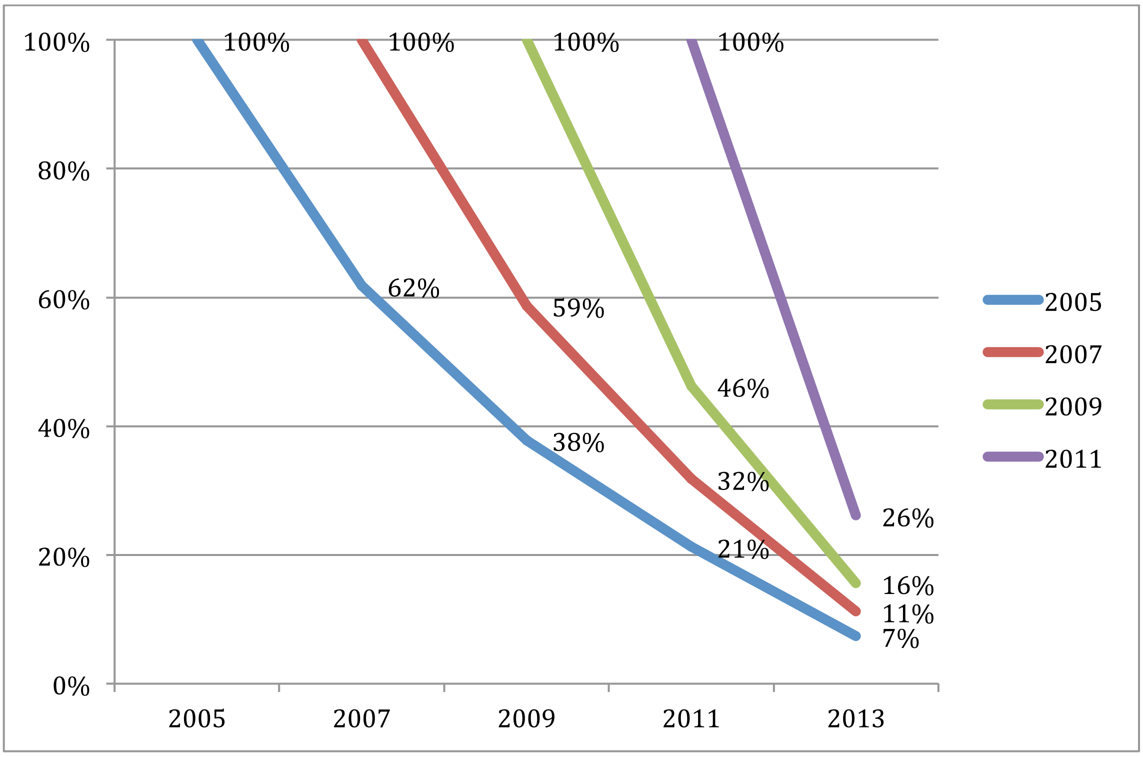
Figure 1: Survival rates of innovator and non-innovator cohorts by year

