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Foreign direct investment and product quality in host economies

Sajid Anwar[1] | **Sizhong Sun**[2]

[1]University of the Sunshine Coast, Sippy Downs, Queensland, Australia

[2]James Cook University, Townsville, Queensland, Australia

Correspondence
Sajid Anwar, University of the Sunshine Coast, Sippy Downs, Qld, Australia.
Email: sanwar@usc.edu.au

Funding information
University of the Sunshine Coast

Abstract

We examine, both theoretically and empirically, how the presence of FDI affects product quality of domestic firms through worker mobility. Mobility of more productive workers from foreign-invested to domestic firms lowers the cost of production and contributes to improvement in the quality of goods produced by domestic firms. Profit maximisation by firms yields a structural relationship between unobserved product quality and observed revenue, which allows us to identify the impact of FDI on product quality. We use the theoretical model to frame empirical estimation, where we propose a novel approach to correct for sample selection bias. Under some mild assumptions, a set of population moments are derived and estimated using firm-level data from China's beverage manufacturing industry. We find that, on average, (i) working for foreign-invested firms boosts the skill level of workers by 11.12 per cent and (ii) the probability that an FDI-trained worker will move to a domestic firm is approximately 0.3. Estimation of the structural parameters shows that a one per cent increase in FDI leads to approximately 1.4 per cent improvement in product quality of domestic firms in China's beverage manufacturing industry.

KEYWORDS

China, FDI, monopolistic competition, product quality, spillovers

1 | INTRODUCTION

Product quality is important to firms because it helps to maintain customer satisfaction and loyalty. Higher quality goods also contribute towards good reputation, brand recognition and expansion. For policymakers, product quality is also important in that it plays an important role in industry development. Owing to its importance, a number of studies have focused on different aspects of product quality (see for example, among others Flam and Helpman, 1987; Kugler and Verhoogen, 2012; Sutton, 2007).

Based on the work of Sutton (2007), among others, it can be argued that product quality is also affected by the process of globalisation. The process of rapid globalisation has coincided with an increase not only in the volume of trade in goods and services but also in foreign direct investment (FDI). A large body of the existing literature in the area of international business and international economics, including the early work of Dunning (1993), suggests that the presence of FDI can generate productivity spillovers to domestic firms in host economies, which in turn can help to improve the quality of goods produced. Numerous empirical studies appear to confirm the presence of positive FDI-related spillover effects.[1] However, to the best of our knowledge, none of the available studies has formally explored the link between FDI and product quality.

One difficulty in investigating this issue is that product quality is not directly observable. Hence, most existing empirical studies utilise a proxy for quality or infer quality from information on prices and quantities. For example, Hallak (2006) uses export prices as a measure of quality. Khandelwal (2010) measures product quality by comparing market shares conditional on price. While examining the impact of FDI on export quality, Harding and Javorcik (2012) measure export quality by unit value of exports. Kugler and Verhoogen (2012) use industry-level Research and Development (R&D) and advertising spending to sales, suggested by Sutton (2007), as proxies for the scope of quality differentiation. Crozet, Head and Mayer (2012) rely on expert assessments to measure the quality of French champagne.[2] By examining variations in quality-adjusted prices, Johnson (2012) attempts to glean some information on quality.

Different from the existing literature, one important feature of this paper is that we attempt to examine the impact of FDI on the quality of goods produced by domestic firms without explicitly measuring product quality. FDI from developed economies can lead to positive productivity spillovers that benefit domestic firms in host economies.[3] Conceptually, the spillover effects can also affect the product quality of domestic firms, which we demonstrate in Section 3. Despite the fact that product quality, which cannot be directly observed and is difficult to measure, as long as the consumers value quality, one can (in principle) estimate the

[1]It is well-known that, through forward and backward linkages, worker mobility, and competition and demonstration effects, FDI can affect the productivity of domestic firms in host economies. An excellent discussion of the related issues can be found in, among others, Javorcik (2004), Meyer and Sinani (2009) and Bajgar and Javorcik (2013).

[2]While examining the impact of competition and debt financing on product quality in the supermarket industry, Matsa (2011a, 2011b) measures quality as product availability in the store. The quality of nursing homes is measured by a public reporting system (Werner et al., 2012) and hospital quality is inferred from patient choices (Romley and Goldman, 2011). Coad (2009) captures product quality by different product attributes. Chen and Rizzo (2012) use a physician survey to measure the quality of antidepressants. FDI and advertising can also signal product quality (Katayama and Miyagiwa, 2009, Linnemer, 2012).

[3]Note that in our empirical evaluation, due to the lack of data, we do not observe whether FDI is sourced from developed countries or not.

impact of FDI on product quality from observed variables, such as firm revenue (as will be shown in Section 3).[4]

In exploring the impact of FDI on the product quality of domestic firms, this paper makes three distinct contributions to the existing literature. First, using a theoretical model with heterogeneous firms as in Bernard et al. (2003), Melitz (2003) and Yeaple (2005), where products are quality differentiated, we show that an increase in the presence of foreign-invested firms, which can be interpreted as an increase in FDI,[5] affects the quality of goods produced by domestic firms through worker mobility. Specifically, workers who were previously employed by foreign-invested firms (i.e. FDI firms) move to domestic firms.[6] While worker mobility has been conceptually identified as an important channel of FDI spillovers to domestic firms in host economies (see e.g. Blomstrom and Kokko, 1998), to the best of our knowledge, none of the available studies have used this link to examine the effect of FDI on product quality.[7]

Worker mobility from FDI to domestic firms has been found to be substantial.[8] For example, Poole (2013) finds that about one-third of workers in the multinational enterprises (MNEs) in Brazil left the MNEs at certain point over the sample period (1996–2001), of which around 23 per cent were re-employed by domestic firms. With substantial worker movement, one can conjecture that it plays an important role in transmitting FDI spillovers.

We demonstrate the transmission of FDI spillover effect through worker mobility by considering a labour market where a proportion of workers have previously worked for FDI (i.e. foreign-invested) firms.[9] FDI firms provide training to their employees, which can result in skill improvement and hence increase in the reservation wage. Workers decide whether to accept a job offer in a first-in-first-accept manner, namely they accept the first job that offers a wage higher than their reservation wage. Workers are allowed a very short time window to accept or reject the

[4]For example, Fieler et al. (2018) utilise the positive correlation between product quality and firm sales revenue as a source of identification in their estimation.

[5]In this paper, we use 'foreign presence' and 'FDI' interchangeably.

[6]We refer to such workers as 'FDI-trained workers'.

[7]Some existing studies have considered the issue of technology spillovers to domestic firms due to FDI via worker mobility. These studies tend to assume that foreign firms have superior technology and they pay higher wages to discourage mobility of their workers to domestic firms in host economies. For example, using a game theoretic framework, Fosfuri, Motta and Rønde (2001) show that, to avoid technology spillovers to domestic firms in host economies arising from mobility of workers from foreign-invested to local firms, multinational firms may prefer to export instead of investing abroad. Using an oligopoly model, Glass and Saggi (2002) argue that to take advantage of possible technology spillovers from foreign to domestic firms due to mobility of foreign-trained workers, host country governments may use policies that attract inward FDI. In a related empirical study, using plant level data from Colombia, Markusen and Trofimenko (2009) consider knowledge spillover to domestic firms in a different setting. They use a model where some domestic firms use foreign experts to train their workers. Mobility of the workers trained by foreign experts to other domestic firms leads to technology spillovers. They highlight the role of the timing of the training provided by foreign experts. However, none of the existing studies have considered the role of worker mobility plays in the link between FDI and product quality. Other empirical studies that highlight the importance of worker mobility in productivity spillovers include Stoyanov and Zubanov (2014, 2012).

[8]To the best of our knowledge, none of the available studies has considered the effect of FDI on worker mobility to domestic firms in China.

[9]In $t = 0$, this proportion is 0.

job offer. Once a job is accepted, both parties enter into a binding agreement, and breaking the contract incurs a prohibitively high penalty. Within this setting, we show the probability that domestic firms will hire FDI-trained workers is strictly positive. If FDI-trained workers are more skilled compared with non-FDI-trained workers then hiring of FDI-trained workers decreases the marginal cost of production of domestic firms (i.e. a positive productivity spillover effect exists).

Second, we show that the impact of FDI on the quality of goods produced by domestic firms can be identified from its impact on the firm revenue. Given that consumers derive higher utility from consuming higher quality products, firm profit maximisation yields an FDI-quality (unobserved) relationship as well as an FDI-revenue (observed) relationship. These two relationships are structurally linked to each other and allow one to estimate the quality impact of FDI without explicitly measuring product quality.

Under some mild assumptions, for example the explanatory variables (demand-side factors in the labour market) are not correlated with the labour endowment (supply-side factors in the labour market), we derive a set of population moments. Fitting the population moments with firm-level data from China's beverage manufacturing industry over the 2005–2007 period,[10] we estimate the parameters of our structural model, which enables us to calculate the marginal impact of FDI on product quality. Our empirical analysis reveals that FDI has a positive impact on product quality of domestic firms in China's beverage manufacturing industry, which is robust to different specifications and alternative instruments.

In our empirical analysis, we also distinguish between FDI in China originating from (i) Hong Kong, Macau and Taiwan (HMT) and (ii) non-HMT regions. FDI from HMT exhibits characteristics different from the non-HMT FDI. On the one hand, the HMT FDI comes from a region with a cultural background similar to that of domestic firms while,[11] on the other hand, the non-HMT FDI generally entails more advanced technology. The empirical results suggest that the effect of an increase in FDI from non-HMT on the quality of goods produced by firms in China's beverage manufacturing industry is larger than that of the HMT FDI.

Third, due to the fact that less capable firms will not enter the industry as they will make an economic loss, the observed firms are not a random sample from the population. Therefore, it is often necessary to correct for sample selection bias when using such data. Note that the classical Heckman sample selection model is not applicable here, in that we do not observe firms that are not included in the sample and hence cannot estimate the probability of being included in the sample. In order to account for sample selection bias in estimating the quality impact of FDI,[12] one option is to explicitly assume a distribution of the Melitz (2003) firm capability endowment and integrate out the sample selection term. Not surprisingly, this option critically depends on the distributional assumption, and an incorrect distributional assumption is likely to bias the estimation results. Instead of using this option in our paper, we propose a novel method to account for the sample selection bias, which can also be used in other studies of a similar type.

[10]Unfortunately, more recent data are not available.

[11]Arguably, the FDI flow is closely linked to such cultural factors (see for example Burchardi et al., 2016).

[12]It can be shown that this selection effect through changing the cut-off capability always works against the direct impact on firm revenue. That is, if foreign presence improves domestic firms' productivity (positive productivity spillovers), it will lower the cut-off capability such that less capable firms that previously cannot survive in the industry will enter the market, and subsequently, average firm revenue is reduced. If there are negative productivity spillovers, the opposite situation occurs.

We assume that the sample selection term $(E\left[ln\lambda|\lambda \geq \underline{\lambda}\right]$, where λ denotes the capability endowment and $\underline{\lambda}$ is the cut-off level) is a continuous function of the cut-off capability endowment, which is a mild assumption in that it only requires the capability endowment to be a continuous random variable with existence of mean. We then approximate the selection term using a K-order Taylor expansion over $\underline{\lambda}$. Using the fact that firm revenue is a monotonically increasing function of its capability endowment, we invert the cut-off capability ($\underline{\lambda}$) as a function of the cut-off revenue ($\underline{r}$). Despite the fact that the cut-off capability is unobserved, the cut-off revenue can be estimated from the data as the minimum firm revenue. With the estimated cut-off revenue and Taylor expansion of the sample selection term, we then proceed to estimate the parameters of interest. Monte Carlo simulations, reported in our Appendix S1, find that our method performs well in correcting for sample selection bias.

The rest of this paper is structured as follows. A review of related studies is presented in Section 2. A theoretical model, which allows one to establish the link between FDI and product quality, is developed in Section 3. Section 4 discusses the empirical strategy utilised to estimate the structural parameters of the model. Section 5 discusses the data. The empirical results are presented and discussed in Section 6, and Section 7 contains some concluding remarks.

