ERIA-DP-2018-17

ERIA Discussion Paper Series

Product Innovation, Exporting, and Foreign Direct Investment: Theory and Evidence from China

Sizhong SUN[*†]

College of Business Law and Governance,

James Cook University, Australia

March 2019

Abstract: *This paper explores the inter-connection between domestic firms' product innovation, exporting, and the presence of foreign direct investment (FDI). We first set up a theoretical model where, in a monopolistically competitive market, heterogeneous firms first make an optimal decision on product innovation and then set prices for their products in both the domestic and foreign markets. Under mild assumptions, the theoretical model generates a set of population moments, which are applied using data on eight three-digit manufacturing industries in China. We find evidence that firms' product innovation is positively correlated with their export revenue, and the presence of FDI affects firms' product innovation and export behaviour both directly and indirectly (via its impact on product innovation), albeit not in all industries. The findings have significant implications for policymakers, not only in China but also other developing countries.*

Keywords: Firm heterogeneity; sorting pattern; product innovation; exporting; FDI; China
JEL Classification: O31; F14; L20; D22

[*] Corresponding author. Sizhong Sun, address: College of Business Law and Governance, James Cook University, 1 Angus Smith Drive, Douglas, 4811, Queensland, Australia. Phone: 61-7-4781 4710; Fax: 61-7-4781 4019. E-mail: sizhong.sun@jcu.edu.au
[†] This research was conducted as a part of the project of the Economic Research Institute for ASEAN and East Asia (ERIA), 'Export Dynamics and Export Industry Development'. The author would like to thank Sadayuki Takii, Chin Hee Hahn, Dionisius Narjoko, and participants of the ERIA Microdata Research Project Workshops for their comments and suggestions. The opinions expressed in this paper are the sole responsibility of the author and do not reflect the views of ERIA.

1. Introduction

Industrial innovation plays a vital role in economic development and is a key source of competitiveness in the market. For firms, a successful innovation may lead to higher quality products or lower production costs, which in turn create advantages against their competitors in the market. For policymakers, innovation is a major driving force of growth, and policies, such as direct subsidies and tax credit, can be implemented to promote innovative activities, e.g. research and development (R&D).

Innovation activities have both an input perspective (namely activities, such as R&D,[1] that generate innovative outcomes) and an output perspective (namely the output of the innovative activities, such as patents[2]). From the output perspective, the Organisation for Economic Co-operation and Development (OECD) and Eurostat (2005) categorise innovation into four types: product innovation[3], process innovation, marketing innovation, and organisational innovation. The clear conceptualisation of these four types of innovation allows researchers to explore them separately. Nevertheless, there is still a lack of empirical studies, particularly in developing countries, possibly due to a lack of data. For instance, to examine organisational innovation, researchers require data on the organisational structure within a firm, which are difficult to obtain. In this paper, owing to the availability of detailed firm-level data, we contribute to the growing literature on innovation by exploring firms' product innovation in China.

For firms, conducting product innovation is not a trivial activity. It requires substantial fixed costs, such as setting up laboratories and hiring highly skilled personnel. Not surprisingly, better-endowed firms are more capable of product innovation. In other words, we can expect a sorting pattern that more capable firms innovate, while less capable firms do not. Besides, firms with successful product innovation are likely to be more competitive in both the domestic and export markets. Therefore, we expect firms' product innovation and export behaviour to be

---

[1] R&D activities have been explored from different angles by researchers, such as R&D and productivity (see for example Aw, Roberts, and Xu, 2008, 2011; Doraszelski and Jaumandreu, 2013; Griliches, 1980).
[2] Patents have also been investigated extensively, for instance, to name a few, Kremer (1998), Galasso, Schankerman, and Serrano (2013), Choi and Gerlach (2015), and Galasso and Schankerman (2015).
[3] Product innovation is defined as 'a good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user friendliness or other functional characteristics' (http://www.oecd.org/site/innovationstrategy/defininginnovation.htm).

positively correlated. Later, in Section 4, we indeed observe such a pattern[4] from the data.

Regarding exporting, a typical fact is that in the same industry, no matter how narrowly defined, there always exist firms that export and firms that do not, which cannot be explained by models with representative firms. Recently, pioneered by Melitz (2003), models with heterogeneous firms have captured this stylised fact, leading to the deep insight that more productive (capable) firms serve both domestic and export markets, while less productive (capable) firms sell only in the domestic market.

Contributing to this strand of research, we extend firm heterogeneity from one dimension (endowment of production capability/productivity) to two dimensions (endowments of production and innovation capability), and discover a richer sorting pattern, where more production-capable and innovation-capable, more production-capable and less innovation-capable, and less production-capable and more innovation-capable firms innovate and export. The complementarity of production and innovation capability results in a positive correlation between product innovation and exporting.[5]

In more detail, firms are endowed with a two-dimensional capability, namely production and innovation capability, and compete in monopolistically competitive markets. Consumers' constant-elasticity-of-substitution (CES) preference generates a demand function, faced with which firms are engaged in a two-stage game. At stage one, firms set prices for their outputs, and at stage two firms make an optimal decision regarding product innovation. Firms' optimal profit, together with the fixed costs of production, innovation and exporting, yields a pattern where more capable firms innovate/export, and innovating (exporting) firms are more likely to export (innovate). This positive correlation arises due to the complementarity between innovation and production capability. That is, a firm with low production (innovation) and high innovation (production) capability will export. In addition, such positive correlation exists despite the endowments of production and innovation capability being independent of each other.

In exploring firms' product innovation and export behaviour, we focus particularly on the role of the presence of inward foreign direct investment (FDI). That is, this paper intends to explore the inter-relationship between the presence of FDI and firms' product innovation and exporting. Conceptually, if the presence of FDI generates positive productivity spillovers

[4] That is, not all firms innovate and there is a positive association between product innovation and exporting.
[5] Note this is not causality. Both product innovation and exporting respond to the same underlying structural forces, and as such they are correlated.

to domestic firms, then it is likely that FDI presence will promote firms' product innovation and export activities, which creates a positive correlation between product innovation and exporting, re-enforcing the positive correlation implied by firm heterogeneity.[6]

Our theoretical modelling generates a set of moment conditions under some mild assumptions. With the set of population moments, we then take the model to data from China's manufacturing sector. Our empirical estimation investigates the inter-relationship between the presence of FDI and firms' product innovation and export, and can answer questions such as: (1) Does the presence of FDI promote domestic firms' product innovation behaviour? If yes, to what extent? (2) Whether/to what extent does the FDI presence affect domestic firms' exporting? (3) Is it more likely for a firm with product innovation to participate in exporting? If yes, to what extent? Note that if the answers to these questions are all 'yes', then we identify a channel through which the presence of FDI can affect domestic firms' export participation, namely via its impact on domestic firms' product innovation.

The identification strategy, implied from the theoretical modelling, is robust. We utilise Monte Carlo simulations to evaluate the power of identification, namely the probability that true parameters fall within the 95% confidence intervals of the estimates. In particular, we allow for several departures from the assumptions in theoretical modelling, such as the endowments are drawn from log-normal distributions rather than the uniform distributions of theoretical modelling. In the Monte Carlo simulations, the identification powers are generally high, suggesting robustness of our identification strategy.

There are a number of existing studies on the productivity spillovers of FDI (see for example Caves, 1974), its impact on exporting (see for example S. Sun, 2009), the export behaviour of heterogeneous firms (see for example Melitz, 2003), and product innovation (see for example the product-cycle models such as Krugman, 1979). Nevertheless, there is a lack of research that combines all these three aspects. Therefore, this study contributes both theoretically and empirically to the existing literature by shedding light on a better understanding of the inter-connection of product innovation, exporting, and FDI presence, three important aspects of economic development. Particularly, we discover a sorting pattern of firm product innovation and export behaviour and complementarity between them.

This study focuses on China. As a large developing economy, China has experienced solid economic growth in the past three decades, with substantial exports and FDI inflows. In

[6] It is also likely that FDI dampens the positive correlation between product innovation and exporting. For example, FDI positively affects exporting and negatively affects product innovation.

this dynamic growth environment, to what extent are firms engaged in innovative activities, and how is innovation related to the presence of FDI and exporting? A better understanding of these issues will provide significant implications for both policymakers and business managers, not only in China but also other developing countries.

The rest of this paper is organised into eight sections. Section 2 briefly reviews the related literature and identifies the gaps. Section 3 reports the background information, namely on FDI inflows, exports, and innovation activities in China. Section 4 examines some stylised facts regarding exporting, product innovation, and the presence of FDI. In Section 5, we construct a theoretical model where heterogeneous firms in a monopolistically competitive market, in the presence of FDI, endogenously select their product innovation and export participation. The theoretical model provides guidance for subsequent empirical modelling. Section 6 sets up the empirical model and discuss the estimation/identification strategy. Section 7 presents the dataset, describing the construction of the variables and the summary statistics of these variables. In Section 8, we discuss the findings, conduct robustness checks, and draw policy implications. Section 9 concludes the paper.

2. Related Literature

The study is related to three strands of existing literature, namely the strands of research on product innovation, exporting behaviour, and FDI spillovers.

Product innovation is naturally embedded in Vernon's (1966) concept of the product cycle, which a number of studies explore theoretically.[7] Krugman (1979) investigated the product cycle trade in a North-South model, where the North produces and exports new products and the South exports old products. Antràs (2005) brought in the influence of incomplete contracts on the product cycle and discovers that the contractual frictions result in goods initially being produced within the product-development country before shifting abroad first within firm boundaries and later to other firms. With non-homothetic preferences, Demmou (2012) showed that via product innovation, the North is able to affect world demand such that the South benefits less from the international trade.

[7] In addition to trade, researchers also examine other issues in the product cycle models. For example, Grossman and Helpman (1991a, 1991b) endogenise the product cycle and explore the interaction between innovation and imitation. Butler (1997) and Zhu (2004) are concerned with the concept that product cycles can deteriorate income inequality. Helpman (1993), Gustafsson and Segerstrom (2011), Branstetter and Saggi (2011) and Bilir (2014) explore the influence of intellectual property rights (IPR) protection.

Compared with theoretical studies on product cycles, empirical studies appear to be relatively scarce. Lee and Stone (1994) tested the impact of product and process innovations on prices, wages, sales, and exports using data from 11 two-digit manufacturing industries in the United States from 1974 to 1988. Using four-digit disaggregated trade data, Gagnon and Rose (1995) found a high degree of persistence in the disaggregated international trade balances, which contradicts the prediction of the product-cycle trade model. Feenstra and Rose (2000) developed a ranking technique to rank countries and commodities using disaggregated American import data, where the result is found to be consistent with the product-cycle international trade theory.

In addition to the product cycle trade models, researchers also examine innovation and trade from other perspectives. Egger and Keuschnigg (2015) examined how financial constraint affects innovation and trade theoretically. Li and Robles (2007) investigated how parallel trade affects product innovation. Empirically, Lachenmaier and Wößmann (2006) found that innovation promotes exports by German manufacturing firms.

In the product cycle models of international trade, new products appear to be new to the whole economy. In contrast, the definition of new products in our study conforms to the OECD definition. In this study, new products are new to the firm and may (not) be new to the whole economy. Besides, the product cycle strand of studies usually looks at the cross-country pattern of trade, while in contrast we will focus on micro (firm) level behaviour.

The second strand of research to which this study is linked is that on firm exporting behaviour. The product cycle models generate a cross-country trade pattern in which the North, where the innovation takes place, exports new products, while the South, where imitation takes place, exports old products. At the firm level, recently, firm heterogeneity has been shown to play an important role in firm exporting behaviour. That is, there exists a sorting pattern along the productivity dimension, where more productive firms serve both the domestic and foreign markets while less productive firms sell only in the domestic market (see for example Ederington and McCalman, 2008; Helpman, Melitz, and Yeaple, 2004; Lu, Lu, and Tao, 2010; Melitz, 2003; Melitz and Ottaviano, 2008; Yeaple, 2005). Compared with models with representative firms, firm heterogeneity models account for the empirical fact that not all firms export, even in the same industry. As such, firm heterogeneity is also widely accounted for in empirical studies (amongst others, see for example Das, Roberts, and Tybout, 2007; Eaton, Kortum, and Kramarz, 2011; Johnson, 2012; Kee and Tang, 2016).

Following this strand of research, we model firms’ exporting behaviour by accounting for firm heterogeneity in this study. Different from many previous studies, we allow for two-dimensional firm heterogeneity[8] – production capability (productivity) and innovation capability heterogeneity. In our study, the two-dimensional heterogeneity generates a richer sorting pattern that replicates the stylised fact from the data; namely, not all firms export/innovate, and there exists positive correlation between product innovation and export.

As more productive firms export, one expects factors that affect a firm's productivity will also affect a firm's exporting behaviour. One of these such factors is the presence of FDI, namely FDI productivity spillovers, the third strand of research to which this study is related. Pioneered by Caves (1974), a large volume of studies is dedicated to discovering the productivity spillovers of FDI. However, the empirical testing has found mixed results in the sense that some find positive spillovers, while others find negative or non-existent spillovers.[9] For China, many studies find positive productivity spillovers, for example Buckley, Clegg, and Wang (2002; Buckley, Clegg, and Wang), Chuang and Hsu (2004), and Anwar and Sun (2014). Positive productivity spillovers from FDI imply that more firms will participate in exporting, and the exporting firms will export more, namely positive export spillovers. In China's manufacturing sector, Sun (2009, 2010, 2012) found evidence of such positive export spillovers.

The empirical subject of this research is China. In addition to the above-discussed studies on FDI spillovers, a number of previous studies investigate the innovation activities at the firm level in China, for example Wang and Lin (2013) on technological innovation, Fu, Diez, and Schiller (2013) on informal network and innovation, Sharif and Huang (2012) on innovation and firm survival and relocation, Fang and Ge (2012) on union and innovation, and Sun and Du (2011) on innovation and technological relationships with foreign firms. Girma, Gong, and Gorg (2009) explored whether FDI affects product innovation by state-owned enterprises, and they find that firm-level foreign capital participation is associated with higher innovation, while the inward FDI in the sector negatively affects innovation. Brambilla, Hale, and Long (2009) found that the presence of FDI in China causes domestic firms to imitate more than innovate. Despite these studies, to the best of our knowledge, there is no research that explores the impact of FDI on domestic firms' product innovation and exporting and the inter-relationship between innovation and exporting in China.

