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Innovation Capability of SMEs in Singapore

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Abstract

Singapore performs excellently in the 2020 Global Innovation Index. However, Lim (2016) argues that the innovation capacity between public and private firms are unbalanced. Thus, this paper aims to investigate the innovation capability of Small and Medium Enterprises (SMEs) in Singapore, which is a key component of private sector, accounting more than 70% of total enterprise employment (DOS 2021). Using survey data conducted by ACI, we find that only 26% of 272 SMEs introduced new products or services in 2015. Innovation is concentrated in Food Manufacturing and Retail industries, while Logistics, Precision Engineering and Transport Engineering industries lack of innovation capability. The main drivers for firms to innovate include skilled labour, firm's R&D expenditure and the presence of international competition. These factors will increase the innovation probability by 22%, 17% and 10% respectively.

Keywords: Singapore's SME; Innovation; R&D Expenditure

1 Introduction

Since 1991, Singapore government began to invest in R&D in a structured manner (Lim 2016). Every five year, a Science & Technology plan, which later renamed as the Research, Innovation & Enterprise plan, is established in an effort to position Singapore as an innovation-driven, knowledge-based economy. This continuous effort leads to Singapore's excellent performance in the Global Innovation Index (GII). In 2020, Singapore ranks 8th among the 131 economies, and ranks first in the innovation input sub-index. However, regarding the innovation output, Singapore only ranks 15th. In this regard, transferring innovation input into output remains to be a challenge to Singapore.

The government-led development mode of Singapore's innovation system results in an unbalanced innovation capacity between public and private sector (Lim 2016). In 2018, 75 public institutions reported a total R&D expenditure of 3.6 billion. Meanwhile, 857 private companies reported that they spent 5.6 billion on business R&D expenditure in total. On average, a public institution invests 7 times more on R&D than a private firm. However, to further boost Singapore's innovation capability, private sector, especially the innovation of SMEs is crucial.

Small and Medium Enterprises (SMEs) are defined as companies with at least 30% local shareholding and group annual sales turnover of not more than $100 million or group employment size of not more than 200 employees (Skills Connect 2014). In 2020, there are 279.7 thousand small and medium-sized enterprises (SMEs) in Singapore. They provided 2.36 million jobs, which accounts for 70% of total enterprises employment, and contributed to 183 billion dollars value added (DOS 2021). However, as a key component of the private sector,

its innovation capacity is deficient. In this working paper, we intend to study the factors that affect the innovation in SMEs.

Various literature has discussed the firm's innovation capability. One of the most well-known propositions is the Schumpeterian Hypothesis which states that larger firms are more likely to generate innovation (Scherer and Ross 1970). Many studies attempt to test this hypothesis, however, controversial results are found. For instance, Holmstrom (1989) argues that comparing to smaller firms, large firms encounter higher incentive costs, which place them at comparative disadvantage in terms of innovation. Hansen (1992) uses survey data from the US National Science Foundation and finds negative relationship between firm size and number of new products. On the contrary, the study of Oum, Narjoko, and Harvie (2014) supports the Schumpeterian Hypothesis. There are also scholars claim ambiguous relationship between firm size and innovation, such as Wan, Ong, and Lee (2005) who use Singapore data and find that firm size does not exhibit a significant relationship with innovation. Utilizing Spanish data, Martínez-Ros and Labeaga (2002) point out that firm size has a non-linear effect.

Other factors relating to innovation, such as firm age, skilled labour, R&D expenditure, industry concentration, unionization, capital intensity, and internationalisation are also studied. Most existing papers show evidence that younger firms are more likely to innovate. These include evidence from the US (Hansen 1992), Spain (Huergo and Jaumandreu 2004), Israel (Shefer and Frenkel 2005), and ASEAN and China (Oum, Narjoko, and Harvie 2014). This is usually because younger firms incline to invest more in R&D activities (Shefer and Frenkel 2005). Skilled labour is shown to have a positive relationship to innovation, as studied by Acs and Audretsch (1988) and Oum, Narjoko, and Harvie (2014). Acs and Audretsch (1988) employ US Small Business Administration data and find R&D expenditure positively affects innovation while industry concentration and unionization negatively affects it. Utilizing data from the Netherlands, Dijk et al. (1997) find capital intensity affects small-firm R&D but not large-firm R&D. For small firms, a significantly negative effect is detected. Internationalisation is found to raise the firms' tendency to innovate with survey data in 10 economies in Eastern Europe and Central Asia (Boermans and Roelfsema 2015).