2 | RELATED LITERATURE

In recent years, a large number of empirical and theoretical studies have considered different aspects of product quality. Using non-homothetic preferences, the issue of gains from trade has been re-examined when goods are quality differentiated. It has been suggested that higher-income countries produce higher quality goods. Based on models of firm heterogeneity, more recent studies have shown that firms that pay higher wages also produce higher quality products.

Copeland and Kotwal (1996) argue that, when goods are quality differentiated, there may not be any gains from trade among countries with large differences in income. Murphy and Shleifer (1997) argue that countries with a high level of human capital tend to have a comparative advantage in relatively higher quality goods. Hummels and Klenow (2005) and Khandelwal (2010), among others, suggest that current international trade is characterised by a strong quality dimension. Eswaran and Kotwal (2007) argue that some developing countries, like India, where labour is relatively cheap, tend to produce low-quality products at a high cost. They suggest that this situation arises due to monopolistic provision of certain non-traded inputs. Accordingly, trade liberalisation, by reducing the cost of intermediate inputs, can enhance product quality. Verhoogen (2008) shows that quality upgrading links trade and wage inequality in developing countries.

As product quality is unobservable, most empirical studies utilise a proxy for product quality. Using export price as an indicator of quality, Hallak (2006) empirically examines the link between trade and product quality. Alcalá (2009) considers the link between comparative advantage and product quality. It is argued that lower quality is related to lower wages. Alcalá suggests that average quality within an industry is an increasing function of the wage rate. In a significant departure from previous studies, using an innovative measure of quality that involves information on both prices and quantities, Khandelwal (2010) confirms the results of earlier studies that have shown that higher-income countries export higher quality goods.[13] Using the same measure

[13]Using a theoretical model, Antoniades (2015) derives a similar result.

of quality, the empirical work of Amiti and Khandelwal (2013) suggests that import competition can affect quality upgrading.

Dana and Fong (2011) investigate the relationship among product quality, reputation and market structure. Baldwin and Harrigan (2011) develop a model where competitiveness of firms depends on their quality-adjusted price. They find that, in equilibrium, higher quality goods are relatively more costly to produce but also more profitable. Lu, Ng and Tao (2012) show that outsourcing can lead to lower product quality, which in turn can be mitigated by contract enforcement. While investigating the impact of legal institutions on product quality, Essaji and Fujiwara (2012) measure product quality using the approach proposed by Khandelwal (2010) and find that a country with better contracting institutions is more capable of producing better quality products. Martin (2012) finds a positive impact from trade costs on free on board export unit value, which can be explained by higher product quality. Using a measure of quality differentiation, which is based on R&D spending as suggested by Sutton (2007), Kugler and Verhoogen (2012) investigate the impact of quality differences in inputs and outputs on the price-plant size correlation.[14]

So far, only a few studies have explored the issue of product quality in China. While identifying the mechanisms underlying the evolutionary process of industrial development in Wenzhou (China), Sonobe, Hu and Otsuka (2004) find that, upon entry into an industry, many firms initially produce poor-quality products. However, after some time, firms are found to be working towards quality upgrading. Yu (2010) argues that democratisation in the exporting country can improve product quality. While investigating China's export sophistication, Xu (2010) measures the quality of China's exports by means of a relative price index. Manova and Zhang (2012) and Manova and Yu (2017) find that firms in China, which are relatively more successful in exporting, use higher quality inputs to produce higher quality products. Furthermore, Chinese firms export different quality products to different markets.

Using a Melitz-type theoretical model, Anwar and Sun (2018) provide a theoretical justification for using industry export unit value as a proxy for export quality. They use industry-level panel data from China's manufacturing sector to show that FDI has a positive effect on export quality. In addition, Anwar and Sun (2016) also explore the impact of FDI presence on domestic firms' product quality in China, where they discover a negative impact. This study is different from theirs in two aspects. First, we focus on the role of worker mobility in the transmission of FDI spillovers. Second, in estimating the marginal impact of FDI on product quality, we explore more deeply by estimating a structural parameter of skill difference. In contrast, they only estimate the net impact of FDI presence.[15]

In summary, there is a lack of study that formally explores the connection between FDI and product quality. In addition, earlier empirical studies have used unit values or unit-valued-based

[14]Other related studies include Linder (1961), Bardhan and Kletzer (1984), Falvey and Kierzkowski (1987), Grossman and Helpman (1991), Schott (2004), Helpman (2006), Helpman, Melitz and Rubinstein (2008), Choi, Hummels and Xiang (2009), Hallak (2010), Kirchler, Fischer and Hölzl (2010), Fajgelbaum, Grossman and Helpman (2011) and Feenstra and Romalis (2014).

[15]The net impact contains two contrasting forces. They find that FDI presence generates positive productivity spillovers, which encourages less capable firms to enter the industry, and in turn lower the average product quality.

measures of product quality. This paper uses a theoretical model to establish a link between FDI and product quality. We show that, through worker mobility, an increase in the presence of foreign-invested firms can affect the product quality of domestic firms. Using firm-level data from China's beverage manufacturing industry, we estimate the structural parameters of the model. This allows us to determine the impact of variations in FDI on product quality without explicitly measuring quality.

3 | THE MODEL

In this section, we develop a theoretical model to show the impact of FDI on product quality. The model is also used to guide the identification strategy for empirical estimation. We consider an economy where two types of firms exist: domestic and foreign-invested (also known as FDI firms). In the economy, firms' capability endowment is private information, and similarly, workers' skill is not publicly observable. We start with the discussion of the labour market, which allows us to focus on the role of worker mobility in the transmission of FDI-related spillovers.

3.1 | Labour supply and the skill gap between FDI-trained and non-FDI-trained workers

In each period, the economy is endowed with L workers, who seek for jobs in the markets.[16] Workers can be divided into two groups: (i) production workers and (ii) quality control personnel. Production workers and quality control personnel, respectively, account for δ and (1 - δ) proportion of the total. Out of the L workers, γ is the proportion of FDI-trained workers (i.e. these workers were previously employed by FDI firms).[17]

Workers have different skills, which are private information.[18] Working for firms can improve the skills of both quality control and production workers. However, due to the technological difference between domestic and FDI firms, working with FDI firms affects workers' skills to a different extent than working with domestic firms. Let s and $\tilde{s}$, respectively, denote the skill level of a worker if she has never worked for an FDI firm and if instead she has worked for an FDI firm in the past. Then, the skill gap can be written as $\left(\frac{\%\tilde{s}-s}{s}\right)$. Because different workers have different capability endowment and hence are affected by the FDI working experience differently, the skill gap is a random variable with mean β, which we call the skill gap parameter. If $\beta > 0$, this implies that, on average, FDI-trained workers are β more productive than non-FDI-trained workers. Similarly, FDI-trained workers are β less productive, if $\beta < 0$. Note that even though we assume the mean skill gap does not depend on worker type (i.e. whether the worker is involved in production or quality control),[19] the skill gap due to prior experience with FDI firms can vary across the two types of workers.

[16]The L workers consist of both the new entrants to the job market and those who are separated from firms in the previous period.

[17]In the initial period, $\gamma = 0$.

[18]Therefore, it is not feasible to have a mechanism that matches workers with firms, as in Eeckhout and Kircher (2018).

[19]Other moments of the skill gap distribution are unconstrained.

In the labour markets, firms post job advertisements and workers seek for jobs in each period.[20] A worker is only allowed to accept one job offer in each period. Workers are allowed a short time window to accept or reject the job offer. Once the worker accepts a job offer, she enters a binding contract with the firm. If any party, either the firm or worker, wishes to break the contract, a penalty is incurred. For simplicity, we assume the penalty is sufficiently high such that neither the worker nor the firm has an incentive to deviate from the agreement.

Workers decide whether to work or not.[21] If a worker decides not to work, she enjoys leisure and receives an unemployment benefit. If she decides to work (namely to accept a job offer from a firm), she receives a wage as specified in the job offer. In accepting a job offer, the worker behaves in a first-in-first-accept manner (i.e. if she is happy with the job offer she immediately accepts it).[22] The decision to work is based on the comparison of the utility derived from leisure and unemployment benefit with the utility derived from wage. As the utility is an increasing function of wage, there exists a threshold wage, above which the worker will decide to work. This threshold wage is the worker's reservation wage, which equals the unemployment benefit plus the income equivalent to the value of leisure.

Workers are heterogeneous and have different reservation wages. For example, a worker with a higher education level is likely to have a higher reservation wage. Given worker heterogeneity, we assume that their reservation wage is uniformly distributed. Specifically, the reservation wages of non-FDI-trained workers are uniformly distributed over the support $[0, \overline{w}]$. The FDI-trained workers have their reservation wage uniformly distributed over $[0, (1+\beta)\overline{w}]$. Note that FDI-trained workers on average have β higher/lower reservation wage than their non-FDI-trained counterparts, as they are on average β more/less productive.

Define an event A to be {a firm hires a worker by offering wage w}, which is the same as the event {a worker accepts a job offer with wage w}, and event B to be {a worker is previously FDI-trained}. Accordingly, we can compute the following quantities: $Prob(A|B) = w/[(1+\beta)\overline{w}]$, $Prob(A|B^c) = w/\overline{w}$, $Prob(B) = \gamma$, $Prob(A) = \frac{w}{\overline{w}}\left(1 - \frac{\beta}{1+\beta}\gamma\right)$ and $Prob(B|A) = \frac{\gamma}{1+\beta(1-\gamma)}$, where $Prob$ represents a probability measure and the superscript c denotes complement. Note $Prob(B|A)$ is the proportion of FDI-trained workers in a firm, which is a function of the industry-level FDI presence (γ) and is strictly positive as long as $\gamma \neq 0$ (namely there are workers in the labour markets who are previously FDI-trained).[23]

[20]To be more concrete, one can imagine that there exists a platform, for example like the Job Openings for Economists at AEAWeb, where firms post their advertisements and workers seek for jobs. Once a firm's wage offer is higher than a worker's reservation wage, they enter into a binding employment contract. For simplicity, we abstract away from such detailed activities as shortlisting and interview.

[21]Workers may first decide which job market to enter, which in turn affects the relative labour supply $\left(\frac{1-\delta}{\delta}\right)$. However, we do not model this layer of decision making because this supply-side factor is uncorrelated with the demand-side factors and as such it does not affect our empirical estimation. Besides, once a worker enters a market, she cannot switch to the other market. That is, the two types of workers cannot exchange their roles.

[22]Note that a worker cannot hold a job offer in the hope of a better one, as she only has a short period of time to accept or reject the offer. In addition, the penalty for breaking the contract is sufficiently high. In other words, the labour market institution ensures that workers do not behave strategically.

[23]In the initial period, $\gamma = 0$. After that, $\gamma > 0$ as FDI firms will employ workers in the host economy. One can enodgenise the level of FDI presence by investigating the long-run equilibrium where free entry and exit results in both domestic and FDI firms to earn zero economic profit. We do not need to proceed along this line as we are not interested in examining the determinants of FDI presence.

Therefore, in the production worker market, the aggregate supply of labour is:

$$L^s(w) = Prob(A)\delta L = \left(1 - \frac{\beta}{1+\beta}\gamma\right)\frac{w}{\overline{w}}\delta L \tag{1}$$

where w is the wage rate and L^s represents the aggregate supply of labour. Similarly, the aggregate labour supply in the market for quality control personnel is as follows:

$$L_z^s(\%\overline{w}) = Prob(A)(1-\delta)L = \left(1 - \frac{\beta}{1+\beta}\gamma\right)\frac{\widetilde{w}}{\overline{w}}(1-\delta)L \tag{2}$$

where $\widetilde{w}$ denotes the wage rate and L_z^s is the aggregate labour supply.

Three observations are worth of noting here. First, in the labour market, it can be that firms of a certain type more actively seek for workers of a certain type. For example, capable firms will seek for skilful workers more actively as they value skills more than less capable firms (complementarity between firm capability and worker skill). Let C represent such firm type, and then $Prob(B|A) = Prob(B|A,C)$ as workers derive utility only from their wages (not from firm type).