To summarise, there exist a number of studies that explore product innovation, exporting behaviour, and FDI spillovers. Nevertheless, there is a lack of studies that combine

[8] Such two-dimensional heterogeneity has been explored by previous studies. For example, Fasil and Borota (2013) allowed for the firm heterogeneity in not only productivity but also product quality.
[9] See Blomstrom and Kokko (1998), Saggi (2002), Gorg and Greenaway (2004), and Smeets (2008) for detailed surveys.

all three aspects and comprehensively investigate the inter-relationship amongst them, both theoretically and empirically. This study therefore intends to fill in this gap in the existing literature.

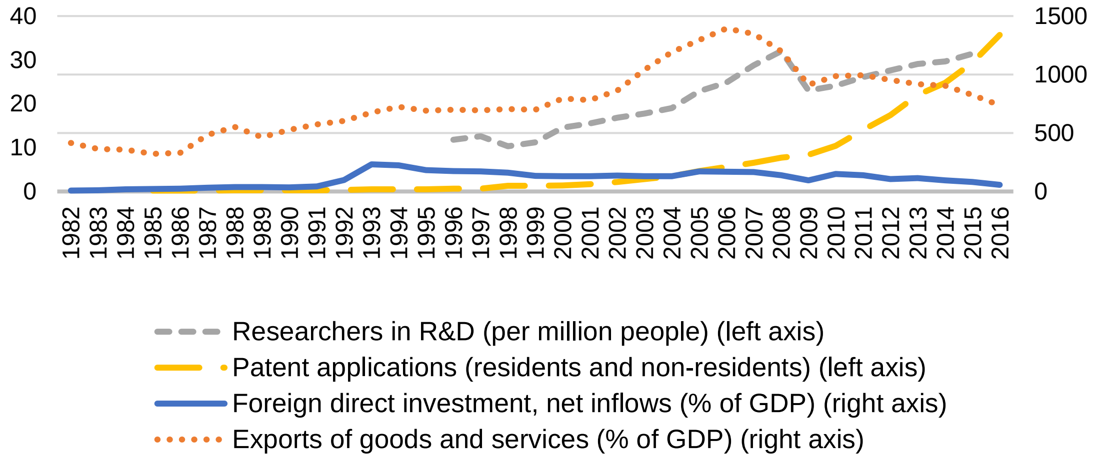
3. Background

Since the opening and reform in the early 1980s, the Chinese economy grew quickly at an average annual rate of around 10% from 1982 to 2016. The economic growth tapered off into the 6%–7% zone from 2015, transitioning into a so-called 'New Normal' period. China's economic growth exhibits three features.

First, there is a significant presence of FDI, particularly in the manufacturing sector. From 1982 to 2016, the average ratio of net inflows of FDI against GDP was as high as around 2.88%. The ratio increased from 0.21% in 1982 to its peak of 6.19% in 1993, and then gradually slowed down to 1.52% in 2016 (see the blue solid curve in Figure 1). Despite the slowdown, due to the fact that GDP grew faster than the FDI inflow, one can still observe the significant presence of FDI.

Second, exports play an important role in economic growth. Figure 1 displays the trend of exports of goods and services as a share of GDP. It increased from 8.58% in 1985 to peak at 37.17% in 2006, and then slowed down to 19.64% in 2016. The average share of exports of goods and services in GDP from 1982 to 2016 was as high as 20.58%. Not surprisingly, exports play an important role in China's economic growth.

Figure 1. Net FDI Inflows, Exports, R&D, and Patents in China

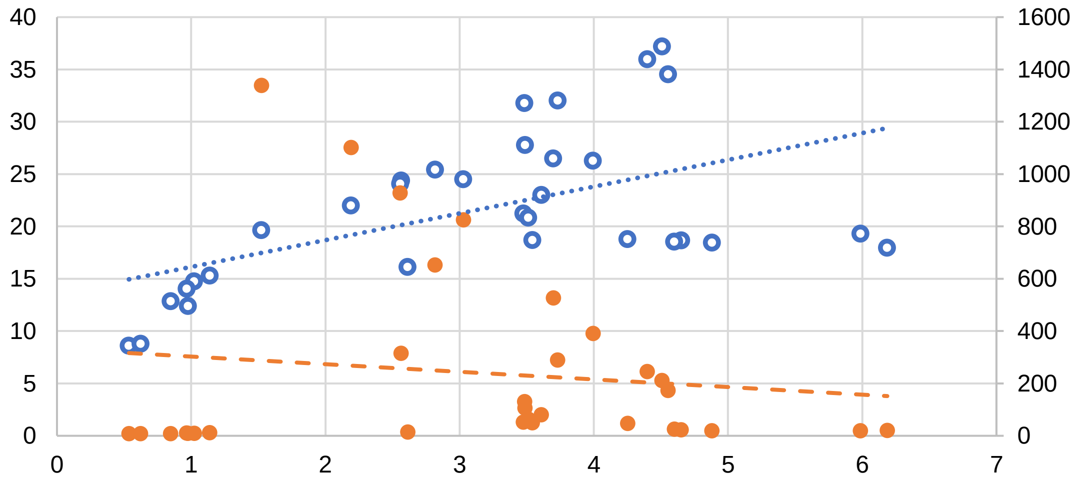


Source: World Development Indicators (2018).

Third, China is increasingly engaged in innovation activities, measured in terms of either input (R&D researchers) or output (patent applications). For example, on researchers in R&D (per million people), the number increased from around 442 in 1996 to almost 1,200 in 2016, with an average annual growth rate of 6%. In terms of patent applications, the rate was even higher, with an average annual growth rate of almost 19% from 1982 to 2016. Although one may argue the extent to which patents are used in production, the trends clearly indicate that innovation activities are substantial in China.

Figure 2 plots the exports of goods and services and patent applications against the net inflows of FDI. For the exports of goods and services, we can observe a clear upward trend; namely, a higher level of FDI inflow is associated with a higher level of exports of goods and services. In contrast, the trend of patent applications against net FDI inflows appears to be downward sloping, suggesting that net FDI inflows are negatively correlated with patent applications. This appears to be consistent with previous studies on the impact of FDI on innovation in China (see for example Brambilla et al., 2009).

Figure 2. Exports and Patent Applications versus Net FDI Inflows



Note: The blue circles are exports (% of GDP, left vertical axis) versus net FDI inflows (% of GDP, horizontal axis); the orange points are patent applications (per million people, right vertical axis) versus net FDI inflows; the dotted lines are the projected trends.
Source: World Development Indicators (2018).

In summary, at the aggregate level, we can observe that China has significant levels of FDI inflows, exports, and innovation activities. Given this feature, one will naturally ask what the inter-relationship amongst them is at the disaggregate (firm) level, in particular whether the presence of FDI stimulates domestic firms' exporting and product innovation activities at the firm level in China – which is what this paper intends to answer.

4. Stylised Facts of Exporting, Product Innovation, and the Presence of FDI

Before we model firms' behaviour of product innovation and exporting in the presence of FDI, we first look at the data to draw some stylised facts to motivate the theoretical modelling. The dataset is a firm-level dataset for China's manufacturing sector from 2005 to 2007, sourced from China's National Bureau of Statistics (NBS). This comprehensive dataset accounts for more than 85% of China's total industrial output. For the purpose of drawing stylised facts, we investigate three aspects, namely the percentage of firms that export and/or innovate, the association/correlation between product innovation and domestic sales and exports, and the association between FDI presence and product innovation, domestic sales, and exports.

First, not every firm exports and/or innovates. Table 1 summarises the percentage of firms that export/innovate. On average, only less than 10% of firms conducted product innovation from 2005 to 2007, and around 26% of firms exported in this period. In addition, firms that both exported and innovated account for an even smaller proportion, with an average of around 5% that did both activities. To export, firms are faced with both a fixed cost of exporting and variable transportation costs. To overcome these costs and be profitable in foreign markets, firms need to be productive (namely, have a low marginal cost of production). As many previous studies point out, there exists a sorting pattern, where less productive firms serve only the domestic market and more productive firms export.

Similar to product innovation, a fixed cost for innovation is needed, for example to set up laboratories and hire R&D personnel. Holding the demand for their new products constant, whether product innovation is profitable depends on firms' innovation capability (productivity). Conceptually, more productive firms should be more capable of product innovation than less productive firms. Therefore, we expect that there also exists a sorting pattern in terms of product innovation. Later in the theoretical modelling, we will show that this is indeed the case. In addition, we will also find that there exists complementarity between innovation capability (productivity) and production capability (productivity).

Table 1. Share of Firms that Export/Innovate (%)

	2005	2006	2007
Innovate	9.68	9.98	8.49
Export	28.17	26.57	23.67
Innovate × Export	5.88	5.80	4.08

Source: NBS, 2005–2007.

Second, we examine the association (correlation) between product innovation and exporting. Table 2 reports the percentage of firms that export/innovate and the export/innovation intensity by innovation/export. For firms that innovate, 55.56% of them export more than 20% of their outputs. In contrast, only 22.93% of the non-innovation firms export, and on average they export only 15.3% of their outputs. From the perspective of exporting status, nearly 20% of exporting firms conduct product innovation, with around 6% of their outputs being new products. The non-exporting firms appear to innovate less, both in terms of the percentage (5.6%) of firms that conduct product innovation and the average degree of product innovation (2.57%). Therefore, we observe a positive correlation between exporting and product innovation. Everything else equal, an exporting/innovation firm is likely to have a higher capability endowment, which in turn leads the firm to innovate/export, generating a positive correlation between them. Later, our theoretical modelling will generate such a positive correlation between product innovation and export.

Table 2. Correlation between Exporting and Product Innovation

		Export	Export Intensity
Innovate	Yes	0.5556	0.2074
	No	0.2293	0.1530
		Innovate	Degree of Product Innovation
Export	Yes	0.1997	0.0656
	No	0.0560	0.0257

Note: Export intensity is equal to the export value divided by firm total sales. The degree of product innovation is defined as the value of new products against total outputs.
Source: NBS, 2005–2007.

Third, to further examine the correlation and, in particular, incorporate the effect of the FDI presence, we regress exporting/innovation against innovation/exporting and the measure of FDI presence. Table 3 presents the results.[10] The positive correlation between product innovation and exporting in Table 2 is further confirmed in Table 3, with the regression coefficients being significantly positive in all specifications. For example, when we regress whether a firm innovates (a dummy variable that takes a value of one if a firm innovates) against whether a firm exports and FDI, the point estimate of the export coefficient is 0.1516, which is significant at the 1% level.

Regarding the correlation of FDI presence with product innovation and exporting, the outcome is less clear cut. Whether a firm innovates is negatively associated with the presence of FDI. In contrast, for the degree of product innovation, the correlation is insignificant if the decision of whether to export is used in the regression and is significantly positive if export intensity is used in the regression. The correlation between FDI presence and exporting is all significantly positive. Conceptually, the presence of FDI can either positively or negatively affect firm productivity (both production and innovation). On the one hand, FDI can generate positive spillovers to domestic firms through forward/backward linkages, labour mobility, and imitation and competition effects (Blomstrom and Kokko, 1998), while on the other hand, foreign-invested firms tend to attract better quality workers, leaving less-productive workers for domestic firms. Later in our theoretical modelling and empirical estimation, we do not impose a prior restriction on the sign of FDI presence, and instead let the data determine its sign.

One should note that the regression results in Table 3 do not imply causality. A number of issues need to be addressed in order to estimate the causality from the FDI presence to product innovation and exporting. First, the presence of FDI is likely to be endogenous. Second, there exists a sample selection issue as not all firms export/innovate. Third, other control variables are likely to be needed in order for the FDI presence not to pick up the impact of other confounding factors. Later in our estimation we will address these issues.

[10] Note the estimate in Table 3 measures the correlation, rather than causality.

Table 3. The Association of Exporting, Product Innovation, and FDI Presence

	Innovate	Innovate	Degree of product innovation	Degree of product innovation	Export	Export	Export intensity	Export intensity
Innovate					0.3273		0.0553	
Degree of Product Innovation						0.3014		0.1018
Export	0.1516		0.0399					
Export intensity		0.0461		0.0243				
FDI presence	-0.0185	-0.0057	0.00001*	0.0022	0.1162	0.1145	0.1025	0.1019
Constant	0.0646	0.0893	0.0257	0.0310	0.1625	0.1832	0.0941	0.0959
Number of obs.	898,106	898,009	898,106	898,009	898,106	898,106	898,009	898,009
F	23444.66	1150	5752.96	1396.19	48163.52	29247.28	34220.61	34183.01
R2	0.0496	0.0026	0.0126	0.0031	0.0969	0.0611	0.0708	0.0707

Note: All coefficients are statistically significant at the 5% level, except the one indicated by *. Innovate is a dummy variable that takes a value of one if a firm conducts product innovation. Degree of product innovation is the ratio of new product values against total outputs. Export is a dummy variable that takes a value of one if a firm exports. Export intensity is the ratio of export revenue against total sales revenue. FDI presence is measured by the province-industry (four-digit) share of FDI firms' output in the national-industry total output, divided by the share of province manufacturing output in the national total manufacturing output.
Source: Author's calculation.

5. The Model

In the domestic market, consumers have a constant elasticity of substitution (CES) preference, and the utility maximisation yields the following demand for products:

$$q = \Phi p^{\frac{1}{\rho-1}}$$

where q is the quantity of output; p denotes price; Φ represents the aggregate demand that firms take as given; and ρ is the CES preference parameter ($0 < \rho < 1$). The products that a firm produces consist of both old (existing) and new products, where new products are defined as in the previous section. The old and new products are CES aggregated, as follows:

$$q = \left[q_o^{\mu} + (\beta q_n)^{\mu}\right]^{1/\mu}$$

where the subscripts o and n represent old and new products, respectively; μ is the aggregation parameter ($0 < \mu < 1$); and β measures the relative importance of new products in the aggregation,[13], which is exogenous to firms. If $\beta > 1$, new products are more important in the aggregation than the old products. Similarly, in the foreign market, the demand for products[14] is $\tilde{q} = \tilde{\Phi}\tilde{p}^{\frac{1}{\rho-1}}$, where the tilde denotes foreign market and $\tilde{q} = \left[\tilde{q}_o^{\mu} + (\beta \tilde{q}_n)^{\mu}\right]^{1/\mu}$.