However, evidence from Singapore is scant. Therefore, in this working paper, we utilize ACI survey data to empirically test the factors that might affect firm innovation capability in Singapore. The data was collected in 2017 and contains information of 272 SMEs in Singapore. A linear probability model (LPM) is first utilized to study the firms' probability to innovate, and then a Probit and a Logit model are employed to compensate for the limitations of LPM. Given the available survey data, we are interested in the following variables: firm size, firm age, higher education rate of employees, research and development (R&D) expenditure, capital intensity, and internationalisation. In addition, we also control for industry specific effect. Our study finds that skilled labour, R&D expenditure, and internationalisation are significantly related to higher probability of innovation. On the other hand, capital intensity is found to have a negative but minor effect. We find firm size positively relates to innovation in the Probit model, but such effect vanishes in the LPM and Logit model. Contrary to literature, firm age is insignificant towards innovation in our study.

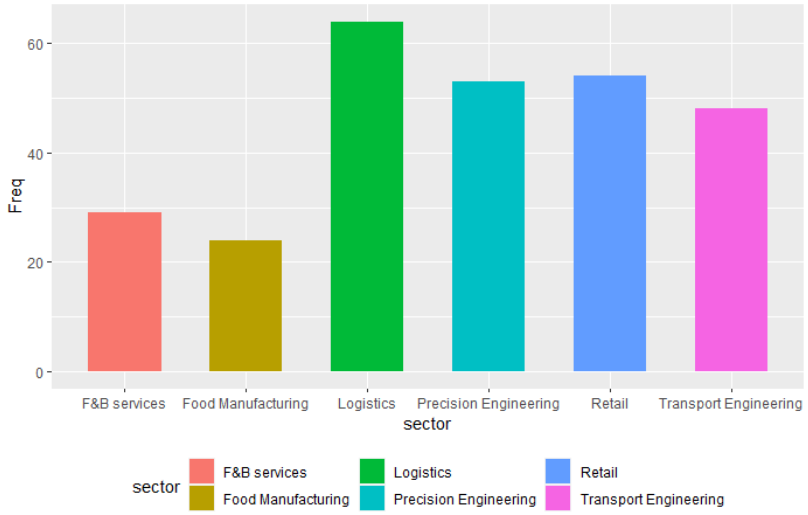
This working paper serves as a sample study and the methodology in this paper could be expanded to other counties and regions in ASEAN to conduct further research. The data and

analysis in this paper might be updated and revised in the future as ACI is planning to conduct another round of survey soon.

The rest of the paper is structured as follows. Section 2 describes the dataset used in the analysis and specifies the econometrics models. The regression results and interpretation are reported in Section 3. Section 4 concludes.

2 Data and Methodology

ACI conducted a survey to SMEs in Singapore in 2017 and received 272 successful responses. These 272 firms, covering six sectors including food and beverage (F&B) services, food manufacturing, logistics, precision engineering, retail, and transport engineering, serves as the foundation of this study.



Source: Asia Competitiveness Institute

Figure 1 Distribution of sample SMEs across sectors.

The indicator used to measure firm innovation is generated from the question "Number of new products and services launched". According to Martínez-Ros and Labeaga (2002), one of the advantages of this measurement is that it captures the innovation activities more precisely, since not all innovation end up in patents. This is especially the case as we are studying SMEs and about 20% of them are in food production and services industry. In addition, since 74% of the firms responded zero new product or service being produced in 2015, we treat this indicator as binary.

In literature, conventionally there are two ways of measuring firm size. One way is to measure firm sales, and the other way is to measure number of employees. Following Hansen (1992), we use the latter measurement.

The survey question, number of full-time employees with tertiary education, is where the skilled labour indicator generated from. In this paper, we use percentage of employees with tertiary education as the measurement for this indicator.

To control for the idiosyncratic characteristics of the firms, R&D expenditure, capital intensity and internationalisation are included. As discussed earlier, all these factors affect innovation capacity. Additionally, we also control for industrial groups as we believe the cost of innovation in different sectors varies which could affect innovation output. For instance, the cost of generating a new product in precision engineering could be much higher than that in F&B services. Table 1 shows the descriptive statistics and table 2 demonstrates the correlation matrix.

Table 1 Descriptive statistics.