Second, if FDI-trained workers are perceived to be more skilful and FDI firms more actively seek for FDI-trained workers, then it is more likely for an FDI-trained worker to receive a job offer from FDI firms. Our modelling is consistent with this possibility. To see this, with slightly abusing notation, let C represent the event {a firm is FDI firm}. Then, conditional on a FDI-trained worker accepting a job offer, the probability that it is from a FDI firm can be written as $Prob(C|A,B) = \frac{Prob(A|B,C)Prob(B|C)}{Prob(C)} = \frac{Prob(A|B)Prob(B)}{Prob(C)}$, where the second equality is due to workers do not derive utility from with whom they work (only from wage) and the independence of events B and C. Similarly, $Prob(C^c|A,B) = \frac{Prob(A|B)Prob(B)}{Prob(C^c)}$. Since it is more difficult to enter a foreign market than the domestic market, $Prob(C) < Prob(C^c)$. Therefore, $Prob(C|A,B) > Prob(C^c|A,B)$, namely a FDI-trained worker is more likely to receive a job offer from FDI than domestic firm, conditional on the job being accepted.

Third, information regarding worker skill and firm capability plays an important role in the modelling. If worker skill and firm capability are publicly observable, one may utilise a positive assortative matching to assign more skilful workers to more capable firms, and workers with different skills will earn different wages, as in Eeckhout and Kircher (2018). If worker skill and firm capability are partially observable, it can be expected that the labour market will be segmented into submarkets by the observable components of worker skill and firm capability. Equilibria in the submarkets will result in workers with different observable skills earn different wages. We leave these two possibilities for future work.

3.2 | Firm behaviour and labour demand

In the goods market, on the demand side, a representative consumer has the following constant elasticity of the substitution (CES) utility function:[24]

[24]Most related studies (for example Crozet, Head and Mayer, 2012, Hallak, 2010, 2006, Kugler and Verhoogen, 2012) use a similar quality augmented CES utility function. The CES utility function used in this paper is slightly different from the one used by Kugler and Verhoogen, and others, in that the exponents of quality and quantity are not identical. This functional form is chosen merely to simplify the empirical estimation. Because quality enters as a shift parameter in the utility function, its exponent does not play any part in any analytical result.

$$U = \left[\int_{\omega \in \Omega} Z(\omega)^{1-\rho} q(\omega)^{\rho} d\omega \right]^{\frac{1}{\rho}}$$

where ω indexes the products; Ω is the set of all available products in the industry; q is the quantity of each product; and Z represents product quality.

Following Kugler and Verhoogen (2012), among others, product quality can be interpreted as product attributes that the representative consumer values. In other words, the consumer derives a higher level of utility from consuming higher quality products, ceteris paribus. All products are substitutes to each other ($0 < \rho < 1$) and have a constant elasticity of substitution of $1/(1-\rho)$. Consumer utility maximisation yields the following Marshallian demand function:

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

where p is the price; $\Phi \equiv \frac{Y}{\int_{\omega \in \Omega} p(\omega)^{\rho/(\rho-1)} Z(\omega) d\omega}$ is the level of aggregate demand; and Y is consumer income.

Each firm takes Φ as given because they are small in size relative to the industry. Accordingly, the impact of a change in the output of each firm on $\Phi$is negligible. The Marshallian demand function suggests that there is a positive relationship between product quality and demand.

On the production side, as indicated earlier, the industry consists of both domestic and FDI firms.[25] Upon entry into the industry, each firm draws a capability/productivity endowment, denoted by λ, from an exogenous distribution, with the cumulative distribution function G(λ) over the support $[0, +\infty)$.[26] As will be shown later, firm profit is a monotonically increasing function of the capability endowment. If the capability of a firm is below a certain level such that its profit becomes negative, it will not enter the industry. Each of the remaining firms produces a single variety of a differentiated product in each period. Firms are engaged in a two-stage game. In stage one, each firm selects its product quality.[27] In stage two, firms set a price that maximises the per-period profit.

During the production process, after incurring the fixed cost of production (f), firms combine workers with an intermediate input to produce output. A non-FDI-trained worker can utilise ν units of the intermediate input to produce $\lambda Z^{-\mu} \zeta$ units of output, which is an increasing function of firm capability endowment (λ) and decreasing function of product quality (i.e. consistent with a number of previous studies, such as Auer, Chaney and Sauré (2018), the higher quality a product has, the more difficult it is to produce, with the elasticity being

[25]In order to ensure consistency between the theoretical and empirical parts of this paper, we divide all firms into two categories: domestic and foreign-invested. Firms with non-zero (and up to 100 per cent) foreign ownership are foreign-invested, whereas firms with zero per cent foreign ownership are domestic firms. The empirical part of this paper is based on data from China where FDI mostly takes the form of partnerships with foreign firms.

[26]Here, we do not explicitly specify the distribution of λ, similar to Grossman, Helpman and Szeidl (2006). The seminal work of Melitz (2003) and a number of related studies, including Melitz and Redding (2012), assume that firm capability/productivity is drawn from a Pareto distribution.

[27]For example, firms decide their investment in (i) training of the quality control personnel, (ii) research and development that improves product quality and (iii) quality control equipment.

$\mu > 0$), and ζ captures all the other factors that affect firm productivity.[28] As FDI-trained workers, on average, are β more/less productive than non-FDI-trained workers, with the same amount of the intermediate input, a FDI-trained worker can on average produce $(1 + \beta)\lambda Z^{-\mu}\zeta$ units of output.

Since $\frac{\gamma}{1+\beta(1-\gamma)}$ proportion of the workers that a firm hires is FDI-trained, the relationship between firm output, product quality and workers used can be written as $q = \frac{1+\beta}{1+\beta(1-\gamma)}\lambda Z^{-\mu}\zeta l$, where q denotes quantity of output and l is the number of production workers. Accordingly, the marginal cost of production is $MC = \frac{(w+v)[1+\beta(1-\gamma)]}{(1+\beta)\lambda Z^{-\mu}\zeta}$, where MC denotes the marginal cost of production and w is the wage rate.

Proposition 1 (Worker Mobility): Through worker mobility (i.e. domestic firms employing workers who were previously employed by FDI firms), the presence of FDI can generate productivity spillovers to domestic firms.

Proof: As described in Section 3.1, by offering wage rate w, a domestic firm has probability $\frac{\gamma}{1+\beta(1-\gamma)}$ of having an FDI-trained worker in its work force. After hiring the FDI-trained workers, the marginal cost of production of a domestic firm can be written as $MC = \frac{(w+v)[1+\beta(1-\gamma)]}{(1+\beta)\lambda Z^{-\mu}\zeta}$. Therefore, if FDI-trained workers are more productive than non-FDI-trained workers (i.e. $\beta > 0$), an increase in γ results in a decrease in MC (i.e. the FDI-related productivity spillovers effect is positive). A negative spillover effect occurs if $\beta < 0$.

Proposition 1 tells us that the presence of FDI can generate productivity spillovers to domestic firms via worker mobility. Given the institutional settings in the labour market, the probability that a domestic firm will employ FDI-trained workers is strictly positive after the initial period. Hence, their marginal cost of production is lowered if $\beta > 0$.

A large body of the existing literature in the area of international business and international economics supports the presence of positive productivity spillovers from foreign to domestic firms.[29] In the case of China, which is the focus of our empirical exercise in Section 4, a number of studies have reported the presence of positive FDI-related productivity spillovers.[30]

The per-period profit of a firm can be written as follows:

$$\pi = \left(p - \frac{(w+v)[1+\beta(1-\gamma)]}{(1+\beta)\lambda Z^{-\mu}\zeta}\right)q - f - MC_z Z$$

where π is the profit; p is the price that firm charges; f is the fixed cost of production, which includes the fixed cost of quality production; and MC_z is marginal cost of quality production.

[28]For example, ζ can include the other channels of FDI productivity spillovers, such as the forward and backward linkages and competition and demonstration effect.

[29]For example, see Meyer and Sinani (2009) and references therein.

[30]Using firm level data from 1998 to 2005, Lin, Liu and Zhang (2009) find that domestic firms in China benefit from significant vertical spillover effects. Other studies that report positive productivity spillovers to domestic firms in China include Sun (2011) and Xu and Sheng (2012). However, some studies on China find no spillover effects or even negative spillover effects (for example see Girma et al., 2015, Lu et al., 2017). It is worth mentioning that within the context of the theoretical model used in this paper, the spillover effects can be negative.

In stage two, the firm sets a price to maximise its profit, namely $p = \frac{(w+v)[1+\beta(1-\gamma)]}{\rho(1+\beta)\lambda Z^{-\mu}\zeta}$, which suggests that firms charge a higher price for higher quality products, with the elasticity being μ. This is consistent with empirical results presented by, among others, Johnson (2012) and Manova and Zhang (2012).

Substituting the price into the per-period profit function, the optimal per-period profit (π^*) can be derived as

$$\pi^* = (1-\rho)\rho^{\rho/(1-\rho)}(1+\beta)^{\rho/(1-\rho)}\Phi(w+v)^{\rho/(\rho-1)}[1+\beta(1-\gamma)]^{\rho/(\rho-1)}\zeta^{\rho/(1-\rho)}\lambda^{\rho/(1-\rho)}Z^{\frac{1-\rho(\mu+1)}{1-\rho}} - f - MC_z Z$$

where $0 < \mu < (1-\rho)/\rho$.

In stage one, as with goods production, quality control involves a fixed cost to purchase quality control equipment, which is absorbed into the fixed cost of production (f). With the equipment, one unit of the non-FDI-trained quality control personnel can produce $\lambda\zeta$ units of quality, whereas one unit of FDI-trained quality control personnel can produce $(1+\beta)\lambda\zeta$ quality units. Note that quality production is an increasing function of firm capability endowment, and FDI-trained quality control personnel is on average β more/less productive.

Since $\frac{\gamma}{1+\beta(1-\gamma)}$ proportion of the quality control personnel a firm hires is FDI-trained, the quality production relationship is as follows: $Z = \frac{1+\beta}{1+\beta(1-\gamma)}\lambda\zeta l_z$, where l_z is the number of quality control personnel. Accordingly, the marginal cost of quality production is $MC_z = \frac{\widetilde{w}[1+\beta(1-\gamma)]}{\lambda(1+\beta)\zeta}$, where $\widetilde{w}$ is the wage rate of quality control personnel. Firms choose Z to maximise their per-period profit, which yields the optimal quality level as follows:

$$Z = \rho^{\frac{1}{\mu}}[1-\rho(1+\mu)]^{\frac{1-\rho}{\rho\mu}}(1+\beta)^{\frac{1}{\rho\mu}}\Phi^{\frac{1-\rho}{\rho\mu}}(w+v)^{-\frac{1}{\mu}}\widetilde{w}^{-\frac{1-\rho}{\rho\mu}}[1+\beta(1-\gamma)]^{-\frac{1}{\rho\mu}}\zeta^{\frac{1}{\rho\mu}}\lambda^{\frac{1}{\rho\mu}} \quad (3)$$

Equation (3) suggests firm optimal product quality (Z) is a function of FDI presence via worker mobility (γ). An increase in γ results in a higher probability of hiring FDI-trained quality control personnel, which in turn reduces the marginal cost of quality production if FDI-trained quality control personnel is on average more skilful (namely $\beta > 0$). Subsequently, firms respond by improving their product quality.[31]

By substituting Equation (3) into the profit function, the optimal per-period profit as a function of firm capability can be derived as follows:

$$\pi^*(\lambda) = \mu\rho^{\frac{1+\mu}{\mu}}[1-\rho(1+\mu)]^{\frac{1-\rho(1+\mu)}{\rho\mu}}(1+\beta)^{\frac{1-\rho\mu}{\rho\mu}}\Phi^{\frac{1-\rho}{\rho\mu}}(w+v)^{-\frac{1}{\mu}}\widetilde{w}^{-\frac{1-\rho(1+\mu)}{\rho\mu}}[1+\beta(1-\gamma)]^{-\frac{1-\rho\mu}{\rho\mu}}\zeta^{\frac{1-\rho\mu}{\rho\mu}}\lambda^{\frac{1-\rho\mu}{\rho\mu}} - f$$

The optimal profit is a monotonically increasing function of the capability draw (λ). As $\pi^*(0) = -f < 0$, there exists a cut-off capability ($\underline{\lambda}$) such that $\pi^*\left(\underline{\lambda}\right) = 0$. Accordingly, the cut-off capability can be derived as follows:

$$\underline{\lambda} = \mu^{-\frac{\rho\mu}{1-\rho\mu}}\rho^{-\frac{\rho(1+\mu)}{1-\rho\mu}}[1-\rho(1+\mu)]^{-\frac{1-\rho}{1-\rho\mu}}(1+\beta)^{-1}\Phi^{-\frac{1-\rho}{1-\rho\mu}}(w+v)^{\frac{\rho}{1-\rho\mu}}\widetilde{w}^{\frac{1-\rho(1+\mu)}{1-\rho\mu}}[1+\beta(1-\gamma)]\zeta^{-1}f^{\frac{\rho\mu}{1-\rho\mu}} \quad (4)$$

[31]An opposite situation occurs if $\beta < 0$.