a. Innovators



b. Non-innovators

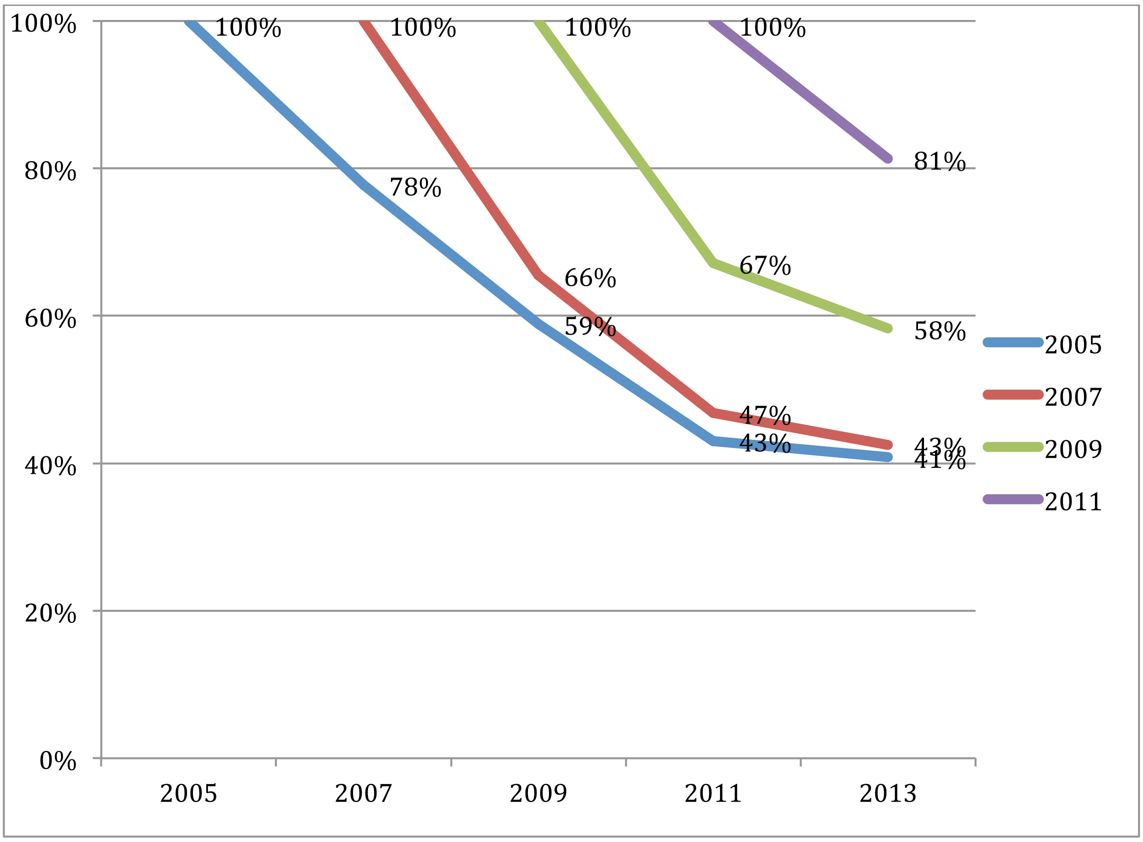


Table 1: Some descriptive statistics

	All sample	Low technology industries	Medium and high technology industries
Introducing new products	3.1%	2.6%	3.7%
	[0.174]	[0.160]	[0.189]
Upgrading existing product	35.7%	31.2%	41.7%
	[0.479]	[0.464]	[0.493]
Upgrading existing production process	12.3%	10.8%	14.8%
	[0.328]	[0.311]	[0.355]
Aggregate innovation index 1	40.0%	35.4%	46.1%
	[0.490]	[0.478]	[0.499]
Aggregate innovation index 2	0.51	0.45	0.60
	[0.701]	[0.668]	[0.740]
Firm's age	22.21	23.35	20.10
	[12.990]	[13.119]	[12.479]
Firm size (log of full time employees)	12.99	11.38	15.97
	[25.162]	[24.377]	[26.303]
Revenue growth	5.64%	4.10%	8.48%
	[1.342]	[1.462]	[1.085]
% employees with college degree	2.79%	1.91%	4.44%
	[0.065]	[0.056]	[0.077]
Owner has college degree	15.78%	12.11%	22.56%
	[0.365]	[0.326]	[0.418]
Owner have technical skills	29.86%	24.74%	39.35%
	[0.458]	[0.432]	[0.489]

Figures in bracket are standard deviations; Low technology industries include food processing, garment, leather, wood processing and waster recycle industries; Medium- and High technology industries include chemical, metal producing, non-metal producing, electronic and other heavy industries.

Table 2: Transition matrix

		All sample	Low technology industry	Medium and high technology industry
Innovator at t	Innovator at t+1	51.7%	49.8%	54.4%
	Non-innovator at t+1	48.4%	50.2%	45.6%
Non innovator at t	Innovator at t+1	27.3%	26.5%	33.7%
	No innovator at t+1	72.7%	73.5%	66.3%

Innovators are firms having at least an innovation activity (that is, introducing new products, upgrading existing products and upgrading existing production procedure.