5.1 The Setup

Upon entry into the market, firms draw two capability endowments, λ_1 and λ_2, from two exogenous independent distributions with the cumulative distribution functions (CDF) being $G_1(\lambda_1)$ and $G_2(\lambda_2)$ over the support $(0, \bar{\lambda}]$. The endowment λ_1 is the production capability, and the endowment λ_2 is the capability of product innovation. Higher values of λ_1 and λ_2 indicate higher capabilities of production and product innovation.

Then firms are engaged in a two-stage game. At stage one, firms make an optimal decision on product innovation, namely to decide the share of new products in their outputs. At stage two, firms set prices in the domestic and foreign markets (export), respectively. If a firm's optimal profit from the domestic market is negative, it will immediately exit. Similarly, if a firm's optimal profit from the foreign market is negative, it will not participate in exporting.

In the production process, firms first pay a fixed cost of production (f), which includes such expenditure as setting up a production line, etc. Then, on average, one worker uses m units

---

[13] If we plug the aggregation into the CES utility function, we can find that with $q_n = q_o$, $MU_n = \beta^{\mu} MU_o$, where MU_n and MU_o represent the marginal utility of new and old products, respectively. Hence, β can also be interpreted as the relative attractiveness of new products.

[14] Note, here we implicitly assume that representative consumers in the domestic and foreign markets have the same elasticity of substitution across different products.

of intermediate inputs to produce s units of old products. That is, the labour productivity of producing existing products is s, which depends on a firm's production capability endowment (λ_1), the presence of FDI (γ), a set of observed factors ($\boldsymbol{z}$), and unobserved factors (ζ), namely $s = \lambda_1 \psi_s(\gamma, \boldsymbol{z}, \zeta)$. The functional form ψ_s will be specified later in the empirical estimation.

Conceptually, on the one hand, it is possible that the presence of FDI generates positive productivity spillovers through firm imitation and labour movement (from FDI firms to domestic firms). On the other hand, it is also likely that FDI firms tend to attract better quality workers, such that an increase in FDI presence results in fewer higher quality workers for domestic firms. Therefore, the presence of FDI can either positively or negatively affect domestic firms' productivity. Accordingly, we do not impose a prior restriction on the sign of $\partial\psi_s/\partial\gamma$ and instead will let the data determine its sign in the later empirical estimation.

Alternatively, in addition to the fixed cost of production, a firm can pay an additional fixed cost of innovation (f_η) to conduct product innovation. In this case, one worker can use m units of intermediate inputs to produce αs units of new products, where $\alpha = \lambda_2 \psi_\alpha(\gamma, \boldsymbol{z}, \zeta)$[15]. The functional form ψ_α will be specified later, and λ_2 is the firm's innovation capability endowment. If $\partial\psi_\alpha/\partial\gamma > 0$, the presence of FDI facilitates the production of new products. If $\partial\psi_\alpha/\partial\gamma < 0$, the FDI presence negatively affects firms' product innovation, *ceteris paribus*. For the same reason discussed above, we do not constrain the sign of $\partial\psi_\alpha/\partial\gamma$ in our empirical estimation.

The marginal cost of producing one unit of the old product is $(w + m)/s$, where w represents the wage rate, and similarly the marginal cost of producing one unit of the new product is $(w + m)/\alpha s$. Let $\eta \equiv q_n/q_o$, namely η is the ratio of new products against old products, which will be endogenously determined by the firms. The marginal cost of production can then be written as $MC = \frac{(\alpha+\eta)(w+m)}{\alpha(1+\beta^\mu\eta^\mu)^{1/\mu}s}$. Firms' profit from the domestic market can be written as $\pi = (p - MC)q - f - f_\eta 1(\eta > 0)$, where π denotes profit and $1(\eta > 0)$ is an indicator function that takes a value of one if $\eta > 0$.

In order to serve the foreign market (export), firms need to pay both a fixed cost of exporting (f_e) and ice-burg trading cost (τ). Hence, the profit from exporting to the foreign market is $\tilde{\pi} = (\tilde{p} - \tau MC)\tilde{q} - f_e$. The presence of FDI is likely to generate informational spillovers such that an increase in FDI presence leads to a reduction in the fixed cost of

[15] Note, the αs measure the labour productivity of producing new products. If $\alpha < 1$, producing new products is more expensive than producing existing (old) products.

exporting (see for example Swenson, 2008). Therefore, $f_e = \underline{f_e}\psi_e(\gamma, \boldsymbol{z})$. As informational spillovers will reduce the fixed cost of exporting, later in our empirical estimation we impose a prior restriction that $\partial\psi_e/\partial\gamma \leq 0$.

5.2 Optimal Pricing and Innovation

At stage two, firms set prices for both the domestic and foreign markets in order to maximise their profits. The optimal domestic and export prices are $p = \frac{MC}{\rho}$ and $\tilde{p} = \frac{\tau MC}{\rho}$ respectively. Thus the optimal profit from the domestic market is $\pi = (1-\rho)\rho^{\frac{\rho}{1-\rho}}\Phi MC^{\frac{\rho}{\rho-1}} - f - f_\eta 1(\eta > 0)$ and the optimal export profit is $\tilde{\pi} = (1-\rho)\rho^{\frac{\rho}{1-\rho}}\tau^{\frac{\rho}{\rho-1}}\tilde{\Phi} MC^{\frac{\rho}{\rho-1}} - f_e$.

At stage one, firms choose η to maximise their profits. Comparing firms' optimal domestic profit and export profit at stage two, we can observe that product innovation affects firm profit through its impact on the marginal cost of production. Therefore, $argmax(\pi) = argmax(\pi + \tilde{\pi}) = argmax\left(\frac{(1+\beta^\mu\eta^\mu)^{1/\mu}}{\alpha+\eta}\right)$, namely the optimal degree of product innovation is as follows:

$$\eta = \alpha^{\frac{1}{1-\mu}}\beta^{\frac{\mu}{1-\mu}} = \lambda_2^{\frac{1}{1-\mu}}[\psi_\alpha(\gamma, \boldsymbol{z}, \zeta)]^{\frac{1}{1-\mu}}\beta^{\frac{\mu}{1-\mu}}$$

The optimal degree of product innovation suggests that a firm's product innovation depends on two factors: α (the marginal cost of producing new products, relative to that of old products) and β (the relative importance/attractiveness of new products). A higher α implies a lower marginal cost of producing new products relative to that of existing products and subsequently results in a higher level of product innovation (η). Similarly, the more attractive new products are, relative to the old products, the degree of product innovation (η) is higher. The presence of FDI affects a firm's optimal degree of product innovation through its impact on the relative marginal cost of production. If $\partial\psi_\alpha/\partial\gamma > 0$, an increase in the FDI presence reduces the marginal cost of producing new products relative to that of old products and subsequently enhances the firm's product innovation. The opposite situation occurs if $\partial\psi_\alpha/\partial\gamma < 0$, and if $\partial\psi_\alpha/\partial\gamma = 0$, the FDI presence does not affect firms' product innovation behaviour.

5.3 Sorting Patterns of Export and Innovation

Given the optimal prices and optimal degree of product innovation, we can find firms' optimal profits from both domestic and foreign markets, which are monotone increasing functions of firm production and innovation capability endowments. Subsequently, we can pin down the sorting patterns of export and innovation over the supports of the distributions of production and innovation capability endowments. For this purpose, we first let $\chi_0 = 1(\pi > 0)$, $\chi_1 = 1(\eta > 0)$, and $\chi_2 = 1(\tilde{\pi} > 0)$, where 1() is the indicator function. We then write the optimal profit from the domestic market as follows:

$$\pi(\lambda_1, \lambda_2 | \chi_1 = 0) = N\lambda_1^{\frac{\rho}{1-\rho}} - f \tag{1}$$

$$\pi(\lambda_1, \lambda_2 | \chi_1 = 1) = N\left(1 + \lambda_2^{\frac{\mu}{1-\mu}} \psi_\alpha^{\frac{\mu}{1-\mu}} \beta^{\frac{\mu}{1-\mu}}\right)^{\frac{\rho}{1-\rho}\frac{1-\mu}{\mu}} \lambda_1^{\frac{\rho}{1-\rho}} - (f + f_\eta) \tag{2}$$

$$\Delta\pi(\lambda_1, \lambda_2) \equiv \pi(\lambda_1, \lambda_2 | \chi_1 = 1) - \pi(\lambda_1, \lambda_2 | \chi_1 = 0) = N\left[\left(1 + \lambda_2^{\frac{\mu}{1-\mu}} \psi_\alpha^{\frac{\mu}{1-\mu}} \beta^{\frac{\mu}{1-\mu}}\right)^{\frac{\rho}{1-\rho}\frac{1-\mu}{\mu}} - 1\right] \lambda_1^{\frac{\rho}{1-\rho}} - f_\eta \tag{3}$$

where $N \equiv (1-\rho)\rho^{\frac{\rho}{1-\rho}} \Phi(w+m)^{\frac{\rho}{\rho-1}} \psi_s^{\frac{\rho}{1-\rho}}$. Equation (1) is the optimal profit that a firm can make from the domestic market if it does not innovate, and equation (2) is the optimal domestic profit if it innovates. The difference between them is equation (3). Clearly, if $\pi(\lambda_1, \lambda_2 | \chi_1 = 0) < 0$ and $\pi(\lambda_1, \lambda_2 | \chi_1 = 1) < 0$, a firm will not serve the domestic market (and not innovate). If $\pi(\lambda_1, \lambda_2 | \chi_1 = 1) > 0$ and $\Delta\pi(\lambda_1, \lambda_2) > 0$, a firm will both innovate and serve the domestic market. In other cases, the firm will serve the domestic market but not innovate. As the profits are monotone increasing functions of λ_1 and λ_2, and $\pi(0,0 | \chi_1 = 0) < 0$, $\pi(0,0 | \chi_1 = 1) < 0$, and $\Delta\pi(0,0) < 0$, there exist cut-off levels of λ_1 above which firms will serve the domestic market/innovate, as follows:

$$\underline{\lambda}_1(\lambda_2 | \chi_1 = 0) = N^{-\frac{1-\rho}{\rho}} f^{\frac{1-\rho}{\rho}} \tag{4}$$

$$\underline{\lambda}_1(\lambda_2 | \chi_1 = 1) = N^{-\frac{1-\rho}{\rho}} \left(1 + \lambda_2^{\frac{\mu}{1-\mu}} \psi_\alpha^{\frac{\mu}{1-\mu}} \beta^{\frac{\mu}{1-\mu}}\right)^{-\frac{1-\mu}{\mu}} (f + f_\eta)^{\frac{1-\rho}{\rho}} \tag{5}$$

$$\underline{\lambda}_1(\lambda_2) = N^{-\frac{1-\rho}{\rho}} \left[\left(1 + \lambda_2^{\frac{\mu}{1-\mu}} \psi_\alpha^{\frac{\mu}{1-\mu}} \beta^{\frac{\mu}{1-\mu}}\right)^{\frac{\rho}{1-\rho}\frac{1-\mu}{\mu}} - 1\right]^{-\frac{1-\rho}{\rho}} f_\eta^{\frac{1-\rho}{\rho}} \tag{6}$$

Equations (4), (5) and (6) define λ_1 as a function of λ_2, above which $\pi(\lambda_1, \lambda_2 | \chi_1 = 0) > 0$, $\pi(\lambda_1, \lambda_2 | \chi_1 = 1) > 0$, and $\Delta\pi(\lambda_1, \lambda_2) > 0$ respectively, and partition the space (λ_1, λ_2) into regions where firms will (not) serve the domestic market and innovate.

For exporting, similarly we can write the optimal profit if a firm does not innovate as follows:

$$\tilde{\pi}(\lambda_1, \lambda_2 | \chi_1 = 0) = \tau^{\frac{\rho}{\rho-1}} \tilde{N} \lambda_1^{\frac{\rho}{1-\rho}} - f_e \tag{7}$$

where $\tilde{N} \equiv (1-\rho)\rho^{\frac{\rho}{1-\rho}} \tilde{\Phi}(w+m)^{\frac{\rho}{\rho-1}} \psi_s^{\frac{\rho}{1-\rho}}$. If a firm already innovates for the domestic market, it can make the following profit from exporting:

$$\tilde{\pi}_1(\lambda_1, \lambda_2 | \chi_1 = 1) = \tau^{\frac{\rho}{\rho-1}} \tilde{N} \left(1 + \lambda_2^{\frac{\mu}{1-\mu}} \psi_\alpha^{\frac{\mu}{1-\mu}} \beta^{\frac{\mu}{1-\mu}}\right)^{\frac{\rho}{1-\rho}\frac{1-\mu}{\mu}} \lambda_1^{\frac{\rho}{1-\rho}} - f_e \tag{8}$$

Note that for any realisations of λ_1 and λ_2, since the fixed cost of innovation has already been paid in serving the domestic market, the firm will always have product innovation in its exports (provided that it exports); namely, the profit in equation (8) is always higher than that of equation (7). If a firm does not innovate in serving the domestic market, its export profit with product innovation is as follows:

$$\tilde{\pi}_2(\lambda_1, \lambda_2 | \chi_1 = 1) = \tau^{\frac{\rho}{\rho-1}} \tilde{N} \left(1 + \lambda_2^{\frac{\mu}{1-\mu}} \psi_\alpha^{\frac{\mu}{1-\mu}} \beta^{\frac{\mu}{1-\mu}}\right)^{\frac{\rho}{1-\rho}\frac{1-\mu}{\mu}} \lambda_1^{\frac{\rho}{1-\rho}} - (f_e + f_\eta) \tag{9}$$