Equation (4) shows that, when FDI-trained workers are on average more productive than non-FDI-trained workers (i.e. $\beta > 0$), the presence of FDI generates positive productivity spillovers to domestic firms, and an increase in foreign presence reduces the cut-off capability of domestic firms.[32]

Equation (3) shows that optimal product quality is a function of FDI presence. However, we do not directly observe firm product quality. Instead, data on firm revenue are usually observable to researchers. Firm revenue can be derived as follows:

$$r = \rho^{\frac{1}{\mu}}[1-\rho(1+\mu)]^{\frac{1-\rho(1+\mu)}{\rho\mu}}(1+\beta)^{\frac{1-\rho\mu}{\rho\mu}}\Phi^{\frac{1-\rho}{\rho\mu}}(w+v)^{-\frac{1}{\mu}}\widetilde{w}^{-\frac{1-\rho(1+\mu)}{\rho\mu}}[1+\beta(1-\gamma)]^{-\frac{1-\rho\mu}{\rho\mu}}\zeta^{\frac{1-\rho\mu}{\rho\mu}}\lambda^{\frac{1-\rho\mu}{\rho\mu}} \quad (5)$$

where r is firm revenue.

We now show that the impact of FDI presence on unobserved product quality can be identified from its impact on the observed firm revenue, as summarised in Proposition 2.[33]

Proposition 2 (Identification): The marginal impact of FDI presence on product quality can be identified from its impact on firm revenue, that is $\frac{\partial \ln r}{\partial \gamma} = (1-\rho\mu)\frac{\partial \ln Z}{\partial \gamma}$.

Proof: From Equations (3) and (5), we get $r = \rho^{\rho}[1-\rho(1+\mu)]^{-\rho}\Phi^{1-\rho}(w+v)^{-\rho}\widetilde{w}^{\rho}Z^{1-\rho\mu}$, which yields $\frac{\partial \ln r}{\partial \gamma} = (1-\rho\mu)\frac{\partial \ln Z}{\partial \gamma}$.

With the optimal price and product quality level, we can then obtain the firm's demand for labour as follows:[34]

$$l = \rho^{\frac{1-\mu}{\mu}}[1-\rho(1+\mu)]^{\frac{1-\rho(1+\mu)}{\rho\mu}}(1+\beta)^{\frac{1-\rho\mu}{\rho\mu}}\Phi^{\frac{1-\rho}{\rho\mu}}(w+v)^{-\frac{1+\mu}{\mu}}\widetilde{w}^{-\frac{1-\rho(1+\mu)}{\rho\mu}}[1+\beta(1-\gamma)]^{-\frac{1-\rho\mu}{\rho\mu}}\zeta^{\frac{1-\rho\mu}{\rho\mu}}\lambda^{\frac{1-\rho\mu}{\rho\mu}}$$

$$l_Z = \rho^{\frac{1}{\mu}}[1-\rho(1+\mu)]^{\frac{1-\rho}{\rho\mu}}(1+\beta)^{\frac{1-\rho\mu}{\rho\mu}}\Phi^{\frac{1-\rho}{\rho\mu}}(w+v)^{-\frac{1}{\mu}}\widetilde{w}^{-\frac{1-\rho}{\rho\mu}}[1+\beta(1-\gamma)]^{-\frac{1-\rho\mu}{\rho\mu}}\zeta^{\frac{1-\rho\mu}{\rho\mu}}\lambda^{\frac{1-\rho\mu}{\rho\mu}}$$

Using the above demand functions, the aggregate demand for the two types of workers is as follows:

$$L^D(w) = \rho^{\frac{1-\mu}{\mu}}[1-\rho(1+\mu)]^{\frac{1-\rho(1+\mu)}{\rho\mu}}(1+\beta)^{\frac{1-\rho\mu}{\rho\mu}}\Phi^{\frac{1-\rho}{\rho\mu}}(w+v)^{-\frac{1+\mu}{\mu}}\widetilde{w}^{-\frac{1-\rho(1+\mu)}{\rho\mu}}[1+\beta(1-\gamma)]^{-\frac{1-\rho\mu}{\rho\mu}}\iint_{\underline{\lambda}}^{\infty}\zeta^{\frac{1-\rho\mu}{\rho\mu}}\lambda^{\frac{1-\rho\mu}{\rho\mu}}g(\lambda)\widetilde{g}(\zeta)d\lambda d\zeta \quad (6)$$

$$L_Z^D(\%\widetilde{w}) = \rho^{\frac{1}{\mu}}[1-\rho(1+\mu)]^{\frac{1-\rho}{\rho\mu}}(1+\beta)^{\frac{1-\rho\mu}{\rho\mu}}\Phi^{\frac{1-\rho}{\rho\mu}}(w+v)^{-\frac{1}{\mu}}\widetilde{w}^{-\frac{1-\rho}{\rho\mu}}[1+\beta(1-\gamma)]^{-\frac{1-\rho\mu}{\rho\mu}}\iint_{\underline{\lambda}}^{\infty}\zeta^{\frac{1-\rho\mu}{\rho\mu}}\lambda^{\frac{1-\rho\mu}{\rho\mu}}g(\lambda)\widetilde{g}(\zeta)d\lambda d\zeta \quad (7)$$

[32] This result is consistent with Alfaro and Chen (2013). In a different context, where product quality is not explicitly considered, Alfaro and Chen have shown that entry of foreign firms increases the cut-off capability of domestic firms. Within the context of the model used in our paper, an increase in FDI increases the cut-off capability of domestic firms, if the FDI-related spillover effect is negative.

[33] One may argue that many factors can influence product quality and revenue, for example R&D. In equations (3) and (5), such factors are captured in the term ζ. Proposition 2 states that a profit maximising firm will make decisions optimally such that its product quality is structurally related to its revenue, which can be utilised for identification in our empirical estimations. Note that this structural relationship is robust to firm heterogeneity, namely no matter what capability endowment a firm has, its product quality is always related to its revenue as described in Proposition 2.

[34] Note that for our purpose, we do not need to explicitly model the details of firms posting vacancies and workers searching for jobs in the labour market. Such details in the labour market can be found in, among others, Kaas and Kircher (2015).

where L^D and L_Z^D, respectively, are the aggregate demand for production workers and quality control personnel, and $\widetilde{g}(\zeta)$ is the probability density function of ζ.

3.3 | Equilibria in the labour markets

In the markets for both the production workers and quality control personnel, wage rates adjust such that aggregate demand equals aggregate supply of labour (i.e. $L^D(w) = L^s(w)$ and $L_Z^D(\%\tilde{w}) = L_z^s(\%\tilde{w})$), as follows:

$$R\rho^{-1}(w+v)^{-1} = \left(1 - \frac{\beta}{1+\beta}\gamma\right)\frac{w}{\overline{\overline{w}}}\delta L$$

$$R[1-\rho(1+\mu)]\widetilde{w}^{-1} = \left(1 - \frac{\beta}{1+\beta}\gamma\right)\frac{\widetilde{w}}{\overline{\overline{w}}}(1-\delta)L$$

where$R \equiv \rho^{\frac{1}{\mu}}[1-\rho(1+\mu)]^{\frac{1-\rho(1+\mu)}{\rho\mu}}(1+\beta)^{\frac{1-\rho\mu}{\rho\mu}}\Phi^{\frac{1-\rho}{\rho\mu}}(w+v)^{-\frac{1}{\mu}}\widetilde{w}^{-\frac{1-\rho(1+\mu)}{\rho\mu}}[1+\beta(1-\gamma)]^{-\frac{1-\rho\mu}{\rho\mu}}\iint_{\underline{\lambda}}^{\infty}\zeta^{\frac{1-\rho\mu}{\rho\mu}}\lambda^{\frac{1-\rho\mu}{\rho\mu}}g(\lambda)\widetilde{g}(\zeta)d\lambda d\zeta\cdot$

We normalise such that $w = 1$. Accordingly, we can solve for the equilibrium wage rate for quality control personnel ($\widetilde{w}$), as follows:

$$\widetilde{w} = \rho^{-\frac{1}{2}}[1-\rho(1+\mu)]^{\frac{1}{2}}(1+v)^{\frac{1}{2}}\left(\frac{\delta}{1-\delta}\right)^{\frac{1}{2}} \tag{8}$$

Note that both the aggregate demand and supply of labour are functions of FDI presence (γ), which has industry–province–time variations. Therefore, we are implicitly assuming that labour markets are industry, province and time specific. It is not unreasonable that in each period and for each industry, the labour markets have different aggregate demand and supply. Regarding the province dimension, later in Section 6.1, we find that the standard deviation of provincial average real wage exhibits an increasing time trend, which seems to suggest that labour markets are somewhat segmented by provinces, as otherwise we shall observe the average real wage converges.

That said, this distinction is not important for our study. We can aggregate the supply and demand to a national level, for example the aggregate supply of production workers at a national level can be written as $L^s(w) = \int\left(1 - \frac{\beta}{1+\beta}\gamma\right)\overline{g}(\gamma)d\gamma\frac{w}{\overline{\overline{w}}}\delta L$ where $\overline{g}(\gamma)$ is the pdf of γ. Equating the aggregate demand with aggregate supply and normalising the wage rate of production worker, we then find the equilibrium wage rate of quality control personnel is the same as Equation (8).

4 | ESTIMATION STRATEGY

In Section 3, using a theoretical model, we show that the presence of FDI affects the quality of goods produced by domestic firms through worker mobility. In this section, guided by the theoretical model, we present the estimation strategy.

4.1 | Measurement of FDI presence via worker mobility

The variable of interest in the previous theoretical modelling is γ_{jkt}, the share of workers who have previously (i.e. in years $\tau = t-1, \cdots, 0$) been employed by FDI firms in industry j, province k and year t.[35] In order to measure γ_{jkt}, we can construct the share of workers who are employed by FDI firms in year t ($\widetilde{\gamma}_{jkt}$) from the data. Lemma 1 states the link between γ_{jkt} and $\widetilde{\gamma}_{jkt-1}$, which allows us to compute γ for empirical estimations.

Lemma 1 (Measurement of FDI presence via worker mobility): Let $\widetilde{\gamma}_{jkt}$ denote the share of workers who are employed by FDI firms in industry j, province k and year t (i.e. the employment share of FDI). Then, γ_{jkt} is a continuous and non-decreasing function of $\widetilde{\gamma}_{jkt-1}$, and $\gamma_{jkt} = \left[\gamma_{jkt-1} + \%\widetilde{\gamma}_{jkt-1}\left(1-\gamma_{jkt-1}\right)\right]\frac{1}{1+g_{jkt+1}}$, where g_{jkt+1} is the effective growth rate of the number of workers, and $\gamma_{jk0} = 0$.