Table 3: Dynamic RE probit estimator (marginal effects)

	[1]	[2]	[3]	[4]
Dependent variable	Introduce new products	Updating the existing products	Updating the existing production procedure	Aggregate innovation index 1
Lagged dependent variable	-0.002	0.066***	0.011	0.068***
	[0.009]	[0.019]	[0.015]	[0.020]
Value of dependent variable at t=0	0.013**	0.087***	0.036***	0.105***
	[0.006]	[0.017]	[0.011]	[0.018]
Firm age	0	-0.057***	-0.024***	-0.066***
	[0.005]	[0.013]	[0.009]	[0.013]
Firm size (lagged)	0.012	0.036*	0.035***	0.025
	[0.008]	[0.019]	[0.012]	[0.019]
Revenue growth	-0.002	0.030***	0.010**	0.029***
	[0.002]	[0.007]	[0.004]	[0.007]
Capital intensity	0.003	-0.012	0.011**	-0.006
	[0.003]	[0.007]	[0.005]	[0.008]
% employees with college degree	-0.047	0.433***	0.278***	0.405***
	[0.052]	[0.135]	[0.083]	[0.141]
Owner has college degree	0.046**	0	0.017	0.025
	[0.020]	[0.040]	[0.027]	[0.041]
Owner has technical skills	-0.011	-0.043	-0.014	-0.043
	[0.016]	[0.031]	[0.023]	[0.031]
Being a micro firm	-0.002	0.013	0.045**	-0.004
	[0.011]	[0.028]	[0.020]	[0.028]
Being a corporate firm	0.014	-0.007	0.006	0.008
	[0.017]	[0.047]	[0.031]	[0.048]
σ	0.071	0.192	0.157	0.096
	[0.629]	[0.088]	[0.140]	[0.162]
ρ	0.005	0.036	0.024	0.009
	[0.088]	[0.031]	[0.042]	[0.030]
*N*T*	4792	4792	4792	4792

Figures in bracket are standard deviations, calculated using delta method. ***, ** and * denote coefficient significant at 1%, 5% and 10% statistical level, respectively. In all specifications, we include mean of all independent variables. We also include for industry dummies, location dummies and year dummies.

Table 4: Dynamic RE probit estimator (marginal effects), by technology level

	[1]	[2]	[3]	[4]
Dependent variable	Introduce new products	Updating the existing products	Updating the existing production procedure	Aggregate innovation index 1
Panel A: firms in the low technology industries				
Lagged dependent variable	0	0.046**	0.005	0.060***
	[0.011]	[0.023]	[0.018]	[0.018]
Value of dependent variable at t=0	0.013*	0.090***	0.029**	0.097***
	[0.007]	[0.021]	[0.013]	[0.020]
Firm age	-0.001	-0.043***	-0.017	-0.056***
	[0.006]	[0.016]	[0.011]	[0.016]
Firm size (lagged)	0.017*	0.024	0.040**	0.021
	[0.009]	[0.023]	[0.016]	[0.024]
Revenue growth	-0.003	0.032***	0.012**	0.028***
	[0.002]	[0.008]	[0.005]	[0.008]
Capital intensity	0	-0.023**	0.009	-0.019**
	[0.003]	[0.009]	[0.006]	[0.009]
% employees with university degree	0.004	0.483***	0.260**	0.474**
	[0.066]	[0.181]	[0.110]	[0.192]
Owner has college degree	0.047*	-0.028	0.024	0.008
	[0.025]	[0.052]	[0.035]	[0.054]
Owner have technical skills	-0.003	-0.023	-0.001	-0.023
	[0.020]	[0.037]	[0.028]	[0.038]
Being a micro firm	-0.001	0.014	0.041*	-0.012
	[0.013]	[0.033]	[0.023]	[0.034]
Being a corporate firm	0.022	-0.081	-0.006	-0.033
	[0.021]	[0.061]	[0.040]	[0.064]
σ	0.140	0.223	0.127	0.005
	[0.463]	[0.101]	[0.217]	[0.034]
ρ	0.019	0.048	0.016	0.000
	[0.125]	[0.041]	[0.054]	[0.000]
*N*T*	3112	3112	3112	3112