In this case, the profit difference between that with and without product innovation is as follows:

$$\Delta\tilde{\pi}(\lambda_1, \lambda_2) \equiv \tilde{\pi}_2(\lambda_1, \lambda_2 | \chi_1 = 1) - \tilde{\pi}(\lambda_1, \lambda_2 | \chi_1 = 0) = \tau^{\frac{\rho}{\rho-1}} \tilde{N} \left[\left(1 + \lambda_2^{\frac{\mu}{1-\mu}} \psi_\alpha^{\frac{\mu}{1-\mu}} \beta^{\frac{\mu}{1-\mu}}\right)^{\frac{\rho}{1-\rho}\frac{1-\mu}{\mu}} - 1\right] \lambda_1^{\frac{\rho}{1-\rho}} - f_\eta \tag{10}$$

Equations (7), (8), (9), and (10) imply a cut-off level of λ_1 as a function of λ_2:

$$\underline{\tilde{\lambda}}_1(\lambda_2 | \chi_1 = 0) = \tau \tilde{N}^{-\frac{1-\rho}{\rho}} f_e^{\frac{1-\rho}{\rho}} \tag{11}$$

$$\underline{\tilde{\lambda}}_{11}(\lambda_2 | \chi_1 = 1) = \tau \tilde{N}^{-\frac{1-\rho}{\rho}} \left(1 + \lambda_2^{\frac{\mu}{1-\mu}} \psi_\alpha^{\frac{\mu}{1-\mu}} \beta^{\frac{\mu}{1-\mu}}\right)^{-\frac{1-\mu}{\mu}} f_e^{\frac{1-\rho}{\rho}} \tag{12}$$

$$\underline{\tilde{\lambda}}_{12}(\lambda_2 | \chi_1 = 1) = \tau \tilde{N}^{-\frac{1-\rho}{\rho}} \left(1 + \lambda_2^{\frac{\mu}{1-\mu}} \psi_\alpha^{\frac{\mu}{1-\mu}} \beta^{\frac{\mu}{1-\mu}}\right)^{-\frac{1-\mu}{\mu}} (f_e + f_\eta)^{\frac{1-\rho}{\rho}} \tag{13}$$

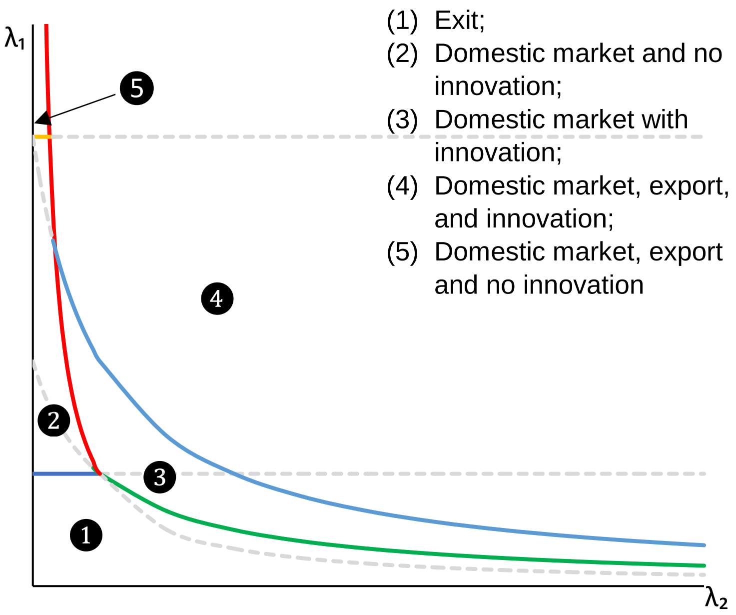
$$\underline{\tilde{\lambda}}_1(\lambda_2) = \tau \tilde{N}^{-\frac{1-\rho}{\rho}} \left[\left(1 + \lambda_2^{\frac{\mu}{1-\mu}} \psi_\alpha^{\frac{\mu}{1-\mu}} \beta^{\frac{\mu}{1-\mu}} \right)^{\frac{\rho}{1-\rho}\frac{1-\mu}{\mu}} - 1 \right]^{-\frac{1-\rho}{\rho}} f_\eta^{\frac{1-\rho}{\rho}} \qquad (14)$$

In order to identify the patterns of product innovation and export, we assume that $\tilde{\Phi} = \Phi$ (namely the domestic and foreign aggregate demands are comparable) and $f_e = f + f_\eta$ (which ensures that the graph of equation (11) is above that of equation (4), and the graph of equation 12 is above that of equation (5)). In other words, we assume that the iceberg trading cost, domestic and foreign demands, and the fixed costs are such that the cut-off production capability (λ_1) of serving the foreign market is higher than serving the domestic market. This appears to be a reasonable starting point, as data suggest that only a small proportion of firms export, and exporting firms usually also serve domestic market. In addition, we also assume that $\underline{\tilde{\lambda}}_{11}(\lambda_2|\chi_1 = 1) > \underline{\lambda}_1(\lambda_2|\chi_1 = 1)$; namely, if a firm has a realised production capability higher than $\underline{\tilde{\lambda}}_{11}(\lambda_2|\chi_1 = 1)$, it must decide to innovate in serving the domestic market. Given this, comparing equation (14) with equation (6), we can observe that $\underline{\tilde{\lambda}}_1(\lambda_2) > \underline{\lambda}_1(\lambda_2)$; namely, if a firm draws a production capability higher than $\underline{\tilde{\lambda}}_1(\lambda_2)$ such that innovation is better than no innovation in serving the foreign market, it must be the case that in serving the domestic market, innovation is preferred over non-innovation.

Equations (4), (5), (6), (11), (12), (13), and (14) together partition the space (λ_1, λ_2) into five regions where firms endogenously choose whether to serve the domestic and foreign markets and conduct product innovation. Such patterns are summarised in Figure 3. In region (1), the realised production and innovation capability endowments are so low that it is not profitable to serve the domestic and foreign markets or to innovate. Such firms exit immediately (χ_0 = 0, χ_1 = 0, and χ_2 = 0). Note that in later empirical estimations, such firms are not observed in the sample, resulting in sample selection issues that need to be addressed. Region (2) contains firms that serve only the domestic market and do not conduct product innovation (χ_0 = 1, χ_1 = 0, and χ_2 = 0), and these firms have endowments of moderate production and innovation capabilities.

Firms in region (3) have a moderate production capability endowment and high innovation capability endowment and, therefore, choose to conduct product innovation and serve only the domestic market (χ_0 = 1, χ_1 = 1, and χ_2 = 0). Firms located in region (4) have the right mix of production and innovation capability endowments such that they will innovate and serve both the domestic and foreign markets (χ_0 = 1, χ_1 = 1, and χ_2 = 1). For example, on the bottom right of region (4), even though firms have a low production capability endowment, they have a sufficiently high innovation capability endowment, which makes innovation, domestic sales, and exports all profitable. Hence, we observe complementary between these two capability endowments, even if the two endowments are independent of each other. Firms in region (5) have a low innovation capability endowment and sufficiently high production capability endowment and, therefore, they serve both the domestic and foreign markets but do not innovate ($\chi_0 = 1$, $\chi_1 = 0$, and $\chi_2 = 1$).

Figure 3. Sorting Patterns of Product Innovation and Export



Source: Author's calculation.

To better observe the complementarity between these two capability endowments, let us first ignore the dimension of innovation capability. Then the cut-off production capability for serving domestic market (namely entry to the market) is the lower dashed horizontal grey line in Figure 3, and the cut-off production capability for exporting is the upper dashed horizontal grey line in Figure 3. Firms located below the lower dashed horizontal grey line will exit the market. Firms located between these two dashed horizontal lines will serve only the domestic market, and firms above the upper dashed horizontal line will serve both the domestic and foreign markets, which is the usual sorting pattern identified in previous studies (see for example Helpman et al., 2004). When the dimension of product innovation is added in, we can clearly observe that firms that previously would have exited the market can now serve the domestic market and even export.

The sorting patterns in Figure 3 also conform to the empirical stylised facts; namely, in an industry, no matter how narrowly defined, some firms export/innovate and others do not, and exports and product innovation appear to be positively correlated. The positive correlation arises due to the fact that both exports and product innovation respond to the same underlying production and innovation capabilities, which are complementary to each other.

The presence of FDI can affect such sorting patterns through its impacts on labour productivity (ψ_s and ψ_α) and the fixed cost of exporting (ψ_e). For example, suppose the FDI presence does not affect labour productivity ($\partial\psi_s/\partial\gamma = 0$ and $\partial\psi_\alpha/\partial\gamma = 0$) but reduces the fixed cost of exporting through informational spillovers ($\partial\psi_e/\partial\gamma \leq 0$). Then, region 5, where firms export and do not innovate, will expand as the cut-off λ_1 decreases. Similarly, region 4 will expand as the lower boundary curve shifts downward. The expansion of regions 4 and 5 suggests that more firms, for whom export was not profitable previously, are able to export now. However, note that this does not mean the average export will increase, and, in contrast, the average export, conditional that firms export, will decrease. For the pre-expansion exporting firms, their export quantity (price and revenue) will not change in the post-expansion. For the new exporting firms in the post-expansion, they are less productive compared with the pre-expansion exporting firms, and as such their export quantity (price and revenue) is less than the average of the pre-expansion exporting firms. Subsequently, the post-expansion average export, conditional that firms export, is lower than the pre-expansion.

We summarise the findings of the model by the following proposition:

Proposition: In an industry, there exist sorting patterns of product innovation and exporting in the dimensions of production and innovation capability endowments, where:

(1) Not all firms export/innovate. Firms with low production and innovation capability endowments will not export or conduct product innovation;

(2) Production capability and innovation capability are complementary to each other, and product innovation is positively correlated with exporting; and

(3) Through its impact on labour productivity and the fixed cost of exporting, the presence of FDI can affect such sorting patterns.

Proof: The modelling above results in the sorting patterns and the summarised findings in the proposition.

□

6. Identification Strategy

Our purpose is to explore the inter-connection of product innovation, exporting, and the presence of FDI. To do so, we first examined several stylised facts from the data in Section 4 and then modelled firms' product innovation and export behaviour in the presence of FDI in Section 5. In this section, we discuss the estimation/identification strategy. In summary, we utilise the structural relationship implied from the theoretical modelling to develop a set of population moments, under some mild assumptions (for example the assumption that firms are small relative to the market such that they take the aggregate demand as given in their decision making, namely that aggregate demand is exogenous). Data for three-digit industries will then be used to fit the population moments, which in turn will allow us to estimate the parameters of interest by using the generalised method of moments (GMM) estimator.

For the purpose of the estimation, we parameterise the labour productivity in production (ψ_s), the labour productivity in innovation (ψ_α), and the fixed cost of exporting (ψ_e), as follows:

$$\psi_s(\gamma, \mathbf{z}, \zeta) = \zeta e^{\delta_0\gamma+\delta_3 z_1+\delta_4 z_2+\delta_5 z_3}$$

$$\psi_\alpha(\gamma, \mathbf{z}, \zeta) = \zeta e^{\delta_1\gamma+\delta_6 z_1+\delta_7 z_2+\delta_8 z_3}$$

$$\psi_e(\gamma, \mathbf{z}) = e^{\delta_2\gamma+\delta_9 z_1+\delta_{10} z_3}$$

where z_1 denotes the year; z_2 represents a measure of the provincial concentration of manufacturing activities; z_3 is a measure of the provincial concentration of exporting activities; and the δs are coefficients to be estimated. We are interested in estimating the coefficients of FDI presence (δ_0, δ_1, and δ_2), and control for the time trend and possible impacts by provincial concentration of manufacturing and exporting activities. For the labour productivity, we allow for any unobserved effect (ζ). For the fixed export cost, the concentration of exporting activities is likely to reduce the cost, namely $\delta_{10} < 0$, and FDI presence can generate informational spillovers that decrease the fixed export cost ($\delta_2 < 0$). We impose these two sign restrictions in our later estimation.

Upon entry, firms draw their production and innovation capability endowments (λ_1 and λ_2) from exogenous independent distributions. For simplicity, we assume that λ_1 and λ_2 are independently and uniformly distributed over the support $(0, \bar{\lambda}]$. Note that λ_1 and λ_2 are fixed effect components in firms' labour productivity, which will be integrated out in our estimation. The distributions of λ_1 and λ_2 also allow us to address the sample selection issue in the estimation. To facilitate estimation, we also normalise such that $\mu = \rho$ by choosing appropriate numeraire.

The first step of our estimation process is to identify the CES preference parameter ρ. Firms' profit maximisation implies that $MC \times q = \rho r$, where *r* denotes the sales revenue in the domestic market. Therefore, for non-exporting firms[16] ($\chi_2 = 0$), we have the following relation between the total variable cost (*TVC*) and domestic sales revenues:

$$TVC = \rho r + \varepsilon \quad (15)$$

where we append an error term ε to capture the measurement error. A similar identification strategy has been used in previous studies (see for example Aw et al., 2011).

In the second step, we utilise domestic[17] non-innovating firms ($\chi_1 = 0$, firms in regions 2 and 5 in Figure 3) to estimate δ_0, δ_3, δ_4, and δ_5, conditional on the estimate of ρ. Firms' sales revenue from domestic market can be written as $ln(r) = \frac{\rho}{1-\rho} ln\rho + ln\Phi - \frac{\rho}{1-\rho}\ln(w+m) + \frac{\rho}{1-\rho} ln(\psi_s) + \frac{\rho}{1-\rho}\ln\left(\frac{\alpha+\eta}{\alpha(1+\beta^{\mu}\eta^{\mu})^{1/\mu}}\right) + \frac{\rho}{1-\rho} ln\lambda_1$. Therefore, conditional that firms do not innovate and serve the domestic market, the expected domestic sales revenue is:

$$E[ln(r)|\chi_0 = 1, \chi_1 = 0] = \theta_0 + \frac{1}{2} ln\Phi - \frac{\rho}{2(1-\rho)}\ln(w+m) + \frac{\rho}{2(1-\rho)} ln\,\zeta + \frac{\rho}{2(1-\rho)}\delta_0\gamma + \frac{\rho}{2(1-\rho)}\delta_3 z_1 + \frac{\rho}{2(1-\rho)}\delta_4 z_2 + \frac{\rho}{2(1-\rho)}\delta_5 z_3 \quad (16)$$

where $\theta_0 = \frac{\rho}{2(1-\rho)} ln\rho + \frac{\rho}{2(1-\rho)} ln\bar{\lambda} - \frac{1}{2}\ln(1-\rho) + \frac{1}{2} lnf$.