Variables	Definition	Obs.	Mean	Max	Min	Std.Dev.
new	1 = has new products or services launched in 2015; 0 = otherwise	272	0.26	1	0	0.44
employment	Number of employees	272	82.75	1683	1	153.06
higher_education_rate	Percentage of employees with tertiary education	272	0.36	1	0	0.32
firm_age	Number of years the firm has founded	272	23.69	83	4	12.01
R&D expenditure	1 = has R&D expenditure in 2015; 0 = otherwise	272	0.07	1	0	0.26
capital_intensity	Total assets/sales revenue	272	132580.3	8552730	44.56	683856.8
Internationalisation	1 = operates overseas; 0 = otherwise	272	0.25	1	0	0.43

Source: Asia Competitiveness Institute

Table 2 Correlation matrix.

	new	employment	higher education rate	firm age	R&D expenditure	capital intensity	internationalisation
new	1						
employment	0.1043	1					
higher education rate	0.146	-0.1895	1				
firm age	-0.0763	0.0274	-0.1289	1			
R&D expenditure	0.1625	0.2308	-0.0152	0.0696	1		
capital intensity	-0.0789	-0.0475	0.0651	0.0093	0.0007	1	
internationalisation	0.1212	0.0218	0.0373	0.0923	0.1111	0.0479	1

Source: Asia Competitiveness Institute

Given that the dependent variable is binary, similar to the methodologies adopted by Martínez-Ros and Labeaga (2002), Rogers (2004), and Oum, Narjoko, and Harvie (2014), we employ a probit and logit framework as specified in equation (1) – (3). As a comparison, a linear probability model is also estimated.

$$P(new_i = 1|X) = G(\beta_0 + \beta_1 employment_i + \beta_2 higher\_education\_rate_i + \beta_3 firm\_age_i + \beta_4 capital\_intensity_i + \beta_5 rdexpenditure_i + \beta_6 internationalisation_i + \delta_i) \quad (1)$$

$$G(z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} \exp\left(\frac{-u^2}{2}\right) du \quad (probit) \quad (2)$$

$$G(z) = \frac{\exp(z)}{1 + \exp(z)} \quad (logit) \quad (3)$$

The right-hand side of Equation (1) is a set of independent variables that might affect the firms' innovation capacity. *Employment*$_i$ represents firm size. It measures the number of employees in firm i. *higher_education_rate*$_i$ measures the percentage of employees with tertiary education. *firm_age*$_i$ is the number of years firm i has founded. *capital_intensity*$_i$ measures the assets needed for one unit of sales. *rdexpenditure*$_i$ is a binary variable which records whether firm i invested in R&D in 2015. *Internationalisation*$_i$ is another binary variable that represents whether the firm operates overseas. Finally, δ_i controls for the industrial groups which includes (1) F&B services, (2) food manufacturing, (3) logistics, (4) precision engineering, (5) retail, and (6) transport engineering. This is because the cost of innovation in different industries varies which could lead to different probability in innovation.

A positive sign of the coefficient signifies a positive relationship between the indicator and the likelihood of new products, and a negative sign indicates otherwise. Subsequently, the Average Partial Effect (APE) can be calculated to determine the direct effect of an indicator.

G(z) is a cumulative distribution function which takes values between zero and one. Equation (2) specifies the G(z) for probit model. Equation (3) specifies the G(z) for logit model.

3 Empirical Results

Applying data to the above-mentioned framework gives us the results in table 3. Most indicators are significant, including higher education rate, R&D expenditure, capital intensity, and internationalisation. As expected, the coefficient of higher education rate is positive and significant in all three models, which is consistent with the literature that skilled labour facilitates innovation. Similarly, R&D expenditure and internationalisation also exhibit positive impacts on new products and services. Capital intensity, on the other hand, is significant but with a negative sign. This result supports the finding of Dijk et al. (1997) which states that high capital intensity hampers the entry of new, small and innovative firms, and thus discourages innovation.

However, the effect of firm size is inconclusive. The significance of this indicator varies across the LPM, Probit, and Logit models and only in the Probit model and at 90% level is firm size significant. It seems that size might have some positive impact on innovation, although the results are not stable once alternative models are employed. Meanwhile, our findings also show no significant effect of firm age which contradicts with most of the literatures.

Table 3 Regression results of LPM, Probit, and Logit model.