Proof: Let L_{jkt} denote the number of workers employed by all firms in industry j, province k in year t ($L_{jkt} \geq 0$), χ_{jkt} denote the proportion of workers who leave the two labour markets in industry j, province k and year t ($0 \leq \chi_{jkt} \leq 1$), and ΔL_{jkt} denote the number of workers who enter the two labour markets in industry j, province k and year t ($\Delta L_{jkt} \geq 0$). Then, the number of workers who have previously (in years $\tau = t-1, \cdots, 0$) been employed by FDI firms in industry j, province k in year t can be written as $L_{jkt}\gamma_{jkt}$.In year $t+1$, the total number of workers is $L_{jkt+1} = L_{jkt}\left(1-\chi_{jkt}\right) + \Delta L_{jkt+1}$, out of which $L_{jkt}\gamma_{jkt}\left(1-\chi_{jkt}\right)$ workers were previously employed by FDI firms (in years $\tau = t-1, \cdots, 0$) and continue to be in the labour markets in year $t+1$. Since the share of workers employed by FDI firms in year t is $\widetilde{\gamma}_{jkt}$, of the $L_{jkt}\left(1-\gamma_{jkt}\right)\left(1-\chi_{jkt}\right)$ workers who have never been employed by FDI firms in the past (i.e. in years $\tau = t-1, \cdots, 0$), there are $L_{jkt}\left(1-\gamma_{jkt}\right)\left(1-\chi_{jkt}\right)\widetilde{\gamma}_{jkt}$ workers who are employed by FDI firms in year t. Therefore, in year $t+1$, the number of workers who were previously (i.e. in years $\tau = t, \cdots, 0$) employed by FDI firms consist of those who were employed in years $\tau = t-1, \cdots, 0$ $\left[L_{jkt}\gamma_{jkt}\left(1-\chi_{jkt}\right)\right]$ and those who were employed in year t $\left[L_{jkt}\left(1-\gamma_{jkt}\right)\left(1-\chi_{jkt}\right)\widetilde{\gamma}_{jkt}\right]$. Accordingly, we can write the share of workers who were previously (i.e. in years $\tau = t, \cdots, 0$) employed by FDI firms in year $t+1$ as follows:

$$\gamma_{jkt+1} = \frac{L_{jkt}\gamma_{jkt}\left(1-\chi_{jkt}\right) + L_{jkt}\left(1-\gamma_{jkt}\right)\left(1-\chi_{jkt}\right)\widetilde{\gamma}_{jkt}}{L_{jkt}\left(1-\chi_{jkt}\right) + \Delta L_{jkt+1}} = \left[\gamma_{jkt} + \%\widetilde{\gamma}_{jkt}\left(1-\gamma_{jkt}\right)\right]\frac{1}{1+g_{jkt+1}} \quad (9)$$

where $g_{jkt+1} = \frac{\Delta L_{jkt+1}}{L_{jkt}\left(1-\chi_{jkt}\right)}$ is the effective growth rate of the number of workers, and $\gamma_{jk0} = 0$.

Therefore, γ_{jkt} is a continuous and non-decreasing function of $\widetilde{\gamma}_{jkt-1}$.

We first approximate g_{jkt+1} by the growth rate of workers employed by all firms in industry j and province k from year t to $t+1$, that is $g_{jkt+1} \approx \frac{L_{jkt+1} - L_{jkt}}{L_{jkt}}$, where L_{jkt} is directly observable from the data. Let $t_0$be the first period of the sample (year 2005 for our data). We then assume $\gamma_{jkt_0} = \widetilde{\gamma}_{jkt_0}$, that is in the first period, the share of workers who were previously employed by FDI firms is the same as the share of workers who were employed by FDI firms in t_0. Given this assumption and the calculated g_{jkt+1}, we can utilise Equation (9) to construct γ_{jkt}.

[35]In this section, we make use of the subscripts to highlight the level of variations in the relevant variable. In other sections, we supress the subscripts for notational simplicity.

Conceptually, it is not surprising that the share of previously FDI-trained workers is a function of the share of workers employed by FDI firms in each year, as they are inherently linked to each other. Nevertheless, one may wonder how significant such worker mobility is and whether it promotes spillovers. Poole (2013) documents that around 31 per cent of workers who worked in FDI firms left their jobs in the sample period of 1996–2001 in Brazil, of whom approximately 23 per cent were rehired by domestic firms. Stoyanov and Zubanov (2012) discover a 0.35 per cent productivity gain associated with workers moving from more to less productive firms in the Danish manufacturing sector, despite that they do not particularly focus on the worker mobility from FDI to domestic firms. Given these existing studies, we expect worker mobility to play an important role in the FDI spillovers in China. To the best of our knowledge, there are no available data that track movement of workers from FDI to domestic firms in China. Lemma 1, with some weak assumptions, allows us to measure the worker mobility FDI presence in China.

4.2 | Sample selection issue

Proposition 2 identifies the impact of FDI presence on optimal product quality of a firm from its impact on firm revenue. Therefore, we can estimate firm revenue as a function of FDI presence (see Equation 5) and infer the impact on product quality from the estimation result. A complicating issue here is that firm revenue also depends on the unobserved capability endowment (λ). Since firms with capability endowment lower than $\underline{\lambda}$ will not enter the market and hence are not observable to researchers, econometric estimation using the quantities that directly depend on the capability endowment is necessarily subject to a sample selection issue.

Let $\underline{r}$ denote the cut-off revenue above which firms are included in the sample (the associated firm capability endowment is the cut-off capability $\underline{\lambda}$). So, firms are observed only if $\lambda \geq \underline{\lambda}$ (i.e. $r \geq \underline{r}$). Therefore, we can write $\underline{\lambda}$ as a function of $\underline{r}$ as follows:

$$\underline{\lambda} = \rho^{-\frac{1+\rho(1-\mu)}{2(1-\rho\mu)}} [1-\rho(1+\mu)]^{-\frac{1-\rho(1+\mu)}{2(1-\rho\mu)}} (1+\beta)^{-1} (1+\nu)^{\frac{1+\rho(1-\mu)}{2(1-\rho\mu)}} \Phi^{-\frac{1-\rho}{1-\rho\mu}} \left(\frac{1-\delta}{\delta}\right)^{-\frac{1-\rho(1+\mu)}{2(1-\rho\mu)}} [1+\beta(1-\gamma)]\zeta^{-1} \underline{r}^{\frac{\rho\mu}{1-\rho\mu}} \quad (10)$$

Equation (10) is derived using Equations (5) and (8) and the normalisation of production workers' equilibrium wage rate ($w = 1$). The fact that firm revenue is a monotonically increasing function of the capability endowment allows us to invert the capability endowment as a function of revenue, which is helpful in that even though we do not observe $\underline{\lambda}$, we are able to estimate $\underline{r}$.

Conditional on firms being observed in the sample, plugging Equation (8) and setting $w \equiv 1$ in Equation (5), we can re-write firm revenue as follows[36]:

$$\begin{aligned} E\left[lnr|\lambda \geq \underline{\lambda}\right] = \; & ln\left\{\rho^{\frac{1+\rho(1-\mu)}{2\rho\mu}} [1-\rho(1+\mu)]^{\frac{1-\rho(1+\mu)}{2\rho\mu}} (1+\beta)^{\frac{1-\rho\mu}{\rho\mu}} (1+\nu)^{-\frac{1+\rho(1-\mu)}{2\rho\mu}}\right\} + \frac{1-\rho}{\rho\mu} ln\Phi + \frac{1-\rho(1+\mu)}{2\rho\mu} ln\frac{1-\delta}{\delta} \\ & - \frac{1-\rho\mu}{\rho\mu} ln[1+\beta(1-\gamma)] + \frac{1-\rho\mu}{\rho\mu} ln\zeta + \frac{1-\rho\mu}{\rho\mu} E\left[ln\lambda|\lambda \geq \underline{\lambda}\right] \end{aligned} \quad (11)$$

where $E\left[ln\lambda|\lambda \geq \underline{\lambda}\right]$ is due to the sample selection.

[36]Note that one can argue that firms' revenue depends on a number of other factors, in addition to FDI. In equation (11), we use ζ to capture all these factors.

As mentioned in the introduction section, the sample selection issue here cannot be resolved by using the Heckman two-step approach, due to the fact that we do not observe firms that are not included in the sample. To address the sample selection issue, we instead approximate $E\left[ln\lambda|\lambda \geq \underline{\lambda}\right]$ by a polynomial function of $\underline{\lambda}$.Since λ is a continuous random variable, $E\left[ln\lambda|\lambda \geq \underline{\lambda}\right]$ is a continuous function of $\underline{\lambda}$. Therefore, using a K-order Taylor expansion at an arbitrary level of $\underline{\lambda}$ (or invoking the Weierstrass Approximation Theorem),[37] we can approximate $E\left[ln\lambda|\lambda \geq \underline{\lambda}\right]$ as follows:

$$E\left[ln\lambda|\lambda \geq \underline{\lambda}\right] \approx c_0 + \sum_{k=1}^{K} c_k \Phi^{-k\frac{1-\rho}{1-\rho\mu}} \left(\frac{1-\delta}{\delta}\right)^{-k\frac{1-\rho(1+\mu)}{2(1-\rho\mu)}} [1+\beta(1-\gamma)]^k \zeta^{-k} \underline{r}^{k\frac{\rho\mu}{1-\rho\mu}}$$

where c_0 and c_k are constants, and we plug Equation (10) into the approximation.

We then replace the sample selection term in Equation (11), as follows:

$$\begin{aligned} E\left[lnr|\lambda \geq \underline{\lambda}\right] \approx \quad & ln\left\{\rho^{\frac{1+\rho(1-\mu)}{2\rho\mu}}[1-\rho(1+\mu)]^{\frac{1-\rho(1+\mu)}{2\rho\mu}}(1+\beta)^{\frac{1-\rho\mu}{\rho\mu}}(1+\nu)^{-\frac{1+\rho(1-\mu)}{2\rho\mu}}\right\} + \frac{1-\rho}{\rho\mu} ln\Phi \\ & + \frac{1-\rho(1+\mu)}{2\rho\mu} ln\frac{1-\delta}{\delta} - \frac{1-\rho\mu}{\rho\mu} ln[1+\beta(1-\gamma)] + \frac{1-\rho\mu}{\rho\mu} ln\zeta + \frac{1-\rho\mu}{\rho\mu} c_0 \\ & + \sum_{k=1}^{K} \frac{1-\rho\mu}{\rho\mu} c_k \Phi^{-k\frac{1-\rho}{1-\rho\mu}} \left(\frac{1-\delta}{\delta}\right)^{-k\frac{1-\rho(1+\mu)}{2(1-\rho\mu)}} [1+\beta(1-\gamma)]^k \zeta^{-k} \underline{r}^{k\frac{\rho\mu}{1-\rho\mu}} \end{aligned} \quad (12)$$

Equation (12) will be used in our empirical estimations.

In order to address the sample selection issue, one can also assume a distribution of the capability endowment and compute $E\left[ln\lambda|\lambda \geq \underline{\lambda}\right]$ explicitly. However, not surprisingly, this approach of accounting for the sample selection issue critically depends on the assumption of the distribution of λ. Violation of the distributional assumption is likely to result in substantial bias in the estimate. Compared with this distributional assumption approach, our approach to account for the sample selection issue is robust in that it does not require any explicit distributional assumption. We only require that λ is a continuous random variable that has a conditional mean.

4.3 | Estimation steps

In computing the marginal impact of foreign presence on domestic product quality, three underlying structural parameters play key roles: the CES preference parameter (ρ), the quality elasticity of price (μ) and the skill gap parameter (β). Once we know these structural parameters, it is possible to derive the point estimates of the marginal impact of foreign presence on domestic product quality, without explicitly using data on product quality.[38]

[37] $\underline{\lambda}$ is then assumed to take values within a compact interval.

[38] Note for the estimation purpose, we do not need to distinguish the two types of workers (production worker and quality control personnel). In our data, the worker type is not observable.

However, the parameter μ, which reflects our contention that higher quality products are more difficult to produce and thus sell at a higher price in the market, is not identifiable.[39] Therefore, we first assume a level of μ (that is, $\mu = 0.05, 0.1, 0.2$).[40] We start with estimating the preference parameter ρ. In order to identify this parameter, we utilise the relationship between the total variable cost and firm revenue, implied by profit maximisation, as follows:[41]

$$TVC = \rho r + \varepsilon \tag{13}$$

where TVC is the total variable cost, r is firm revenue from sales in the domestic market, and we append an exogenous error term (ε) to capture measurement error.