Let $\boldsymbol{X}$ denote a vector of instruments, which includes the vector $\boldsymbol{z}$, consumers' income in the domestic and export markets, the firm average wage, and instruments for FDI presence that will be discussed later. We assume $E[ln\Phi|X] = lnY$, where Y denotes the representative consumers' income[18] and $E[ln\zeta|X] = 0$. The market is monopolistically competitive, and firms are small relative to the market such that they take the aggregate demand as given in their decision marking ($E[ln\Phi|X] = lnY$). The unobserved factor ζ can be correlated with the FDI presence in the industry, and in the estimation, we use the FDI presence in other industries that are neither upstream nor downstream industries as instruments. The FDI presence in these industries is affected by common macroeconomic factors and thus shall be correlated with FDI presence in the industry of study, and it appears plausible that the FDI presence in the instrumenting industries shall not be affected by the unobserved factor ζ and the price index in the studying industry as these industries are not directly linked to the studying industry. Hence,

[16] Note, observations of exporting firms are not used due to the presence of iceberg trading costs.
[17] As we intend to investigate the FDI spillover effect, we constrain the firms in the sample to be domestic firms.
[18] Note, the aggregate demand, Φ, equals consumers' income divided by an aggregate price index.

we assume $E[ln\zeta|X] = 0$. With these assumptions, the population moments for estimating equation (16) are as follows:

$$E\left[\left(ln(r) + \frac{\rho}{2(1-\rho)}\ln(w+m) - \frac{1}{2}lnY - \theta_0 - \frac{\rho}{2(1-\rho)}\delta_0\gamma - \frac{\rho}{2(1-\rho)}\delta_3 z_1 - \frac{\rho}{2(1-\rho)}\delta_4 z_2 - \frac{\rho}{2(1-\rho)}\delta_5 z_3\right)X\right] = 0$$

where the estimation is made over firms that do not innovate.

Armed with the estimations in steps 1 and 2, in step 3 we address the possible informational spillovers of FDI (namely its impact on the fixed export cost) by examining the export revenue of firms that export and do not innovate (namely firms in region 5 in Figure 3). Firms' export revenue can be written as $ln(\tilde{r}) = \frac{\rho}{1-\rho}ln\rho + \frac{\rho}{1-\rho}ln\tau + ln\tilde{\Phi} - \frac{\rho}{1-\rho}\ln(w+m) + \frac{\rho}{1-\rho}ln(\psi_s) + \frac{\rho}{1-\rho}\ln\left(\frac{\alpha+\eta}{\alpha(1+\beta^\mu\eta^\mu)^{1/\mu}}\right) + \frac{\rho}{1-\rho}ln\lambda_1$, and the expected export revenue, conditional that firms export and do not innovate, is as follows:

$$E[ln(\tilde{r})|\chi_1 = 0, \chi_2 = 1] = \theta_1 + \frac{1}{2}ln\tilde{\Phi} - \frac{\rho}{2(1-\rho)}\ln(w+m) + \frac{\rho}{2(1-\rho)}ln\,\zeta + \frac{\rho}{2(1-\rho)}\delta_0\gamma + \frac{\rho}{2(1-\rho)}\delta_3 z_1 + \frac{\rho}{2(1-\rho)}\delta_4 z_2 + \frac{\rho}{2(1-\rho)}\delta_5 z_3 + \frac{1}{2}\delta_2\gamma + \frac{1}{2}\delta_9 z_1 + \frac{1}{2}\delta_{10} z_3 \quad (17)$$

where $\theta_1 = \frac{\rho}{2(1-\rho)}ln\rho - \frac{\rho}{2(1-\rho)}ln\tau + \frac{\rho}{2(1-\rho)}ln\bar{\lambda} - \frac{1}{2}\ln(1-\rho) + \frac{1}{2}ln\underline{f_e}$. Assuming that the instruments are uncorrelated with the aggregate price index in the foreign market (namely $E\big[ln\tilde{\Phi}\big|X\big] = ln\tilde{Y}$, where $\tilde{Y}$ represents foreign income), the population moments are as follows:

$$E\left[\left(\tilde{y} - \theta_1 - \frac{1}{2}\delta_2\gamma - \frac{1}{2}\delta_9 z_1 - \frac{1}{2}\delta_{10} z_3\right)X\right] = 0$$

where $\tilde{y} = ln(\tilde{r}) + \frac{\rho}{2(1-\rho)}\ln(w+m) - \frac{1}{2}ln\tilde{Y} - \frac{\rho}{2(1-\rho)}\delta_0\gamma - \frac{\rho}{2(1-\rho)}\delta_3 z_1 - \frac{\rho}{2(1-\rho)}\delta_4 z_2 - \frac{\rho}{2(1-\rho)}\delta_5 z_3$.

At step 4, we explore the impact of FDI presence on product innovation by estimating the probability of innovation as a function of FDI presence and other control variables. As in Figure 3, the probability of product innovation is the measure of regions 3 and 4, which can be written as follows:

$$Prob(\chi_1 = 1) = E[\chi_1] = 1 - n_0\Phi^{-\frac{1-\rho}{\rho}}(w+m)\psi_s^{-1}\psi_\alpha^{-1}\left\{n_1 - \frac{1-\rho}{\rho}ln\Phi + \ln(w+m) + ln\psi_s^{-1}\right\} \quad (18)$$

where $n_0 \equiv \frac{1}{\bar{\lambda}^2}(1-\rho)^{-\frac{1-\rho}{\rho}}\rho^{-1}\beta^{-1}f_\eta^{\frac{1-\rho}{\rho}}$ and $n_1 \equiv ln\bar{\lambda} - \frac{1-\rho}{\rho}lnf + \frac{1-\rho}{\rho}ln(1-\rho) + ln\rho - \frac{1-\rho}{\rho}\left(1+\frac{f_\eta}{f}\right)^{\frac{1-\rho}{\rho}}\int_{-1}^{\frac{f_\eta}{f}} x^{\frac{1-\rho}{\rho}}(1+x)^{-\frac{1-\rho}{\rho}-1}dx$. In addition to the assumptions that $E[ln\Phi|X] = lnY$ and $E[ln\zeta|X] = 0$, we also assume $E\left[\Phi^{-\frac{1-\rho}{\rho}}\zeta^{-2}\middle|X\right] = c_1Y^{-\frac{1-\rho}{\rho}}$, $E\left[\Phi^{-\frac{1-\rho}{\rho}}\zeta^{-2}ln\Phi\middle|X\right] = c_1Y^{-\frac{1-\rho}{\rho}}lnY - c_2Y^{-\frac{1-\rho}{\rho}}$, and $E\left[\Phi^{-\frac{1-\rho}{\rho}}\zeta^{-2}ln\zeta\middle|X\right] = c_3Y^{-\frac{1-\rho}{\rho}}$, where c_1, c_2 and c_3 are constant. With these assumptions, we can derive the following population moments:

$$E\left[\left(\chi_1 - 1 + \theta_2\left(\theta_3 + ln(w+m) - \delta_0\gamma - \delta_3z_1 - \delta_4z_2 - \delta_5z_3 - \frac{1-\rho}{\rho}lnY\right)(w + m)Y^{-\frac{1-\rho}{\rho}}e^{-\delta_0\gamma-\delta_3z_1-\delta_4z_2-\delta_5z_3}e^{-\delta_1\gamma-\delta_6z_1-\delta_7z_2-\delta_8z_3}\right)X\right] = 0$$

where $\theta_2 \equiv \frac{n_0}{c_1}$ and $\theta_3 \equiv \frac{c_1n_1+\frac{1-\rho}{\rho}c_2-c_3}{c_1}$.

As described above, the estimation process consists of four steps, where the latter steps are conditioned on the estimates of previous steps, and the GMM estimations in steps 2, 3, and 4 are one-step estimations. The point estimates of the coefficients are consistent; however, the standard errors need to account for the fact the estimation is conditioned on previous steps. Therefore, we use a bootstrap method to compute the standard errors. That is, we re-sample (with replacement) the data and apply the four-step procedure to re-estimate the parameters of interest 100 times. The standard errors are calculated from the distribution of the coefficient estimate.

In summary, guided by the theoretical model, we establish a four-step procedure to estimate the parameters of interest, which will allow us to evaluate the impact of FDI presence on firm product innovation and export behaviour and the association between product innovation and export behaviour. The four-step procedure utilises the following economic and econometric assumptions:

Economic assumptions:

(1) The market is monopolistically competitive;
(2) Constant marginal cost of production.

Econometric assumptions:

(1) The measurement error (ε) is exogenous;
(2) The aggregate demands are exogenous to firms, namely $E[ln\Phi|X] = lnY$ and $E[ln\tilde{\Phi}|X] = ln\tilde{Y}$;

(3) The unobserved factor is exogenous to the instruments, namely $E[ln\zeta|X] = 0$;

(4) Their combinations are exogenous, namely $E\left[\Phi^{-\frac{1-\rho}{\rho}}\zeta^{-2}\middle|X\right] = c_1Y^{-\frac{1-\rho}{\rho}}$, $E\left[\Phi^{-\frac{1-\rho}{\rho}}\zeta^{-2}ln\Phi\middle|X\right] = c_1Y^{-\frac{1-\rho}{\rho}}lnY - c_2Y^{-\frac{1-\rho}{\rho}}$, and $E\left[\Phi^{-\frac{1-\rho}{\rho}}\zeta^{-2}ln\zeta\middle|X\right] = c_3Y^{-\frac{1-\rho}{\rho}}$.

Not surprisingly, these assumptions play an important role in the identification. Later we will verify the assumption of a monopolistically competitive market by calculating the Herfindahl index (sum of the squared market share). A monopolistically competitive market should have a low value of the Herfindahl index as firms are small compared with the market. Hence, a large value of the Herfindahl index will reject this assumption. Regarding the assumption of a constant marginal cost of production,[19] it is more difficult to verify. Anecdotal evidence appears to suggest that many firms in China's manufacturing industries operate close to the range of constant marginal cost of production.[20]

The assumption on the measurement error is natural and also used in previous studies. The assumption on the exogenous aggregate demand stems from the monopolistically competitive assumption. If the assumption of a monopolistically competitive market holds, one expects this assumption to hold as well. For the unobserved factor that affects firm labour productivity (ζ), we use the FDI presence in non-linked (neither upstream nor downstream) industries as an instrument. Even if the FDI presence in the studying industry can be correlated with ζ, it is unlikely that ζ will be correlated with the FDI presence in other industries.

7. Data and Variable Construction

As discussed in Section 4, this study will employ a firm-level dataset for China's manufacturing sector from 2005 to 2007.[21] Table 4 presents the industries that we investigate. Firms within the same industry produce similar products and directly compete with each other. With the estimations by industry, we utilise only the within-industry variations rather than the between-industry variations in the identification, which is robust to industry heterogeneity. There exists significant heterogeneity in the three-digit industries (see Table 5). Given this heterogeneity, a disaggregated analysis by industry can lead to a better understanding of the

[19] Note it is constant with respect to the quantity of output. Different firms may have different marginal costs of production.

[20] For example, in a field trip, the author interviewed a manager of a light bulb manufacturing firm on how the firm sets prices for its products. The manager responded that they first worked out the average cost per light bulb and then put a mark-up on top of the average cost, which suggests that the firm was operating more or less in the range of constant marginal cost of production.

[21] This dataset has been used in previous studies, for example Kee and Tang (2016).

role of FDI, product innovation, and firm exporting in China's manufacturing sector. In addition, we focus on domestic firms as we intend to capture the possible spillover effect of FDI.

Table 4. The Industries

Industry Code		Industry Name	Number of Domestic Firms		
			2005	**2006**	**2007**
152		*Alcoholic beverage manufacturing*	*1,578*	*1,718*	*1,855*
	1521	Liquor manufacturing	909	1,016	1,119
	1522	Beer manufacturing	407	423	413
	1523	Yellow wine manufacturing	90	91	89
	1524	Wine manufacturing	93	97	127
	1529	Other alcoholic beverage manufacturing	79	91	107
171		*Cotton, chemical fibre textile, printing and fine processing*	*8,244*	*9,469*	*10,686*
	1711	Cotton, chemical fibre textile processing	6,887	8,016	9,162
	1712	Cotton, chemical fibre printing and fine processing	1,357	1,453	1,524
181		*Textile and garment manufacturing*	*6,430*	*7,215*	*8,352*
	1810	Textile and garment manufacturing	6,430	7,215	8,352
272		*Chemical medicine manufacturing*	*839*	*894*	*923*
	2720	Chemical medicine manufacturing	839	894	923
372		*Automobile manufacturing*	*592*	*606*	*634*
	3721	Automobile manufacturing	191	192	204
	3722	Modified car manufacturing	391	403	412
	3723	Electric car manufacturing	10	11	18
395		*Household appliances manufacturing*	*1,319*	*1,473*	*1,693*
	3951	Household refrigeration appliances manufacturing	110	130	152
	3952	Home air conditioner manufacturing	126	120	132
	3953	Household ventilation appliances manufacturing	136	144	163
	3954	Household kitchen appliances manufacturing	325	377	438
	3955	Household cleaning appliances manufacturing	107	120	137
	3956	Household beauty, health appliances manufacturing	70	71	81
	3957	Household appliances accessories manufacturing	206	247	280
	3959	Other household appliances manufacturing	239	264	310
401		*Communication equipment manufacturing*	*732*	*731*	*786*
	4011	Communication transmission equipment manufacturing	177	169	192
	4012	Communication switching apparatus manufacturing	110	111	111
	4013	Communication terminal equipment manufacturing	124	125	133
	4014	Mobile communications and terminal equipment manufacturing	101	97	98
	4019	Other communication equipment manufacturing	220	229	252
404		*Computer manufacturing*	*403*	*407*	*453*
	4041	Computer manufacturing	85	78	82
	4042	Computer network equipment manufacturing	83	79	76
	4043	Computer peripheral manufacturing	235	250	295

Source: NBS, 2005–2007.

The variables observed in the dataset include the sales revenue from domestic market, export revenues, value of new products, total wage payment, total intermediate inputs, total number of workers, and whether a firm is FDI invested, where variables with monetary values are deflated by using the producer price index obtained from the *China Statistical Yearbook 2008*.