Dependent variable: new	Model (1) LPM	Model (2) Probit	Model (3) Logit
employment	0.0003	0.0011*	0.0020
	(0.0002)	(0.0007)	(0.0012)
higher_education_rate	0.2209**	0.7552***	1.2921***
	(0.0868)	(0.2767)	(0.4723)
firm_age	-0.0028	-0.0110	-0.0183
	(0.0023)	(0.0081)	(0.0137)
rd_expenditure	0.2025*	0.5901*	0.9557*
	(0.1199)	(0.3349)	(0.5544)
capital_intensity	-0.0000***	-0.0000*	-0.0000*
	(0.0000)	(0.0000)	(0.0000)
internationalisation	0.1072*	0.3175*	0.5739*
	(0.0629)	(0.1930)	(0.3240)
2.sector	0.2953**	1.1313***	1.9017***
	(0.1158)	(0.3888)	(0.6813)
3.sector	0.0812	0.4655	0.7643
	(0.0801)	(0.3394)	(0.6126)
4.sector	0.1030	0.5664	0.9462
	(0.0927)	(0.3676)	(0.6612)
5.sector	0.1509	0.6449*	1.0497*
	(0.0917)	(0.3429)	(0.6247)
6.sector	0.1049	0.5835	0.9628
	(0.0909)	(0.3609)	(0.6559)
constant	0.0813	-1.3762***	-2.3046***
	(0.0727)	(0.3293)	(0.6004)
R^2	0.106	0.104	0.103
N	272	272	272

Notes: (1) Robust standard errors in parentheses; (2) * p<0.10, ** p<0.05, *** p<0.01
(2) McFadden R^2 for probit and logit model

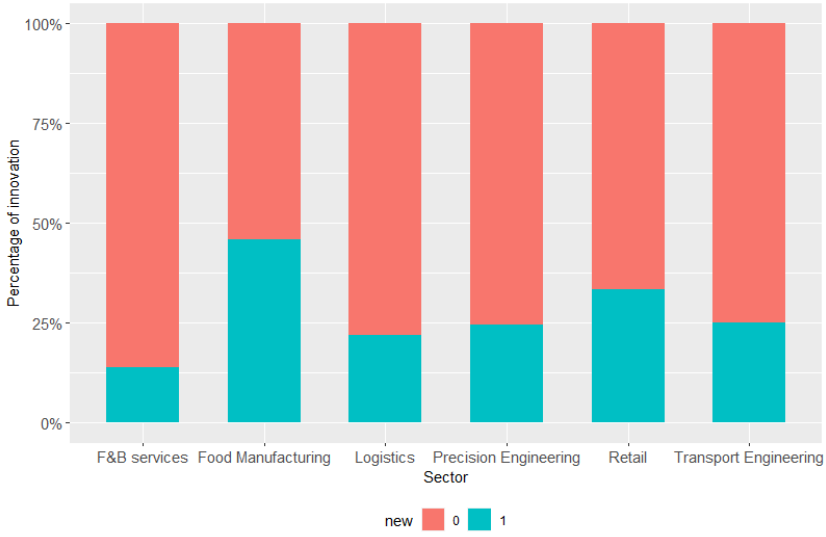
Table 4 reports the average partial effect of all the indicators. For every additional employee in SMEs, the probability of having new products or services increases by 0.03%. The effect of skilled labour is quite large, which accounts for approximately 22% increase in firm innovation for one percent increase in the proportion of employees with tertiary education. Engaging in R&D expenditure increases the probability of innovation by 20%, 17%, and 16% respectively as measured by LPM, Probit, and Logit model. Engaging in internationalisation boosts such probability by 11%, 9%, and 10%. The marginal effect of capital intensity is rather small. This means that although capital intensive firms tend to be less innovative, the actual impact of this indicator is slim.

Table 4 Average partial effect of independent variables.

Dependent variable: new	Model (1) LPM	Model (2) Probit	Model (3) Logit
employment	0.0003	0.0003*	0.0003*
	(0.0002)	(0.0002)	(0.0002)
higher_education_rate	0.2209**	0.2207***	0.2220***
	(0.0868)	(0.0779)	(0.0773)
firm_age	-0.0028	-0.0032	-0.0031
	(0.0023)	(0.0024)	(0.0023)
rd_expenditure	0.2025*	0.1724*	0.1642*
	(0.1199)	(0.0962)	(0.0935)
capital_intensity	-0.0000***	-0.0000*	-0.0000*
	(0.0000)	(0.0000)	(0.0000)
internationalisation	0.1072*	0.0928*	0.0986*
	(0.0629)	(0.0552)	(0.0539)
2.sector	0.2953**	0.3298***	0.3283***
	(0.1158)	(0.1087)	(0.1084)
3.sector	0.0812	0.1093	0.1023
	(0.0801)	(0.0740)	(0.0750)
4.sector	0.1030	0.1386	0.1332
	(0.0927)	(0.0855)	(0.0873)
5.sector	0.1509	0.1627**	0.1519*
	(0.0917)	(0.0810)	(0.0833)
6.sector	0.1049	0.1438*	0.1362
	(0.0909)	(0.0851)	(0.0876)
N	272	272	272