In step one, to recover the underlying preference parameters, we regress the total variable cost against the revenue of firm sales in the domestic market. In order to avoid the unnecessary complication that arises due to exporting, we restrict out attention to non-exporting firms.

In step two, we estimate the cut-off revenue ($\underline{r}$), which will be used in addressing the sample selection issue as in Equation (12). The cut-off revenue has province–industry–time variations and is estimated as the minimum value of firm sales in each province–industry–year, namely $\underline{r}_{jkt} = min\left\{ r_{1jkt}, \cdots, r_{N_{jkt}jkt} \right\}$, where N_{jkt} is the number of firms in province j, industry k in year t.

Using the assumed values of μ and the estimates of ρ and $\underline{r}$, we proceed to estimate β in step 3, using the generalised method of moments estimator.[42] Let $X = \left\{ \gamma, \underline{r} \right\}$. To obtain population moments, we rely on three assumptions as follows:

Assumption 1: $E\left[ln\Phi|X\right] = 0$, and $E\left[\Phi^{-\frac{1-\rho}{1-\rho\mu}j}\middle|X\right] \overset{!!}{=} \Phi_j$, $\forall j = 1, 2, 3$.

Assumption 2: $E\left[ln\left(\frac{1-\delta}{\delta}\right)\middle|X\right] = 0$, $E\left[\left(\frac{1-\delta}{\delta}\right)^{-\frac{1-\rho(1+\mu)}{2(1-\rho\mu)}j}\middle|X\right] \overset{!!}{=} \delta_j$, $\forall j = 1, 2, 3$.

Assumption 3: $E\left[ln\zeta|X\right] = 0$, and $E\left[\zeta^{-j}\middle|X\right] \overset{!!}{=} \zeta_j$, $\forall j = 1, 2, 3$.

Assumption 1 is concerned with the (non-negative) aggregate demand. Since the product market is monopolistically competitive, firms are small relative to the market. Therefore, a firm's influence on aggregate market demand is negligible. In Assumption 2, $\frac{1-\delta}{\delta}$ is the relative endowment of workers (the ratio of quality control personnel against production workers), which is a

[39]It is not uncommon that some structural parameters are unidentified. For example, in studying firm sorting and agglomeration, Gaubert (2018) first calibrates a number of parameters before the structural estimation.

[40]μ is the quality elasticity of price. Using the hedonic pricing approach, a number of previous studies estimate the impact of quality on price. For example, for wine, Oczkowski (2001) finds that a one unit increase in quality rating increases the wine price by 12, 48 and 90 per cent, respectively, depending on the quality rating systems used. Schamel and Anderson (2003) find that a one unit increase in the vintage rating increases the Australian wine price by 2.3–15.6 per cent. Combris, Lecocq and Visser (1997) find that a one unit increase in the ranking leads to around 31 per cent increase in price for Bordeaux wine. These estimates are not directly comparable to μ. Nevertheless, in light of these estimates, it appears that our setting of μ is reasonable.

[41]A similar identification strategy is used by Aw et al. (2011).

[42]We use bootstrapped standard errors to account for the fact that the estimated data are used in GMM estimation.

non-negative supply-side factor $\left(\frac{1-\delta}{\delta} \geq 0\right)$. In contrast, the presence of FDI (γ) and the cut-off revenue ($\underline{r}$) are demand-side factors in the labour market, that is these factors only affect the firms' demand for production workers and quality control personnel.

Therefore, it is reasonable to assume that the vector X does not affect the relative labour endowment. In Assumption 3, ζ captures all the other factors that affect the firm productivity and its distribution is exogenous. Accordingly, we assume that the means of $ln\zeta$ and ζ^{-j} do not depend on X.[43]

Using Assumptions 1–3 and Equation (12), we can derive the following population moments:

$$E\left[\left\{lnr-\theta_0+\frac{1-\rho\mu}{\rho\mu}ln[1+\beta(1-\gamma)]-\sum_{k=1}^{K}\theta_k[1+\beta(1-\gamma)]^k\underline{r}^{k\frac{\rho\mu}{1-\rho\mu}}\right\}\Lambda(X)\middle|\lambda\geq\underline{\lambda}\right]=0 \quad (14)$$

where θs are the parameters and $\Lambda(\bullet)$ is a function of X.

In an Appendix S1, by utilising the Monte Carlo simulations, we find that this estimation strategy is effective in recovering the underlying structural parameters. In Section 6, we will fit data to the population moments (Equation 14) to estimate the underlying structural parameter β. Once we have estimated the relevant structural parameters, we can compute the marginal impact of FDI presence on product quality using Equation (3) as follows:

$$\frac{\partial lnZ}{\partial\gamma}=\frac{\beta}{\rho\mu[1+\beta(1-\gamma)]} \quad (15)$$

The right-hand side of Equation (15) is a monotonically increasing function of γ.

5 | THE DATA

To estimate the quality impact of FDI, we use firm-level data from China's beverage manufacturing industry (two-digit industry) that cover all state and collectively owned firms and private firms with sales revenue above 5 million Yuan from 2005 to 2007.[44] Focusing on one industry, our estimations then only utilise the within-industry variations in the identification. Compared with using data of the whole manufacturing sector,[45] which contains the between-industry variations, this approach is robust to industry heterogeneity. As will be observed in Table 2, the within-industry variations are still substantial for us to identify the impact of FDI.

We choose the beverage manufacturing industry for two reasons.[46] First, consumption of beverage is clearly non-dynamic and therefore is consistent with our modelling of demand in

[43]In our online Appendix, we also relax this assumption by including a set of control variables, such as the forward and backward linkages and competition and demonstration effects.

[44]While our dataset also covers 2004, we restrict our sample period to 2005–2007 as data on some key variables, such as firm sales revenue, for 2004, is missing. In addition, using a sample involving a short time length, we are able to avoid the potential impact of policy (institutional) changes in China's labour market.

[45]It is straightforward to extend our analysis to the whole manufacturing sector, for which, however, one then risks the undesired impact of industry heterogeneity.

[46]This industry also appears to be characterised by free entry and exit. In the dataset, each year approximately 8 per cent of the firms are new. Approximately 12 per cent of the firms appear only for one year and 19 per cent of the firms appear for two years.

TABLE 1 Summary statistics

Variable	Obs	Mean	Std. dev.	Min	Max
Domestic sales revenue (r)	9659	67501.46	351934.30	0	1.95E+07
Total variable cost (TVC)	9659	51405.28	244330.70	57.4496	1.33E+07
Number of employees	9659	206.9742	675.2835	8	29,565
FDI employment share ($\tilde{\gamma}_{jkt}$)	9659	0.1632	0.2206	0	0.9941
of which from non-HMT regions	9659	0.1129	0.1756	0	0.9927
of which from HMT	9659	0.0524	0.1151	0	0.8877
Foreign presence (γ_{jkt})	9659	0.2266	0.2647	0	0.9925
of which from non-HMT regions	9659	0.1669	0.2249	0	0.9910
of which from HMT	9659	0.0813	0.1549	0	0.8909

Note: HMT refers to Hong Kong, Macau, and Taiwan; Unit: thousand Yuan.
Source: NBS, 2005–2007.

TABLE 2 Structural parameter estimations

Coef.	(1) $\mu = .05$	(2) $\mu = .1$	(3) $\mu = .2$
ρ	0.7427***	0.7427***	0.7427***
	(0.0068)	(0.0068)	(0.0068)
β	0.0576**	0.1112***	0.1939***
	(0.0276)	(0.0159)	(0.0456)
θ_0	−30.7615***	−10.6441***	−0.6943*
	(0.0499)	(0.4312)	(0.4155)
θ_1	37.7294***	12.8222***	2.6601***
	(0.0093)	(0.4137)	(0.1711)
θ_2	−6.8047***	−1.5925***	−0.1328***
	(0.0708)	(0.0871)	(0.0154)
Obs.	9411	9411	9411

Note: Bootstrapped standard errors in parentheses; ***$p < .01$, **$p < .05$, *$p < .1$.
Source: Authors' estimations.

Section 3. Second, the product market is monopolistically competitive, as can be observed by the Herfindahl index (see Table A2 in our Appendix S1). In addition, labour also plays an important role in the beverage manufacturing industry. The ratio of labour against total sales revenue in the beverage manufacturing industry is almost the same as that in the whole manufacturing sector.

All data are sourced from China's National Bureau of Statistics (NBS).[47] Before attempting to estimate the relevant structural parameters, we first clean the dataset by excluding firms that (i)

[47]A number of existing studies are based on data collected from the same source. For example Hu, Jefferson and Qian (2005), Jefferson, Rawski and Zhang (2008), Sun (2009), Anwar and Sun (2013), Kee and Tang (2016), Brandt et al. (2017).

employ fewer than eight workers as they may not have reliable accounting systems (Jefferson, Rawski and Zhang, 2008) and (ii) report negative net values of fixed assets, wage, output and value added. The dependent and explanatory variables are constructed using the cleaned dataset. The total variable cost (*TVC*) is the sum of a firm's total wage payment and the cost of intermediate inputs, which is deflated to year 2005 by the producer price index for manufactured goods from *China Statistical Yearbook 2008*. The domestic sales revenue is reported in the dataset and is also deflated to year 2005.

We first compute the employment share of FDI firms in the province-industries (four-digit) in each year ($\widetilde{\gamma}_{jkt}$). Then, as described in Section 4.1, we use $\widetilde{\gamma}_{jkt}$ to construct the foreign presence via worker mobility (γ_{jkt}, the share of workers who have previously been employed by FDI firms). Note γ_{jkt} has province-industry-year variations. In the two-digit beverage manufacturing industry, there are 13 four-digit industries, where firms are located in more than 30 provincial-level administrative zones. With three years' data, there exist substantial variations in our foreign presence (γ_{jkt}) measure. The province–industry–year variation allows us to estimate the quality impact of FDI presence.

Table 1 presents the summary statistics. The data contain substantial variations. For example, the average revenue from domestic sales is 67,501.46 thousand Yuan with a standard deviation of 351,934.30 thousand Yuan, which is more than five times higher than the average value. A small proportion of domestic firms (approximately 1.1 per cent) reported zero sales. Firm sales revenue exhibits an upward trend, with its mean increasing from 59657.22 in 2005 to 75085.19 in 2007, suggesting potential improvement in product quality over time. Foreign presence in China's beverage manufacturing industry is significant. On average, the number of workers employed by foreign-invested firms accounts for more than 16 per cent of the total number of workers in a four-digit industry. On average, approximately 13.5 per cent of the firms are foreign-invested. In addition, compared with FDI originating from the HMT region, within the beverage manufacturing industry, FDI originating from non-HMT regions is more than twice as large, in terms of the number of workers employed.

6 | EMPIRICAL RESULTS

We apply the estimation procedure outlined in Section 4 to estimate the underlying structural parameters. We assume three values of the quality elasticity of price (μ). Specifically, we use 5, 10 and 20 per cent. In estimating the CES preference parameter (ρ), we restrict the sample to non-exporting firms to avoid complications arising from firm exports. The sample consists of a relatively small proportion (about 10 per cent) of exporting observations (firm-year). In our GMM estimation of the skill gap parameter (β), like the case of Monte Carlo simulations, the instruments used are $\gamma, \gamma^2, 1(\gamma > 0), \gamma \times \underline{r}, \underline{r}, \underline{r}^2$ and $ln\left(\underline{r}\right)$. Given the findings of the Monte Carlo simulations, we use the second-order Taylor expansion of the sample selection term $\left(E\left[ln\lambda | \lambda \geq \underline{\lambda}\right]\right)$ in the estimations.