The total variable cost is the sum of the total wage payment and total intermediate inputs. Whether a firm conducts product innovation is a dummy variable (χ_1) that takes a value of one if a firm reports a positive value of new products. We also calculate the share of value of new products in total outputs, which conveys information on the degree of product innovation.

The presence of FDI is the main variable of interest, which is measured as the share of the province-industry FDI outputs in national-industry total output, divided by the share of province total output in national total output, namely:

$$\gamma_{jkt} = \frac{\dfrac{\sum_{i \in I_{jkt}^{f}} y_{ijkt}}{\sum_{k \in K} \sum_{i \in I_{jkt}} y_{ijkt}}}{\dfrac{\sum_{j \in J} \sum_{i \in I_{jkt}} y_{ijkt}}{\sum_{k \in K} \sum_{j \in J} \sum_{i \in I_{jkt}} y_{ijkt}}}$$

where y denotes output; the subscripts i, j, k, and t represent firm, industry, province, and time, respectively; I_{jkt}^{f} is the set of FDI invested firms in industry j, province k and year t, and I_{jkt} is the set of firms in industry j, province k, and year t ($I_{jkt}^{f} \subset I_{jkt}$); J and K are the sets of industries and provinces, respectively. So, we utilise the industry-province-time variation of FDI presence to identify its impact on firm product innovation and exporting.

The measurement of FDI presence has a provincial dimension. So, in addition, we also control for the provincial concentration of manufacturing and exporting activities (z_2 and z_3 respectively). The concentration of manufacturing activities (z_2) is measured as the ratio of the province-industry's share of national-industry total output against the province's share of national total output, as follows:

$$z_{2jkt} = \frac{\dfrac{\sum_{i \in I_{jkt}} y_{ijkt}}{\sum_{k \in K} \sum_{i \in I_{jkt}} y_{ijkt}}}{\dfrac{\sum_{j \in J} \sum_{i \in I_{jkt}} y_{ijkt}}{\sum_{k \in K} \sum_{j \in J} \sum_{i \in I_{jkt}} y_{ijkt}}}$$

The concentration of exporting activities (z_3) is measured as the ratio of the province-industry's share of national-industry total exports against the province's share of national total exports:

$$z_{3jkt} = \frac{\dfrac{\sum_{i \in I_{jkt}} \tilde{r}_{ijkt}}{\sum_{k \in K} \sum_{i \in I_{jkt}} \tilde{r}_{ijkt}}}{\dfrac{\sum_{j \in J} \sum_{i \in I_{jkt}} \tilde{r}_{ijkt}}{\sum_{k \in K} \sum_{j \in J} \sum_{i \in I_{jkt}} \tilde{r}_{ijkt}}}$$

where $\tilde{r}$ is the firm export revenue. The vector $\boldsymbol{z}$ also includes a time trend (z_1) that allows labour productivity to grow over time.

Export revenue is directly reported in the dataset. The dummy variable of whether a firm exports (χ_2) is constructed from the export revenue, namely $\chi_2 = 1(\tilde{r} > 0)$. The variable cost per worker ($w + m$) is the ratio of the total variable cost against the total number of workers. The representative consumer's income in the domestic market (Y) is measured by the per-capita average disposable income of urban residents, which is deflated by the consumer price index obtained from the *China Statistical Yearbook 2008*. The income in the export market ($\tilde{Y}$) is measured by the per-capita gross national income (constant 2010 US$) of the world, obtained from the World Development Indicators.

Table 5 reports the summary statistics. We can observe that even within the three-digit industries, there exists substantial variation, measured in terms of the ratio of standard deviation against the mean. For example, in the alcoholic beverage manufacturing industry (152), the standard deviation of domestic sales revenue is almost six times that of the mean. Compared with the domestic sales revenue, the ratios of standard deviation against its mean for exports and new product value are generally higher, suggesting even greater variation for the export revenue and new product value. Therefore, there exists sufficient variation for estimation purposes. Note that we only utilise this within-three-digit-industry cross-firm variation in the estimation.[22]

The presence of FDI is significant in these industries, but different industries accommodate quite different levels of FDI presence. The alcoholic beverage manufacturing industry (152) has the lowest average FDI presence (0.27); namely, in each province, the share of FDI invested firms' output in the province is only 27% that of the share of the province's output in the total national output. In contrast, the computer manufacturing industry observes the highest level of FDI presence, with the share of FDI invested firms' output in the province higher than the share of the provincial output in the national total. Given the different level of FDI presence, we expect it will generate different impacts on firm product innovation and export.

[22] If one wishes to use the between-industry variations, appropriate controls need to be in place.

Domestic firms appear to be engaged in product innovation. The lowest average share of new products in total outputs is 0.02 in the cotton, chemical fibre textile, printing, and fine processing industry, and the highest is 0.3 in the computer manufacturing industry. This suggests that even though the new product value is less than that of the old product value, it is not trivial. Both the within and between-industry variation is quite significant. Within industry, the ratio of the standard deviation against the mean ranges between two and five. Across industries, the mean ranges between 0.02 and 0.3, while the standard deviation ranges between 0.12 and 0.36. Namely, the distributions of the shares of new products in total output appear to change significantly across industries.

Export activities are significant as well, even though there are substantial differences both within and between industries. Compared with domestic sales revenue, the alcoholic beverage manufacturing industry (152) has the lowest level of average export revenue, with the export-domestic sales revenue ratio being only 0.02. In contrast, the computer manufacturing industry (404) has the highest level of average export revenue, and the export-domestic sales revenue ratio is as high as 0.37. The total variable cost of production is composed of the total wage payment (*TW*) and total intermediate inputs (*M*). We can observe from Table 2 that the total intermediate inputs dominate the total wage payment.

Table 5. Summary Statistics

Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Industry	**152**		**171**		**181**		**272**	
sales	85747.64	495506.40	66285.40	529683.60	39503.30	157103.40	98556.52	423222.50
exports	1595.02	36391.89	7638.31	83595.40	12160.77	51201.13	3774.15	28495.13
vnp	6644.91	65967.06	3502.60	41685.51	1992.36	38970.91	15348.29	68235.53
eta(share)	0.03	0.12	0.02	0.12	0.03	0.15	0.09	0.23
TW	3790.98	18570.65	3275.10	21322.09	3247.38	12522.41	5192.43	14313.99
TL	0.27	0.89	0.28	1.51	0.23	0.42	0.30	0.58
M	56656.82	296566.00	52015.63	384501.80	30163.69	122911.50	70969.33	300600.00
vcpw	2.53	3.46	2.85	3.55	1.59	2.31	2.59	3.66
FDI	0.27	0.79	0.31	0.26	0.69	0.42	0.51	0.68
z_2	2.92	4.78	1.62	0.71	1.38	0.65	1.38	1.44
z_3	16.13	39.23	1.85	0.92	1.20	0.57	3.99	7.78
Obs	5151		28399		21997		2656	
Industry	**372**		**395**		**401**		**404**	
sales	95614.94	710095.30	166998.00	1792950.00	174125.70	2082780.00	196407.80	1150067.00
exports	5305.30	88217.24	46633.72	567281.80	63065.48	1425781.00	71878.82	968589.60
vnp	24046.21	299454.00	76147.05	1388454.00	53246.65	682460.90	62483.25	514615.30
eta(share)	0.05	0.17	0.07	0.22	0.19	0.35	0.20	0.36
TW	4093.97	18457.29	5410.07	44972.66	13172.48	185542.10	6727.01	18354.46
TL	0.23	0.70	0.28	1.28	0.29	1.68	0.30	0.76
M	76846.91	589457.40	132971.40	1396161.00	132745.80	1629493.00	161809.00	974159.50
vcpw	2.76	6.02	3.04	3.68	4.06	9.12	5.72	22.09
FDI	0.53	0.55	1.28	1.26	1.01	1.53	1.38	1.08
z_2	1.52	1.33	2.59	1.84	1.68	1.75	1.58	1.11
z_3	1.55	2.61	1.66	1.57	0.99	1.48	0.87	0.70
Obs	19432		4485		2249		1263	

Note: *Sales*, domestic sales revenue (thousand yuan); *exports*, export revenue (thousand yuan); *vnp*, new product value (thousand yuan); *eta(share)*, the share of new products in total outputs; *TW*, total wage (thousand yuan); *M*, total intermediate inputs (thousand yuan); *TL*, total number of workers (thousand); *vcpw*, variable cost per worker (thousand yuan/worker); *FDI*, the share of foreign firms' outputs in the province; z_2 is the concentration of manufacturing activities; and z_3 is the concentration of exporting activities.
Source: NBS, China, 2005–2007.

8. Results

We implement the estimation procedure, outlined in Section 6, with firm-level data for eight three-digit industries in China's manufacturing sector. In this section, we report the estimation results and discuss the implications.

8.1 Herfindahl Index

An important assumption that this study makes is on the market structure, namely that the market is monopolistically competitive. In order to verify this assumption, we compute the Herfindahl index (the sum of the squared market share). If the market is indeed monopolistically competitive, we should observe a low Herfindahl index. Conversely, a high value of the Herfindahl index implies a rejection of the market structure assumption. Table 6 presents the average and maximum (across 2005, 2006, and 2007) Herfindahl index of the eight industries. The highest Herfindahl index is 0.3068 in the computer manufacturing industry (4041), and the textile and garment manufacturing industry (1810) appears to have the lowest Herfindahl index with an average of just 0.0021. Therefore, we conclude that there are no dominant firms in the market, which fails to reject the assumption that the market is monopolistically competitive. In addition, the products in these industries are clearly differentiated. For example, in the computer manufacturing industry, a laptop computer is differentiated from a desktop computer. Therefore, the assumption of a monopolistically competitive market is consistent with the data.

Table 6. Herfindahl Index

Industry Code	Mean	Max
152	0.0397	0.1074
171	0.0057	0.0071
181	0.0021	0.0024
272	0.0126	0.0139
372	0.0076	0.2591
395	0.0682	0.1908
401	0.0621	0.1838
404	0.0585	0.3068

Note: Mean and max are the averages and maximums across 2005, 2006, and 2007.
Source: NBS, China, 2005–2007.

8.2 The Instruments

As discussed in Section 6, the vector of instruments $\boldsymbol{X}$ includes the instruments for FDI presence, consumers' income in the domestic and export markets, firm average wage, and a vector $\boldsymbol{z}$. The vector $\boldsymbol{z}$ includes a time trend (z_1) and the concentration of manufacturing and exporting activities (z_2 and z_3, respectively). The time trend (z_1) is, not surprisingly, exogenous and serves as an instrument in the GMM estimation. The concentration of manufacturing and exporting activities intends to control for the impact of the provincial concentration of manufacturing and exporting activities on the labour productivity, which if not controlled for is likely to be picked up by the FDI presence. Given that firms are small to the market, firms take such types of concentration as exogenous in their decision process, and, therefore, z_2 and z_3 serve as instruments in the estimation. Similarly, the consumer incomes and firm average wage are exogenous.

The presence of FDI is likely to be endogenous as conceptually FDI tends to flow into industries with higher labour productivity. To address this possible endogeneity issue, we use the FDI presence in other industries, which are neither upstream nor downstream industries, as the instruments. On the one hand, the FDI presence in these other industries should be correlated with the FDI presence in the industry of study as they are affected by such common factors as the macroeconomic conditions. In contrast, on the other hand, firm labour productivity should not be directly influenced by the FDI presence in other industries, and firms should take the FDI presence in other industries as exogenous in their business decisions. Therefore, it appears appropriate to use the FDI presence in other industries as an instrument.

Three instruments for FDI presence are constructed using the mapping detailed in Table 7. Take the three-digit industry 152 as an example. The first instrument is the FDI presence from industry 372 (the automobile manufacturing industry), which is clearly neither an upstream nor downstream industry for industry 152 (the alcoholic beverage manufacturing industry). To be more specific, the instrument takes the FDI presence of the four-digit industry 3721 if a firm is located in industry 1521, and 3722, 3723, 3724, 3725 if located in industries 1522, 1523, 1524, and 1529, respectively.

Table 7. The Instruments for FDI Presence

Industry	Instruments
152	
1521	3721, 3951, 4011
1522	3722, 3952, 4012
1523	3723, 3953, 4013
1524	3724, 3954, 4014
1529	3725, 3955, 4019
171	
1711	3721, 4011, 4041
1712	3722, 4012, 4042
181	
1810	1521, 3721, 4011
272	
2720	1521, 3951, 4011
372	
3721	1521, 3951, 4041
3722	1522, 3952, 4042
3723	1523, 3953, 4043
3724	1524, 3954, 4041
3725	1529, 3955, 4042
3726	1521, 3956, 4043
395	
3951	3721, 4011, 4041
3952	3722, 4012, 4042
3953	3723, 4013, 4043
3954	3724, 4014, 4041
3955	3725, 4019, 4042
3956	3726, 4011, 4043
3957	3721, 4012, 4041
3959	3722, 4013, 4042
401	
4011	1521, 3951, 3721
4012	1522, 3952, 3722
4013	1523, 3953, 3723
4014	1524, 3954, 3724
4019	1529, 3955, 3725
404	
4041	1521, 3951, 4011
4042	1522, 3952, 4012
4043	1523, 3953, 4013

Note: Three instruments of FDI presence are constructed in the estimation. For example, the first instrument for industry 152 takes the FDI presence of the four-digit industry 3721 if a firm is located in industry 1521, and 3722, 3723, 3724, and 3725 if located in industries 1522, 1523, 1524, and 1529, respectively.

8.3 Parameter Estimates

Table 8 presents the estimation results. Regarding the CES preference parameter, the point estimate ranges between 0.715 and 0.824, which appears to be reasonable. The alcoholic beverage manufacturing industry (152) and the chemical medicine manufacturing industry (272) have relatively low estimates of ρ, being 0.723 and 0.715, respectively, which implies the elasticity of substitution is 3.61 and 3.51, respectively. The point estimate in the computer manufacturing industry (404) is 0.818, suggesting an elasticity of substitution of 5.49. Not surprisingly, the scope of substitution between the different chemical medicines is quite limited, and the elasticity of substitution is relatively small. The elasticity of substitution amongst different varieties of alcohol appears to be limited as well. For example, beer appears not to be a good substitute for liquor. In contrast, different types of computers are generally highly substitutable to each other, yielding a high elasticity of substitution. For example, one can easily switch from one type of laptop computer to another type and even from a laptop computer to a desktop computer.