Notes: (1) Robust standard errors in parentheses; (2) * p<0.10, ** p<0.05, *** p<0.01

We also notice that different sectors are subject to different probability of generating new products or services. Using F&B services as the base, we find that food manufacturing and retail are roughly 30% and 15% more likely to innovate. Figure 2 confirms that a higher proportion of firms, 46% and 33% respectively, in these two sectors had new products or services in 2015, while the percentage of firms with innovations in the other four sectors are all below 25%. This is plausible as food manufacturing and retail industry tend to evolve rapidly to cater for the different preferences of customers. Also, the cost of generating innovation in these two industries might be lower compared to the other manufacturing and engineering industries, as the it might be less costly to invent a new flavor than to invent a whole new machine.



Source: Asia Competitiveness Institute

Figure 2 Number of firms with new products or services in 2015 (by sector).

4 Extension

In this section, we will present a biprobit model using firm's number of new products or services and R&D expenditure, because the two variables may be correlated in the following ways: (1) new products or services may induce more R&D expenditure, and (2) R&D expenditure may lead to new products or services. Wald test shows a significant correlation of the two dependent variables at 0.346 (Table 5). The regression results on the number of new products or services are very similar to those in Table 4. However, only larger firms would like to invest more in R&D. The other factors such as skilled labour and internationalisation will not significantly induce firms to do more research.

The biprobit model would determine the joint probability of two dependent variables. Table 6 shows the average partial effect of the independent variables. It is interesting to note that skilled labour and internationalisation will reduce the joint probability of making no new products or services and no R&D expenditure by 21.6% and 12.0% respectively. The effect of a larger firm size is marginal, only reducing this probability by 0.05%. The results also shows the importance of internationalisation, to survive in the global competition, firms are more likely to both invest in R&D and introduce new products or services.

Table 5 Regression results of Biprobit model

Dependent variable:	Model (1)	Model (2)
	New	R&D Expenditure
Firm age	-0.0102	0.00719
	(-0.00812)	(-0.00898)
Employment	0.00134**	0.00231***
	(-0.00058)	(-0.00078)
Higher education rate	0.756***	0.0894
	(-0.276)	(-0.322)
Internationalisation	0.347*	0.411
	(-0.193)	(-0.267)
Capital intensity	-1.19e-06*	9.15E-08
	(-6.61E-07)	(-1.22E-07)
2.sector	1.186***	0.973**
	(-0.385)	(-0.45)
3.sector	0.47	0.366
	(-0.336)	(-0.455)
4.sector	0.617*	0.896*
	(-0.362)	(-0.458)
5.sector	0.678**	0.792*
	(-0.329)	(-0.457)
6.sector	0.577	-0.149
	(-0.352)	(-0.531)
Constant	-1.396***	-2.654***
	(-0.322)	(-0.36)
Obs.	272	272
Rho	0.3457726	
Wald test of rho=0: chi2(1) = 4.88874; Prob > chi2 = 0.0270		

Notes: (1) Robust standard errors in parentheses; (2) * p<0.10, ** p<0.05, *** p<0.01

Table 6 Average partial effect of independent variables

	Prob(new=0, R&D=0)	Prob(new=0, R&D=1)	Prob(new=1, R&D=0)	Prob(new=1, R&D=1)
Firm age	0.0024	0.0006	-0.0032	0.0001
Employment	-0.0005***	0.0001*	0.0003	0.0001***
Higher education rate	-0.2164***	-0.01	0.2076***	0.0189
Internationalisation	-0.1204**	0.0165	0.0798	0.0242*
Capital intensity	0.0000*	0	-0.0000**	0

Notes: (1) * p<0.10, ** p<0.05, *** p<0.01

5 Conclusion

Since Simon Kuznets (1962), scholars have been discussing the factors affecting innovative output, measured by new products or patents. These innovation-inducing factors include R&D expenditure, market concentration, capital intensity, firm size, skilled labour and industrial groups. This paper examines the innovation capability of Small and Medium Enterprises (SMEs) in Singapore, using firm-level number of new products and services as the output and some of the aforementioned factors as the inputs. Our research shows that higher education rate among employees, R&D expenditure, and internationalisation significantly facilitate innovation, which account for roughly 22%, 17%, and 10% of increase in the likelihood of innovation. Capital intensity negatively affect SMEs' innovation capacity, but the impact is rather small. However, our research shows no robust evidence on the impact of firm size and firm age. We here at ACI are to conduct another survey to further investigate these issues.

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