Panel B: firms in medium and high technology industries

Lagged dependent variable	-0.011	0.092***	0.013	0.072***
	[0.016]	[0.025]	[0.021]	[0.025]
Value of dependent variable at t=0	0.011	0.071***	0.057***	0.114***
	[0.011]	[0.027]	[0.019]	[0.030]
Firm age	0.003	-0.064***	-0.038**	-0.068***
	[0.009]	[0.022]	[0.016]	[0.022]
Firm size (lagged)	0.003	0.061*	0.035*	0.037
	[0.014]	[0.033]	[0.021]	[0.031]
Revenue growth	0.005	0.023*	0.003	0.030**
	[0.006]	[0.013]	[0.009]	[0.013]
Capital intensity	0.010*	0.003	0.016*	0.012
	[0.006]	[0.013]	[0.009]	[0.013]
% employees with college degree	-0.139	0.359*	0.298**	0.304
	[0.093]	[0.207]	[0.133]	[0.210]
Owner has college degree	0.042	0.033	0.006	0.045
	[0.036]	[0.065]	[0.045]	[0.063]
Owner have technical skills	-0.035	-0.069	-0.035	-0.071
	[0.031]	[0.054]	[0.040]	[0.053]
Being a micro firm	-0.004	0.011	0.065*	0.017
	[0.022]	[0.050]	[0.038]	[0.049]
Being a corporate firm	0.01	0.092	0.02	0.074
	[0.029]	[0.073]	[0.050]	[0.073]
σ	0.001	0.003	0.003	0.010
	[0.088]	[0.029]	[0.029]	[0.098]
ρ	0.000	0.000	0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.002]
*N*T*	1680	1680	1680	1680

Figures in bracket are standard deviations, calculated using delta method. ***, ** and * denote coefficient significant at 1%, 5% and 10% statistical level, respectively. In all specifications, we include mean of all independent variables. We also include for industry dummies, location dummies and year dummies. We use stata command quadchk to check the accuracy of the results.

Table 5: Dynamic RE ordered probit (Marginal effects)

	[1]	[2]	[3]	[4]
	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Lagged dependent variable	-0.033***	0.018***	0.013***	0.002***
	[0.010]	[0.005]	[0.004]	[0.001]
Value of dependent variable at t=0	-0.043***	0.023***	0.017***	0.003***
	[0.007]	[0.004]	[0.003]	[0.001]
Firm age	0.052***	-0.028***	-0.021***	-0.003***
	[0.012]	[0.007]	[0.005]	[0.001]
Firm size (lagged)	-0.051***	0.027***	0.020***	0.003***
	[0.017]	[0.009]	[0.007]	[0.001]
Revenue growth	-0.023***	0.013***	0.009***	0.001***
	[0.006]	[0.003]	[0.002]	[0.000]
Capital intensity	-0.001	0	0	0
	[0.007]	[0.004]	[0.003]	[0.000]
% employees with college degree	-0.456***	0.247***	0.181***	0.029***
	[0.123]	[0.067]	[0.049]	[0.009]
Owner has college degree	-0.037	0.02	0.014	0.002
	[0.038]	[0.021]	[0.015]	[0.002]
Owner have technical skills	0.045	-0.024	-0.018	-0.003
	[0.030]	[0.016]	[0.012]	[0.002]
Being a micro firm	-0.03	0.016	0.012	0.002
	[0.026]	[0.014]	[0.010]	[0.002]
Being a corporate firm	-0.014	0.008	0.006	0.001
	[0.043]	[0.023]	[0.017]	[0.003]
*N*T*	4792	4792	4792	4792

Figures in bracket are standard deviations, calculated using delta method. ***, ** and * denote coefficient significant at 1%, 5% and 10% statistical level, respectively. Outcome 1 indicates that the firm does not have any innovation activities, while outcome 4 indicates firms having three innovation activities. In all specifications, we include mean of all independent variables. We also include for industry dummies, location dummies and year dummies. We use stata command quadchk to check the accuracy of the results.