The parameters δ_0, δ_1, and δ_2 are parameters of interest, where δ_0 measures the impact of FDI presence on the production labour productivity (marginal cost of production), δ_1 measures the impact of FDI presence on the product innovation labour productivity, and δ_2 captures FDI's impact on the fixed export cost. δ_0 is found to be statistically significant in four industries, where three industries observe positive estimates and the other one industry has a negative estimate. As discussed previously, on the one hand, the presence of FDI is likely to generate positive productivity spillovers via such channels as imitation, the competition effect, and labour mobility. On the other hand, it is also likely that FDI invested firms attract better quality workers, leaving lower quality workers for domestic firms, resulting in a negative impact on their productivity.

For the impact of FDI presence on the labour productivity of product innovation (δ_1), the point estimate is significantly positive in the cotton, chemical fibre textile, printing, and fine processing industry (171) and the automobile manufacturing industry (372). It is significantly negative in the textile and garment manufacturing industry (181). In other industries, the point estimate is statistically insignificant. Therefore, we observe that the presence of FDI can generate a significantly positive or negative impact on labour productivity in product innovation, albeit not in all industries. For informational spillovers, conceptually, one can expect that the presence of FDI is likely to reduce firms' fixed costs of export. In this study, the estimations generally fail to find evidence of such informational spillovers, except in the chemical medicine manufacturing industry (272).

In addition to FDI presence, we also control for other factors, namely the time trend (δ_3, δ_6 and δ_9) and the concentration of manufacturing (δ_4 and δ_7) and exporting (δ_5, δ_8 and δ_{10}) activities. For the time trend, the labour productivity of production generally exhibits a significantly positive growth trend across years, except in the computer manufacturing industry (404). For example, in the alcoholic beverage manufacturing industry, the point estimate of δ_3 is 0.219, which is statistically significant at the 1% level and suggests that labour productivity in the industry grows substantially each year. In contrast, the labour productivity of product innovation and the fixed cost of exporting generally do not exhibit a significant time trend, except in the alcoholic beverage manufacturing industry (152).

Conceptually the concentration of manufacturing activities should affect labour productivity. Our estimation results appear to support this expectation. Regarding the impact on labour productivity in production (δ_4), the estimate is significantly positive in two industries, negative in two industries, and insignificant in the other industries. The point estimates for the labour productivity of product innovation (δ_7) are statistically significant in three industries and insignificant in the rest. The mixed signs of the point estimates suggest that the concentration of manufacturing activities can be both a benefit and a cost. On the one hand, one can observe the agglomeration benefit that helps improve productivity, while on the other hand, there are costs associated with the agglomeration, such as additional competition and the problems of crowding and congestion.

In addition to the concentration of manufacturing activities, the concentration of exporting activities can play a role in labour productivity, both in production and product innovation, and can reduce the fixed export cost through informational spillovers. The estimation in Table 8 finds evidence of a significant impact from the concentration of manufacturing activities in the labour productivity of both production (δ_5) and product innovation (δ_8), where five industries observe statistically significant estimates of δ_5, and two industries find statistically significant estimates of δ_8. In contrast, the concentration of exporting activities appears not to significantly affect the fixed export cost, as the estimates of δ_{10} are insignificant in all eight industries.

In summary, our estimations suggest that the presence of FDI can affect domestic firms' labour productivity, which in turn will affect their product innovation and exporting (revenue and likelihood), although not in all industries.[23] In industries where FDI presence positively

[23] As a comparison, we also run an estimation over the whole manufacturing sector, where we treat the FDI presence as being exogenous. The point estimates for ρ and δ_0 are 0.78 and -0.035, respectively, both of which are significant at the 1% level. The point estimates for δ_1 and δ_2 are statistically insignificant.

affects the labour productivity of both production and product innovation, for example the cotton, chemical fibre textile, printing, and fine processing industry (171), in addition to its direct impact on export revenue, the presence of FDI can also affect export revenue (and export likelihood in some industries) indirectly via product innovation.

8.4 Policy Implications

By investigating the inter-relationship between FDI presence and domestic firms' product innovation and export participation, we can draw some important policy implications. Conceptually, a clear understanding of the link will help policymakers to fine-tune their policies in order to better harvest the benefit of FDI inflows, innovation, and export participation.

In our empirical exercises, we find that it is indeed possible that the presence of FDI can promote both domestic firms' product innovation and exporting. In addition, product innovation can be positively associated with exporting by domestic firms, and vice versa. Hence, in such a situation, promoting FDI is beneficial, both directly and indirectly. The positive correlation between product innovation and exporting also implies that innovation (export) policies are likely to have an unintended consequence, namely policies that promote innovation (export) will also promote exporting (innovation).

Nevertheless, policymakers need to be aware that such benefits are not guaranteed to exist in every industry. Different industries are affected to a different extent, and some industries may receive a negative impact. Such industry heterogeneity calls for policies to be industry specific. Note that even though this study focuses on China, a large developing country, the implications are also of policy relevance to policymakers in other developing countries, particularly for developing countries in ASEAN and East Asia.

Table 8. Estimation Results

	152	171	181	272	372	395	401	404
ρ	0.723***	0.808***	0.824***	0.715***	0.786***	0.768***	0.816***	0.818***
	(0.0142)	(0.00447)	(0.00900)	(0.0310)	(0.0198)	(0.0382)	(0.0314)	(0.120)
δ_0	1.373***	1.082***	-0.0442	0.960	0.716*	-0.268***	0.190	0.139
	(0.360)	(0.156)	(0.150)	(0.874)	(0.387)	(0.0872)	(0.148)	(1.386)
δ_1	-0.405	0.617***	-0.354***	2.010	1.199**	-0.0507	-0.149	-2.211
	(0.276)	(0.183)	(0.117)	(1.330)	(0.566)	(0.0651)	(0.562)	(2.271)
δ_2	-1.447	0	0	-2.991***	0	0	0	0
	(1.723)	(0)	(0)	(1.034)	(0.292)	(0)	(0.0374)	(1.249)
δ_3	0.219***	0.116***	0.0912***	0.228***	0.222***	0.0631***	0.0780*	0.0690
	(0.0444)	(0.00949)	(0.00905)	(0.0663)	(0.0607)	(0.0242)	(0.0470)	(0.0809)
δ_4	-0.151***	-0.247***	0.186*	-1.040	-0.0956	0.248***	-0.00543	-0.223
	(0.0381)	(0.0813)	(0.110)	(0.682)	(0.103)	(0.0648)	(0.0831)	(1.168)
δ_5	0.0159***	0.201***	-0.150***	0.0395	0.0114	-0.154***	-0.172**	0.115
	(0.00420)	(0.0472)	(0.0354)	(0.0353)	(0.0174)	(0.0263)	(0.0831)	(0.319)
δ_6	-0.0766***	-0.00121	-0.00627	0.00204	-0.0283	-0.0133	-0.0700	-0.218
	(0.0218)	(0.00851)	(0.0118)	(0.112)	(0.0789)	(0.0273)	(0.293)	(0.198)
δ_7	0.0391*	-0.379***	0.262***	-1.129	-0.169	-0.0215	0.00383	2.029
	(0.0219)	(0.0854)	(0.0831)	(0.835)	(0.152)	(0.0558)	(0.416)	(2.014)
δ_8	-0.00295	0.225***	-0.0627***	0.0853	0.0126	0.0304	0.204	0.152
	(0.00233)	(0.0494)	(0.0140)	(0.0581)	(0.0338)	(0.0376)	(0.303)	(0.490)
δ_9	0.264	-0.0129	0.000238	-0.493	0.0327	-0.00893	0.162	0.132
	(0.621)	(0.106)	(0.0548)	(0.800)	(0.951)	(0.160)	(0.585)	(0.715)
δ_{10}	0	-0.215	0	-0.0120	0	0	0	0
	(0.00458)	(0.131)	(0)	(0.0898)	(0.119)	(0)	(0.200)	(0.978)
θ_0	5.246***	5.863***	4.818***	6.417***	7.094***	6.383***	6.763***	7.132
	(0.135)	(0.0614)	(0.0726)	(0.355)	(0.343)	(0.303)	(0.436)	(5.952)

θ_1	3.404***	5.649***	4.449***	6.759***	5.666***	5.922***	5.002***	6.131
	(0.635)	(0.158)	(0.0936)	(1.006)	(1.118)	(0.345)	(0.650)	(3.759)
θ_2	-7.144***	-2.471	-3.202***	-4.113	-1.284**	-1.697	-1.044	0.000246
	(2.768)	(2.658)	(0.657)	(3.077)	(0.568)	(2.330)	(2.002)	(1.750)
θ_3	0.168	-0.652	-0.446*	0.505	-1.350	-1.468	-1.444	902.5***
	(0.622)	(2.627)	(0.262)	(13.55)	(37.54)	(7.974)	(798.7)	(42.12)
Observations	5,151	28,399	21,997	2,656	1,832	4,485	2,249	1,263

Note: Bootstrap standard errors are in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
Source: Author’s estimation with data from NBS, China, 2005–2007.

8.5 Robustness Check

Our identification strategy relies on the theoretical model. How robust is the identification strategy? In particular, to what extent will the departure from the assumptions in theoretical modelling invalidate our estimations above? To answer these questions, we use the Monte Carlo simulations to compute the power of identification, namely the probability that the true parameter values fall in the 95% confidence intervals of the estimates. A high power of identification suggests that the identification strategy is robust.

We start from the following set of true structural parameters: ρ = 0.6, μ = 0.6, β = 1.1, $\Phi = \tilde{\Phi} = 10000$, f = 1, f_η =1, $\underline{f_e} = 5$, τ = 5, δ_0 = 0.5, δ_1 = 0.8, δ_2 = -0.2, $\lambda_1 \sim U[0, 0.1]$, $\lambda_2 \sim U[0, 0.1]$, $\varepsilon \sim N(0,1)$, $ln(\zeta) \sim N(0,0.001)$, which is the baseline scenario in the Monte Carlo simulations ([I] in Table 9). Given the FDI presence (γ) in industry 401, we generate data as follows: the labour productivity, $s = \lambda_1 \times \zeta \times e^{\delta_0 \gamma}$ and $a = \lambda_2 \times \zeta \times e^{\delta_1 \gamma}$, and the fixed cost of export, $f_e = \underline{f_e} \times e^{\delta_2 \gamma}$. With the labour productivity, demand functions, and fixed costs of production, innovation, and exporting, firms endogenously set prices and make decisions on product innovation and serving the domestic and export markets, as described in Section 5. With this parameterisation, around 9% of firms conduct product innovation, and around 22% of firms export, which roughly replicates the real data. We also append the measurement error (ε) to the total variable cost in the data generating process.

With the generated data, we then apply the identification strategy of Section 6 to estimate the structural parameters (ρ, δ_0, δ_1, and δ_2). We use the Wald χ^2 test to test whether the point estimates are statistically different from the true values at the 5% level, namely whether the true values fall within the 95% confidence intervals of the estimates. We repeat this exercise 100 times, and compute the frequency of failing to reject the null hypothesis in the Wald test, which is the probability of correct identification.[24]

In addition to the baseline scenarios (scenario I in Table 9) we also explore several departures from the baseline assumptions. In scenario II, we allow consumers in the domestic and export markets to have different elasticities of substitution ($\rho = 0.6, \tilde{\rho} = 0.65$). Scenario III has capability endowments drawn from log-normal distributions ($ln(\lambda_1) \sim ln(0.03) + N(0,1)$ and $ln(\lambda_2) \sim ln(0.03) + N(0,1)$). In scenario IV, we allow for the possibility that more capable firms benefit more from the presence of FDI; namely, the productivity data are generated as $s = \lambda_1^{1+0.1\gamma} \times \zeta \times e^{\delta_0 \gamma}$ and $a = \lambda_2^{1+0.1\gamma} \times \zeta \times e^{\delta_1 \gamma}$.

---

[24] Ideally, we would wish to repeat this more than 100 times. However, the large computing time prevents us from doing so.

Table 9 reports the computation results. We can observe that the power of our identification strategy is quite high. In the baseline scenario, the true values of ρ, δ_0, and δ_1 fall within the 95% confidence interval estimate in all 100 repeats. The identification power of δ_2 is relatively low at 67%. In scenario II, despite relaxing the assumption that consumers in the domestic and export markets have the same elasticity of substitution, we still correctly estimate ρ in all 100 repeats. The identification power for δ_2 increases to 0.81, compared with the baseline scenario. For scenario III, the identification powers of ρ and δ_0 are relatively low, but acceptable. For scenario IV, our identification strategy performs very well. Therefore, we conclude that our identification strategy is robust.

Table 9. Power of Identification

	[I]	[II]	[III]	[IV]
ρ	1	1	0.75	0.99
δ_0	1	1	0.76	1
δ_1	1	1	1	1
δ_2	0.67	0.81	1	1

Note: [I] is the baseline scenario; [II] uses different CES preference parameters (ρ) in the domestic and foreign markets; [III] uses endowments drawn from the log-normal distributions; in [IV], more capable firms benefit more from FDI.

9. Concluding Remarks

This paper investigates the inter-connection between the presence of FDI, domestic firms' product innovation, and export behaviour. For this purpose, we first set up a theoretical model wherein a monopolistically competitive market, heterogeneous firms first make an optimal decision on product innovation and then set the prices for their products in both the domestic and foreign markets. We show that there exists a sorting pattern along the dimensions of the production and innovation capability endowments, where more capable firms innovate and export. Furthermore, the two endowments are complementary to each other, despite that they are independent of each other. The complementarity results in firms' product innovation being positively correlated with their exporting. In addition, the presence of FDI affects firms' product innovation and export behaviour both directly and indirectly (via its impact on product innovation).

We then bring the model to the data by estimating the impacts of FDI presence on firm labour productivity (both production and product innovation) and the fixed export cost in eight three-digit industries in China's manufacturing sector. Under a set of mild economic and econometric assumptions, we find evidence that is consistent with the prediction of the theoretical model, albeit not in all industries. Subsequently, we identify a channel where FDI presence can affect exporting by domestic firms, namely indirectly through its impact on firms' product innovation, in addition to the direct impact.