In Appendix S1, we discuss the characteristics of the sample used, especially in relation to the structure of the product and labour markets. In the theoretical model in Section 3, we assume that product market is monopolistically competitive and labour markets are segmented by provinces (more localised). How reasonable is this setting? We verify these two market

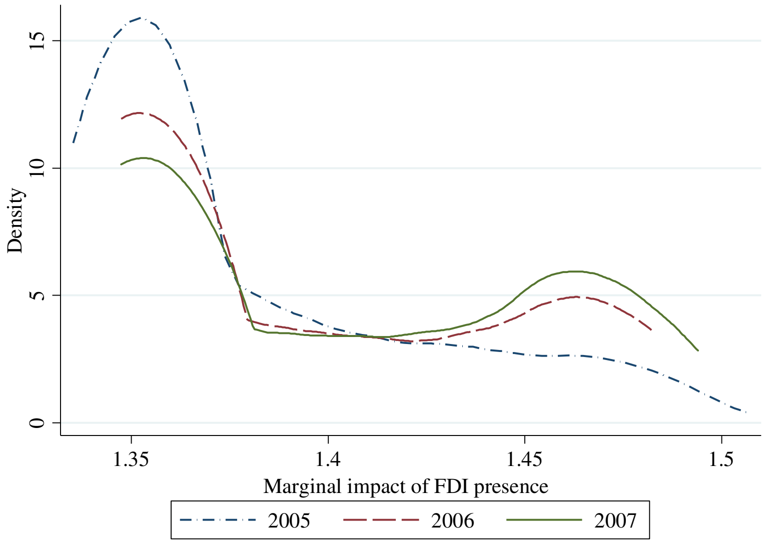

FIGURE 1 Distributions of the marginal impact of FDI by year.
Note: $\rho = 0.743$, $\mu = 0.1$, and $\beta = 0.112$.
Source: Authors' estimation

structure assumptions by checking the standard deviations of provincial average real wage and the Herfindahl index. The two assumptions are largely consistent with the data, except for the solid beverage manufacturing industry (i.e. industry code 1535) which has a Herfindahl index as high as 0.5454 and is excluded from the sample used for parameter estimation.

The estimated results concerning the impact of foreign presence from all sources on product quality of domestic firms in China's beverage manufacturing industry are reported in Table 2. In an Appendix S1, we also report the results of a number of robustness checks.

6.1 | Impact of FDI presence

The CES preference parameter (ρ) is estimated to be 0.7427, suggesting an elasticity of substitution of 3.8865. This level of elasticity of substitution is not surprising as firms in the beverage industry produce similar products that are close substitutes in consumption. The estimate of the preference parameter appears to be in line with previous studies. For example, Aw et al. (2011) report an estimate of 0.84 for the electronics manufacturing industry in Taiwan.

As far as the quality elasticity of price (μ) is concerned, for a one per cent increase in product quality, we consider three levels of price responses (i.e. price increases by 5, 10 or 20 per cent). The corresponding estimated values of the skill gap parameter (β), respectively, are 0.0576, 0.1112 and 0.1939. All three estimated values are statistically significant at the ten per cent level. Therefore, despite the differences in the magnitudes of the point estimates, it seems that working for FDI firms contributes to a higher level of skill development for the workers compared with domestic firms.[48] In light of the previous studies on the price-quality relationship for wine (e.g.

[48]Note this does not mean that working with domestic firms does not improve a worker's skill level.

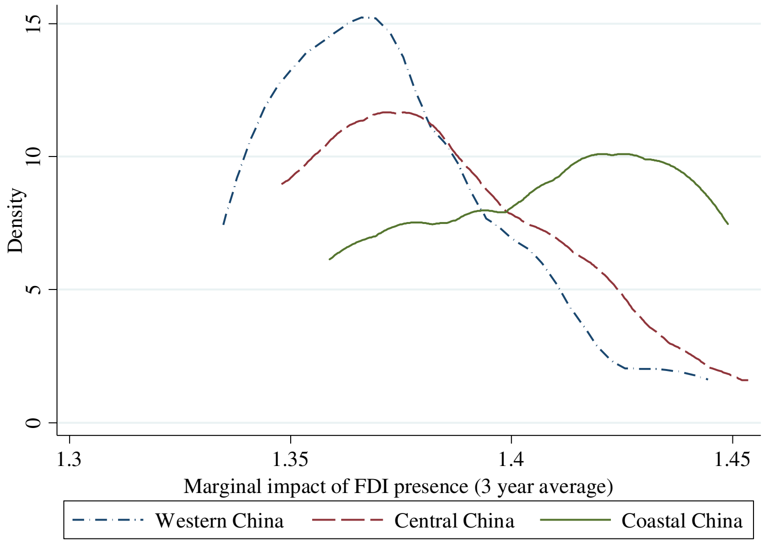

FIGURE 2 Distributions of the marginal impact of FDI by region.
Note: $\rho = 0.743$, $\mu = 0.1$, and $\beta = 0.112$.
Source: Authors' estimation

Schamel and Anderson, 2003), the interpretation in the following is based on the assumption that $\mu = 0.1$ (see Column 2 of Table 1).

Our estimation results suggest that, compared with a worker who has never worked for an FDI firm, working for an FDI firm (at any time) boosts a worker's skill level by 11.12 per cent (see Column 2 of Table 1). This positive impact is consistent with our expectation as FDI firms tend to have better technology and management know-how. Furthermore, FDI firms tend to provide better training to their employees. The skills gained from working for an FDI firm can enhance the worker productivity and benefit the new employer when the worker moves to a domestic firm or sets up her own business. The probability that an FDI-trained worker will be employed by a domestic firm is $Prob(B|A) = \frac{\gamma}{1+\beta(1-\gamma)}$. From Lemma 1, we can see that γ approaches 1, as long as FDI firms exist in the industry (i.e. $\widetilde{\gamma} \neq 0$). In the limiting case, as γ approaches 1, $Prob(B|A)$ approaches 1. In other words, FDI-trained workers will eventually move to domestic firms for sure. In addition to this limiting case, we can also evaluate $Prob(B|A)$ at the point estimate of β and the sample average of γ. In 2005, the probability of an FDI-trained worker being employed by a domestic firm is 0.21, which increases to 0.28 and 0.33, respectively, in 2006 and 2007.[49]

Given that the estimated skill gap parameter is positive and the probability of hiring FDI-trained workers is non-zero, employing relatively high skilled workers that have previously worked for FDI firms reduces the marginal cost of domestic firms in both product and quality production. The net effect is an increase in product quality of domestic firms, ceteris paribus. Using the point estimates of ρ and β, the marginal impact of FDI presence on product quality can be written as $\frac{\partial lnZ}{\partial \gamma} = \frac{1}{0.0743 \times (9.9928-\gamma)}$, which is an increasing function of γ. Evaluating the marginal impact at sample average of γ, we find that a one per cent increase in γ results in a 1.3690, 1.3787 and 1.3847 per

[49]As a comparison, Poole (2013) finds 23 per cent of displaced workers in FDI firms are re-employed by domestic firms in Brazil over the 1996–2001 period.

cent increase in product quality in 2005, 2006 and 2007, respectively. The estimated marginal effect on product quality shows a weak increasing trend over time.

The increasing trend over time can also be observed in Figure 1, where we evaluate the marginal impact $\left(\frac{\partial lnZ}{\partial \gamma}\right)$ and estimate the density of its distribution for each year. From 2005 to 2007, we observe that the section of the density curves that is below 1.4 shifts downwards, while the section that is above 1.4 shifts upwards. Hence, it is more likely to have a higher marginal impact in 2007 than 2005. This could be attributed to the fact that γ increases each year. In 2005, the average level of γ is 0.1610, which increases to 0.2296 and 0.2724 in 2006 and 2007, respectively. It is also worth mentioning that the estimated density functions in Figure 1 exhibit a bimodal distribution, particularly in 2006 and 2007, with two peaks (around 1.37 and 1.47). Conditional on the estimates (and the relevant assumptions) of the structural parameters, the difference in marginal impacts is solely driven by γ. As such, the bimodal shape is due to the distribution of FDI presence in China, which is highly concentrated in Coastal China (in relative terms, Western China attracts the lowest level of FDI).

The regional pattern of the distribution of marginal impact by FDI is also confirmed by Figure 2. In Figure 2, we first take the three-year average of the evaluated marginal impact in each province–industry and then nonparametrically estimate the density functions by regions. Compared with the distribution in Western China, it is clear in Figure 2 that the distribution of Coastal China is biased to the right, whereas the distribution of Central China is in the middle. On average, a one per cent increase in FDI in Coastal China increases the product quality of firms in that region by 1.4061 per cent, whereas the corresponding effect for firms in Western and Central China, respectively, is 1.3727 and 1.3821 per cent. These results are consistent with the fact that Coastal China attracts the lion's share of FDI in China. Since the beginning of the reform process in China that started in the early 1980s, Coastal China has been growing faster than Western and Central China and also attracting more FDI inflow.

In summary, our estimation results reveal that a worker who has ever worked for an FDI firm can on average increase her skill level by 11.12 per cent, compared with if she has never worked with FDI firms. An FDI-trained worker on average has a probability of around 0.3 to be employed by domestic firms. This non-zero probability of more productive workers moving from FDI to domestic firms lowers the cost of production of domestic firm thereby improving their product quality. The marginal impact of FDI presence (γ) on product quality is an increasing function of γ. On average, a one per cent increase in FDI leads to around 1.4 per cent improvement in product quality.

7 | CONCLUDING REMARKS

Using a theoretical model that features heterogeneous firms with a monopolistically competitive product market and labour markets of two types of workers, this paper argues that the presence of foreign firms can impact the quality of goods produced by domestic firms in host economies. Compared with domestic firms, foreign-invested firms tend to have more advanced technology and production know-how. As a result, a worker who works for foreign-invested firms is likely to have developed more skills compared with if she has never worked for foreign-invested firms. We show that the probability that workers trained by foreign-invested firms will move to domestic firms is strictly positive. Workers trained by foreign-invested firms carry their skills when they move to domestic firms, and the resulting positive productivity spillovers affect the quality of goods produced by domestic firms.

We use firm-level data from China's beverage manufacturing industry over the 2005–2007 period to estimate the effect of FDI on product quality of domestic firm. Specifically, we utilise the structural link between product quality and firm sales revenue to estimate the product quality. In addition, we use a novel approach to account for the sample selection bias. We find that workers who have worked for a foreign-invested firm in the past are on average 11.12 per cent more skilled than those who have not. On average, the probability that an FDI-trained worker will move to a domestic firm is around 0.3. The non-zero probability of worker mobility, together with the fact that FDI-trained workers are more productive, reduces the marginal cost of domestic firms, which contributes to product quality improvement.

We find that, on average, a one per cent increase in FDI presence results in around 1.4 per cent improvement in the quality of goods produced by China's beverage manufacturing industry. The estimated marginal impact exhibits an increasing time trend, driven by the increase in FDI inflow. Owing to the geographic concentration of FDI inflows, we observe a higher marginal impact in Coastal China compared with the Western China.

Our work has important implications for both academics and practitioners. For academics, the method that we identify to estimate product quality from firm revenue and the novel approach that we use to account for sample selection bias can also be used to explore other related issues. For practitioners, our finding that worker mobility can facilitate positive spillovers from FDI suggests that policies that encourage worker mobility are likely to achieve Pareto improvement.

For future research, this study can be extended in at least two directions. First, theoretically, one can investigate the situation where worker skill is publicly (or partially) observable. In such situation, one can utilise a positive assortative matching to assign more skilful workers to more capable firms, where workers of different skills earn different wages. It can be conjectured that as long as worker skill is not fully observable, there exists a strictly positive probability that FDI-trained workers move to domestic firms. Second, empirically, our measurement of FDI presence has industry–province–year variations, which is consistent with a majority of previous studies. Nevertheless, one may be able to measure such presence more ‘accurately’ by computing the share of FDI-trained workers in a firm's work force, which has firm level variation, by using the employee-employer matched data. In our theoretical model, we show that this share is function of industry-level FDI presence.

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DATA AVAILABILITY STATEMENT

Data and codes can be found at: https://data.mendeley.com/datasets/jwg5y9xmvw/1.

ORCID

Sajid Anwar https://orcid.org/0000-0001-9087-1309
Sizhong Sun https://orcid.org/0000-0001-8430-915X

REFERENCES

Alcalá, F. 2009. *Comparative advantage across goods and product quality*. *The BBVA Foundation working papers*. The BBVA Foundation, 1–56.

Alfaro, L., M.X. Chen. 2013. *Market relocation and knowledge spillover: The gains from multinational production*. Harvard Business School Working Papers.