Table 6: Robustness of Estimates for the Dynamic RE Probit Model (Marginal Effects)

	[1]	[2]	[3]	[4]
Dependent variable	Introduce new products	Updating the existing products	Updating the existing production procedure	Aggregate innovation index 1
Panel A				
Lagged dependent variable	-0.001	0.072***	0.021	0.075***
	[0.009]	[0.020]	[0.015]	[0.021]
Value of dependent variable at t=0	0.017***	0.122***	0.080***	0.151***
	[0.006]	[0.018]	[0.012]	[0.020]
Firm age	-0.005	-0.082***	-0.045***	-0.094***
	[0.005]	[0.014]	[0.010]	[0.014]
σ	0.160	0.284	0.353	0.237
	[0.287]	[0.066]	[0.077]	[0.074]
ρ	0.025	0.075	0.111	0.053
	[0.087]	[0.032]	[0.043]	[0.032]
*N*T*	4792	4792	4792	4792
Panel B: low technology industries				
Lagged dependent variable	0.001	0.050**	0.017	0.070***
	[0.010]	[0.024]	[0.019]	[0.025]
Value of dependent variable at t=0	0.017**	0.135***	0.063***	0.147***
	[0.007]	[0.022]	[0.014]	[0.023]
Firm age	-0.007	-0.081***	-0.040***	-0.092***
	[0.006]	[0.017]	[0.011]	[0.017]
σ	0.235	0.328	0.308	0.199
	[0.279]	[0.078]	[0.110]	[0.108]
ρ	0.052	0.097	0.086	0.038
	[0.118]	[0.042]	[0.056]	[0.040]
*N*T*	3112	3112	3112	3112
Panel C: Medium and high technology industries				
Lagged dependent variable	-0.01	0.108***	0.025	0.082**
	[0.016]	[0.034]	[0.027]	[0.036]
Value of dependent variable at t=0	0.017	0.089***	0.107***	0.145***
	[0.012]	[0.031]	[0.021]	[0.035]

Firm age	-0.001	-0.083***	-0.057***	-0.094***
	[0.009]	[0.023]	[0.017]	[0.023]
σ	0.002	0.167	0.350	0.233
	[0.026]	[0.157]	[0.120]	[0.123]
ρ	0.000	0.027	0.109	0.051
	[0.000]	[0.050]	[0.067]	[0.051]
*N*T*	1680	1680	1680	1680

Figures in bracket are standard deviations. ***, ** and * denote coefficient significant at 1%, 5% and 10% statistical level, respectively. In all specifications, we also control for industry dummies, location dummies and time dummies. We use stata command quadchk to check the accuracy of the results.

Table 7: Robustness of Estimates for the Dynamic RE ordered Probit Model (Marginal Effects)

	[1]	[2]	[3]	[4]
	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Lagged dependent variable	-0.039***	0.022***	0.015***	0.002***
	[0.010]	[0.006]	[0.004]	[0.001]
Value of dependent variable at t=0	-0.070***	0.039***	0.027***	0.004***
	[0.008]	[0.005]	[0.003]	[0.001]
Firm age	0.080***	-0.044***	-0.031***	-0.005***
	[0.013]	[0.007]	[0.005]	[0.001]
*N*T*	4792	4792	4792	4792

Figures in bracket are standard deviations. ***, ** and * denote coefficient significant at 1%, 5% and 10% statistical level, respectively. Outcome 1 indicates that the firm does not have any innovation activities, while outcome 4 indicates firms having three innovation activities. In all specifications, we also control for industry dummies, location dummies and time dummies. We use stata command quadchk to check the accuracy of the results.