Policy-wise, promoting FDI is likely to bring both direct and indirect benefits, which justifies policies that facilitate FDI inflows in developing countries. In addition, the positive correlation between product innovation and exporting suggests that promoting product innovation is likely to result in more exports, and vice versa. Hence, policymakers that intend to promote exporting can achieve this policy target by encouraging product innovation, and vice versa. Nevertheless, it should be noted that such benefits are not guaranteed to exist in every industry. In fact, as different impacts are observed in different industries, and some industries may have negative impacts, such industry heterogeneity calls for policies to be industry specific.

References

Antràs, P. (2005), 'Incomplete Contracts and the Product Cycle', *The American Economic Review, 95*(4), pp.1054-1073.

Anwar, S., and S. Sun (2014), 'Heterogeneity and Curvilinearity of FDI-related Productivity Spillovers in China's Manufacturing sector', *Economic Modelling,* 41, pp.23-32.

Aw, B. Y., M.J. Roberts and D.Y. Xu (2008), 'R&D Investments, Exporting, and the Evolution of Firm Productivity', *American Economic Review, 98*(2), pp.451-456.

Aw, B. Y., M.J. Roberts and D.Y. Xu (2011), 'R&D Investment, Exporting, and Productivity Dynamics', *American Economic Review, 101*(4), pp.1312-1344.

Bilir, L. K. (2014), 'Patent Laws, Product Life-Cycle Lengths, and Multinational Activity'. *The American Economic Review, 104*(7), pp.1979-2013.

Blomstrom, M., and A. Kokko (1998), 'Multinational corporations and spillovers', *Journal of Economic Survey, 12*(2), pp.247-277.

Brambilla, I., G. Hale and C. Long, (2009), 'Foreign Direct Investment and the Incentives to Innovate and Imitate', *The Scandinavian Journal of Economics, 111*(4), pp.835-861.

Branstetter, L., and K. Saggi (2011), 'Intellectual Property Rights, Foreign Direct Investment and Industrial Development',. *The Economic Journal, 121*(555), pp.1161-1191.

Buckley, P. J., J. Clegg and C. Wang (2002), 'The Impact of Inward FDI on the Performance of Chinese Manufacturing Firms', *Journal of International Business Studies, 33*(4), pp.637-655.

Buckley, P. J. Clegg and C. Wang (2007), 'Is the Relationship between Inward FDI and Spillover Effects Linear? An Empirical Examination of the Xase of China', *Journal of International Business Studies, 38*(3), pp.447-459.

Butler, A. (1997), 'Product Cycles and Domestic Wage Inequality in Innovating Countries', *The Canadian Journal of Economics / Revue canadienne d'Economique, 30*(4b), pp.1007-1026.

Caves, R. E. (1974), 'Multinational Firms, Competition, and Productivity in Host-Country Markets', *Economica, 41 162*, pp.176-193.

Choi, J. P., and H. Gerlach (2015), 'Patent pools, Litigation, and Innovation', *The RAND Journal of Economics, 46*(3), pp.499-523

Chuang, Y., and P. Hsu (2004), 'FDI, Trade, and Spillover Efficiency: Evidence from China's Manufacturing Sector', *Applied Economics, 36*, pp.1103-1115.

Das, S., M.J. Roberts and J.R. Tybout (2007), 'Market Entry Costs, Producer Heterogeneity, and Export Dynamics', *Econometrica, 75*(3), pp.837-873.

Demmou, L. (2012), 'How Product Innovation in the North May Immiserize the South: A new Look at the Ricardian Model with a Continuum of Goods', *Journal of Development Economics, 97*(2), pp.293-304.

Doraszelski, U., and J. Jaumandreu (2013), 'R&D and Productivity: Estimating Endogenous Productivity', *The Review of Economic Studies, 80*(4 (285)), pp.1338-1383.

Eaton, J., S. Kortum and F. Kramarz (2011), 'An Anatomy of International Trade: Evidence From French Firms', *Econometrica, 79*(5), pp.1453-1498.

Ederington, J., and P. McCalman (2008), 'Endogenous firm Heterogeneity and the Dynamics of Trade Liberalization', *Journal of International Economics, 74*(2), pp.422-440.

Egger, P., and C. Keuschnigg (2015), 'Innovation, Trade, and Finance', *American Economic Journal: Microeconomics, 7*(2), pp.121-157.

Fang, T., and Y. Ge (2012), 'Unions and Firm Innovation in China: Synergy or Strife?', *China Economic Review, 23*(1), pp. 170-180.

Fasil, C. B., and T. Borota (2013), 'World Trade Patterns and Prices: The Role of Productivity and quality heterogeneity', *Journal of International Economics, 91*(1), pp.68-81.

Feenstra, R. C., and A.K. Rose (2000), 'Putting Things in Order: Trade Dynamics and Product Cycles', *The Review of Economics and Statistics, 82*(3), pp.369-382.

Fu, W., J. Revilla Diez, and D. Schiller (2013), 'Interactive Learning, Informal Networks and Innovation: Evidence from Electronics Firm Survey in the Pearl River Delta, China', *Research Policy, 42*(3), pp.635-646.

Gagnon, J. E., and A.K. Rose (1995), 'Dynamic Persistence of Industry Trade Balances: How Pervasive Is the Product Cycle?', *Oxford Economic Papers, 47*(2), pp.229-248.

Galasso, A., and M. Schankerman (2015), 'Patents and Cumulative Innovation: Causal Evidence from the Courts', *The Quarterly Journal of Economics, 130*(1), pp.317-369.

Galasso, A., M. Schankerman and C.J. Serrano (2013), 'Trading and Enforcing Patent Rights', *The RAND Journal of Economics, 44*(2), pp. 275-312.

Girma, S., Y. Gong and H. Gorg (2009), 'What Determines Innovation Activity in Chinese State-owned Enterprises? The Role of Foreign Direct Investment', *World Development, 37*(4), pp.866-873.

Gorg, H., and D. Greenaway (2004), 'Much Ado about Nothing? Do Domestic Firms Really Benefit from Foreign Direct Investment?', *World Bank Research Observer, 19*(2), pp.171-197.

Griliches, Z. (1980), 'R&D and the Productivity Slowdown', *The American Economic Review, 70*(2), pp.343-348.

Grossman, G. M., and E. Helpman (1991a), 'Endogenous Product Cycles', *The Economic Journal, 101*(408), pp.1214-1229.

Grossman, G. M., and E. Helpman (1991b), 'Quality Ladders and Product Cycles', *The Quarterly Journal of Economics, 106*(2), pp.557-586.

Gustafsson, P., and P.S. Segerstrom (2011), 'North-South Trade with Multinational Firms and Increasing Product Variety', *International Economic Review, 52*(4), pp.1123-1155.

Helpman, E. (1993), 'Innovation, Imitation, and Intellectual Property Rights', *Econometrica, 61*(6), pp.1247-1280.

Helpman, E., M.J. Melitz, and S.R. Yeaple (2004), 'Export Versus FDI with Heterogeneous Firms', *American Economic Review, 94*(1), pp.300-316.

Johnson, R. C. (2012), 'Trade and Prices with Heterogeneous Firms', *Journal of International Economics, 86*(1), pp.43-56.

Kee, H. L., and H.Tang (2016), 'Domestic Value Added in Exports: Theory and Firm Evidence from China', *American Economic Review, 106*(6), pp. 1402-1436.

Kremer, M. (1998), 'Patent Buyouts: A Mechanism for Encouraging Innovation', *The Quarterly Journal of Economics, 113*(4), pp.1137-1167.

Krugman, P. (1979), 'A Model of Innovation, Technology Transfer, and the World Distribution of Income', *Journal of Political Economy, 87*(2), pp.253-266.

Lachenmaier, S., and L. WößMann (2006), 'Does Innovation Cause Exports? Evidence from Exogenous Innovation Impulses and Obstacles Using German Micro Data', *Oxford Economic Papers, 58*(2), pp.317-350.

Lee, H.-H., and J.A. Stone (1994), 'Product and Process Innovation in the Product Life Cycle: Estimates for U. S. Manufacturing Industries, *Southern Economic Journal, 60*(3), pp.754-763.

Li, C., and J. Robles (2007), 'Product Innovation and Parallel Trade', *International Journal of Industrial Organization, 25*(2), pp. 417-429.

Lu, J., Y. Lu, and Z. Tao (2010), 'Exporting Behavior of Foreign Affiliates: Theory and Evidence, *Journal of International Economics*, *81*(2), pp.197-205.

Melitz, M. J. (2003), 'The Impact of Trade on Intra-industry Reallocations and Aggregate Industry Productivity', *Econometrica, 71*(6), pp.1695-1725.

Melitz , M. J., and G.I.P. Ottaviano (2008), 'Market Size, Trade, and Productivity', *The Review of Economic Studies, 75*(1), pp.295–316.

OECD, and Eurostat (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data* (3rd Editio ed.). Paris: OECD.

Saggi, K. (2002), 'Trade, Foreign Direct Investment, and International Technology Transfer: A Survey', *World Bank Research Observer, 17*(2), pp.191-235.

Sharif, N., and C. Huang (2012), 'Innovation Strategy, Firm Survival and Relocation: The Case of Hong Kong-owned Manufacturing in Guangdong Province, China', *Research Policy, 41*(1), pp.69-78.

Smeets, R. (2008), 'Collecting the Pieces of the FDI Knowledge Spillovers Puzzle', *World Bank Research Observer, 23*(2), pp.107-138.

Sun, S. (2009), 'How Does FDI Affect Domestic Firms' Exports? Industrial Evidence, *World Economy, 32*(8), pp.1203-1222.

Sun, S. (2010), 'Heterogeneity of FDI Export Spillovers and Its Policy Implications: The Experience of China', *Asian Economic Journal*, *24*(4), pp.289-303.

Sun, S. (2012), 'The Role of FDI in Domestic Exporting: Evidence from China, *Journal of Asian Economics*, *23*(4), pp.434-441.

Sun, Y., and D. Du (2011), 'Domestic Firm Innovation and Networking with Foreign Firms in China's ICT industry', *Environment and Planning A, 43*(4), pp.786-809.

Swenson, D. L. (2008), 'Multinationals and the Creation of Chinese Trade Linkages', *Canadian Journal of Economics/Revue canadienne d'économique*, *41*(2), 596-618.

Vernon, R. (1966), 'International Investment and International Trade in the Product Cycle', *The Quarterly Journal of Economics, 80*(2), pp.190-207.

Wang, C. C., and G.C.S. Lin (2013), 'Dynamics of Innovation in a Globalizing China: Regional Environment, Inter-firm Relations and Firm Attributes, *Journal of Economic Geography, 13*(3), pp.397-418.

Yeaple, S. R. (2005), 'A Simple Model of Firm Heterogeneity, International Trade, and Wages', *Journal of International Economics, 65*(1), pp.1-20.

Zhu, S. C. (2004), 'Trade, Product Cycles, and Inequality within and between Countries', *The Canadian Journal of Economics / Revue canadienne d'Economique, 37*(4), pp.1042-1060.

ERIA Discussion Paper Series

No.	Author(s)	Title	Year
2018-17	Sizhong SUN	Product Innovation, Exporting, and Foreign Direct Investment: Theory and Evidence from China	Mar 2019
2018-16	T Yudo WICAKSONO, Carlos MANGUNSONG and Titik ANAS	Failure of an Export Promotion Policy? Evidence from Bonded Zones in Indonesia	Mar 2019
2018-15	Alfons PALANGKARAYA and Elizabeth WEBSTER	Entering the Export Market: Do Trade Missions Help?	Mar 2019
2018-14	Kazunobu HAYAKAWA, Toshiyuki MATSUURA, Nuttawut LAKSANAPANYAKUL, and Taiyo YOSHIMI	Export Dynamics and the Invoicing Currency	Mar 2019
2018-13	Sadayuki TAKII	Imported Intermediate Inputs and Plants' Export DynamicsEvidence from Indonesian Plant-product-level Data	Mar 2019
2018-12	Kaoru NABESHIMA and Ayako OBASHI	Regulatory Dissimilarity: A First Look at the Newly Collected Non-Tariff Measures Database	Mar 2019
2018-11	Masami ISHIDA	Economic Potential of the Vientiane–Ha Noi Expressway Based on Experience of the Mekong Region	Mar 2019
2018-10	Byeongwoo KANG	Innovation Process in Public Research Institute: Case Studies of AIST, Fraunhofer, and ITRI	Mar 2019
2018-09	Ha Thi Tan DOAN and TRINH Quang Long	Technical Change, Exports, and Employment Growth in China: A Structural Decomposition Analysis	Feb 2019
Yu2018-08	Ha Thi Tan DOAN	Multi-product Firms, Tariff Liberalisation, and Product Churning in Vietnamese Manufacturing	Feb 2019
2018-07	DUONG Lan Huong, Tsunehiro OTSUKI and Etsuyo MICHIDA	Quantitative Assessment of the Impact of EMS Standards on the Firms' Attitude towards Product Safety	Feb 2019
2018-06	Nobuya FUKUGAWA, Masahito AMBASHI and Yuanita SUHUD	Division of Labour Amongst Innovation Intermediaries in Agricultural Innovation Systems: The Case of Indonesia	Nov 2018

No.	Author(s)	Title	Year
2018-05	Masako NUMATA, Masahiro SUGIYAMA, Gento MOGI, Wunna SWE and Venkatachalam ANBUMOZHI	Technoeconomic Assessment of Microdrigrids in Myanmar	July 2018
2018-04	Rashesh SHRESTHA and Ian COXHEAD	Can Indonesia Secure a Development Divided from its Resource Export Boom?	June 2018
2018-03	Ayako OBASHI and Fukunari KIMURA	Are Production Networks Passé in East Asia? Not Yet	June 2018
2018-02	Lili Yan ING, Wei TIAN, Miaojie YU	China's Processing Trade and Value Chains	May 2018
2018-01	Richard POMFRET	The Eurasian Land Bridge The Role of Service Providers in Linking the Regional Value Chains in East Asia and the European Union	May 2018

Previous year of ERIA Discussion Paper, can be found at:

http://www.eria.org/publications/category/discussion-papers