Amiti, M., & Khandelwal, A. K. (2013). Import competition and quality upgrading. *Review of Economics and Statistics*, *95*(2), 476–490.

Antoniades, A. (2015). Heterogeneous firms, quality, and trade. *Journal of International Economics*, *95*(2), 263–273.

Anwar, S., & Sun, S. (2018). Foreign direct investment and export quality upgrading in China's manufacturing sector. *International Review of Economics & Finance*, *54*, 289–298.

Anwar, S., & Sun, S. (2016). Foreign direct investment and product quality in host economies. In *The Stanford center on global poverty and development working papers*. Stanford University.

Anwar, S., & Sun, S. (2013). Foreign entry and firm R&D: Evidence from Chinese manufacturing industries. *R&D Management*, *43*(4), 303–317.

Auer, R. A., Chaney, T., & Sauré, P. (2018). Quality pricing-to-market. *Journal of International Economics*, *110*, 87–102.

Aw, B. Y., Roberts, M. J., & Xu, D. Y. (2011). R&D investment, exporting, and productivity dynamics. *American Economic Review*, *101*(4), 1312–1344.

Bajgar, B., B.S. Javorcik. 2013. *Exporters' stargate: Suppling multinationals and entry into new markets. CESifo-Delphi conference on the economics of firm exporting, 26–27 April 2013*.

Baldwin, R., & Harrigan, J. (2011). Zeros, quality, and space: Trade theory and trade evidence. *American Economic Journal: Microeconomics*, *3*(2), 60–88.

Bardhan, P., & Kletzer, K. (1984). Quality variations and the choice between foreign and indigenous goods or technology. *Journal of Development Economics*, *14*(3), 323–330.

Bernard, A. B., Eaton, J., Jensen, J. B., & Kortum, S. (2003). Plants and productivity in international trade. *American Economic Review*, *93*(4), 1268–1290.

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

Brandt, L., Van Biesebroeck, J., Wang, L., & Zhang, Y. (2017). WTO accession and performance of Chinese manufacturing firms. *American Economic Review*, *107*(9), 2784–2820.

Burchardi, Konrad B., Thomas Chaney, Tarek A. Hassan. 2016. *Migrants, ancestors, and investments*. National Bureau of Economic Research Working Paper Series, No. 21847.

Chen, J., & Rizzo, J. A. (2012). Pricing dynamics and product quality: The case of antidepressant drugs. *Empirical Economics*, *42*(1), 279–300.

Choi, Y. C., Hummels, D., & Xiang, C. (2009). Explaining import variety and quality: The role of the income distribution. *Journal of International Economics and Finance*, *77*(2), 265–275.

Coad, A. (2009). On the distribution of product price and quality. *Journal of Evolutionary Economics*, *19*(4), 589–604.

Combris, P., Lecocq, S., & Visser, M. (1997). Estimation of a hedonic Price equation for Bordeaux wine: Does quality matter? *The Economic Journal*, *107*(441), 390–402.

Copeland, B. R., & Kotwal, A. (1996). Product quality and the theory of comparative advantage. *European Economic Review*, *40*(9), 1745–1760.

Crozet, M., Head, K., & Mayer, T. (2012). Quality sorting and trade: Firm-level evidence for French wine. *Review of Economic Studies*, *79*(2), 609–644.

Dana, J. D., & Fong, Y. F. (2011). Product quality, reputation, and market structure. *International Economic Review*, *52*(4), 1059–1076.

Dunning, J. H. (1993). *Multinational enterprises and the global economy*. Addison-Wesley.

Eeckhout, J., & Kircher, P. (2018). Assortative matching with large firms. *Econometrica*, *86*(1), 85–132.

Essaji, A., & Fujiwara, K. (2012). Contracting institutions and product quality. *Journal of Comparative Economics*, *40*(2), 269–278.

Eswaran, M., & Kotwal, A. (2007). Quality-enhancing trade liberalization. *Journal of Development Economics*, *83*(2), 549–561.

Fajgelbaum, P., Grossman, G. M., & Helpman, E. (2011). Income distribution, product quality, and international trade. *Journal of Political Economy*, *119*(4), 721–765.

Falvey, R. E., & Kierzkowski, H. (1987). Product quality, intra-industry trade and (Im)perfect competition. In H. Kierzkowski (Ed.), *Protection and competition in international trade*. Basil Blackwell.

Feenstra, R. C., & Romalis, J. (2014). International prices and endogenous quality. *The Quarterly Journal of Economics*, *129*(2), 477–527.

Fieler, A. C., Eslava, M., & Dy, X. (2018). Trade, quality upgrading, and input linkages: Theory and evidence from Colombia. *American Economic Review*, *108*(1), 109–146.

Flam, H., & Helpman, E. (1987). Vertical product differentiation and north-south trade. *The American Economic Review*, *77*(5), 810–822.

Fosfuri, A., Motta, M., & Rønde, T. (2001). Foreign direct investment and spillovers through Workers' mobility. *Journal of International Economics*, *53*(1), 205–222.

Gaubert, C. (2018). Firm sorting and agglomeration. *American Economic Review*, *108*(11), 3117–3153.

Girma, S., Gong, Y., Görg, H., & Lancheros, S. (2015). Estimating direct and indirect effects of foreign direct investment on firm productivity in the presence of interactions between firms. *Journal of International Economics*, *95*(1), 157–169.

Glass, A. J., & Saggi, K. (2002). Multinational firms and technology transfer. *The Scandinavian Journal of Economics*, *104*(4), 495–513.

Grossman, G. M., & Helpman, E. (1991). *Innovation and growth in the global economy*. MIT Press.

Grossman, G. M., Helpman, E., & Szeidl, A. (2006). Optimal integration strategies for the multinational firm. *Journal of International Economics*, *70*(1), 216–238.

Hallak, J. C. (2010). A product-quality view of the Linder hypothesis. *Review of Economics and Statistics*, *92*(3), 453–466.

Hallak, J. C. (2006). Product quality and the direction of trade. *Journal of International Economics*, *68*(1), 238–265.

Harding, T., & Javorcik, B. S. (2012). Fdi and export upgrading. *The Review of Economics and Statistics*, *94*(4), 964–980.

Helpman, E. (2006). Trade, FDI, and the organization of Firms. *Journal of Economic Literature*, *44*(3), 589–630.

Helpman, E., Melitz, M., & Rubinstein, Y. (2008). Estimating trade flows: Trading partners and trading volumes. *The Quarterly Journal of Economics*, *123*(2), 441–487.

Hu, A. G. Z., Jefferson, G. H., & Qian, J. (2005). R&D and technology transfer: Firm-level evidence from Chinese industry. *Review of Economics and Statistics*, *87*(4), 780–786.

Hummels, D., & Klenow, P. J. (2005). The variety and quality of a Nation's exports. *American Economic Review*, *95*(3), 704–723.

Jefferson, G. H., Rawski, T. G., & Zhang, Y. (2008). Productivity growth and convergence across China's industrial economy. *Journal of Chinese Economic and Business Studies*, *6*(2), 121–140.

Johnson, R. C. (2012). Trade and prices with heterogeneous firms. *Journal of International Economics*, *86*(1), 43–56.

Kaas, L., & Kircher, P. (2015). Efficient firm dynamics in a frictional labor market. *American Economic Review*, *105*(10), 3030–3060.

Katayama, S., & Miyagiwa, K. (2009). FDI as a signal of quality. *Economics Letters*, *103*(3), 127–130.

Kee, H. L., & Tang, H. (2016). Domestic value added in exports: Theory and firm evidence from China. *American Economic Review*, *106*(6), 1402–1436.

Khandelwal, A. (2010). The long and short (of) quality ladders. *The Review of Economic Studies*, *77*(4), 1450–1476.

Kirchler, E., Fischer, F., & Hölzl, E. (2010). Price and its relation to objective and subjective product quality: Evidence from the Austrian market. *Journal of Consumer Policy*, *33*(3), 275–286.

Kugler, M., & Verhoogen, E. (2012). Prices, plant size, and product quality. *Review of Economic Studies*, *79*(1), 307–339.

Lin, P., Liu, Z., & Zhang, Y. (2009). Do Chinese domestic firms benefit from FDI inflow?: Evidence of horizontal and vertical spillovers. *China Economic Review*, *20*(4), 677–691.

Linder, S. (1961). *An essay on trade and transformation*. Almqvist & Wiksell.

Linnemer, L. (2012). Dissipative advertising signals quality: Static model with a continuum of types. *Economics Letters*, *114*(2), 150–153.
Lu, Y., Ng, T., & Tao, Z. G. (2012). Outsourcing, product quality, and contract enforcement. *Journal of Economics & Management Strategy*, *21*(1), 1–30.
Lu, Y., Tao, Z., & Zhu, L. (2017). Identifying FDI Spillovers. *Journal of International Economics*, *107*, 75–90.
Manova, K., & Zhang, Z. W. (2012). Export prices across firms and destinations. *Quarterly Journal of Economics*, *127*(1), 379–436.
Manova, K., & Yu, Z. (2017). Multi-product firms and product quality. *Journal of International Economics*, *109*, 116–137.
Markusen, J. R., & Trofimenko, N. (2009). Teaching locals new tricks: Foreign experts as a channel of knowledge transfers. *Journal of Development Economics*, *88*(1), 120–131.
Martin, J. (2012). Markups, quality, and transport costs. *European Economic Review*, *56*(4), 777–791.
Matsa, D. A. (2011a). Competition and product quality in the supermarket industry. *Quarterly Journal of Economics*, *126*(3), 1539–1591.
Matsa, D. A. (2011b). Running on empty? Financial leverage and product quality in the supermarket industry. *American Economic Journal-Microeconomics*, *3*(1), 137–173.
Melitz, M.J., S.J. Redding. 2012. *Heterogeneous firms and trade*. *NBER Working Paper 18652*.
Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, *71*(6), 1695–1725.
Meyer, K. E., & Sinani, E. (2009). When and where does foreign direct investment generate positive spillovers[quest] a meta-analysis. *Journal of International Business Studies*, *40*(7), 1075–1094.
Murphy, K. M., & Shleifer, A. (1997). Quality and trade. *Journal of Development Economics*, *53*(1), 1–15.
Oczkowski, E. (2001). Hedonic wine price functions and measurement error. *Economic Record*, *77*(239), 374–382.
Poole, J. P. (2013). Knowledge transfers from multinational to domestic firms: Evidence from worker mobility. *The Review of Economics and Statistics*, *95*(2), 393–406.
Romley, J. A., & Goldman, D. P. (2011). How costly is hospital quality? A revealed-preference approach. *Journal of Industrial Economics*, *59*(4), 578–608.
Schamel, G., & Anderson, K. (2003). Wine quality and varietal, regional and winery reputations: Hedonic prices for Australia and New Zealand. *Economic Record*, *79*(246), 357–369.
Schott, P. K. (2004). Across-product versus within-product specialization in international trade. *The Quarterly Journal of Economics*, *119*(2), 647–678.
Javorcik, B. S. (2004). Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages. *American Economic Review*, *94*(3), 605–627.
Sonobe, T., Hu, D. H., & Otsuka, K. (2004). From inferior to superior products: An inquiry into the Wenzhou model of industrial development in China. *Journal of Comparative Economics*, *32*(3), 542–563.
Stoyanov, A., & Zubanov, N. (2014). The distribution of the gains from spillovers through worker mobility between workers and firms. *European Economic Review*, *70*, 17–35.
Stoyanov, A., & Zubanov, N. (2012). Productivity spillovers across firms through worker mobility. *American Economic Journal: Applied Economics*, *4*(2), 168–198.
Sun, S. (2011). Foreign direct investment and technology spillovers in China's manufacturing sector. *The Chinese Economy*, *44*(2), 25–42.
Sun, S. (2009). How does FDI affect domestic firms' exports? Industrial evidence. *The World Economy*, *32*(8), 1203–1222.
Sutton, J. (2007). Quality, trade and the moving window: The globalization process. *Economic Journal*, *117*, F469–F498.
Verhoogen, E. A. (2008). Trade, quality upgrading, and wage inequality in the Mexican manufacturing sector. *Quarterly Journal of Economics*, *123*(2), 489–530.
Werner, R. M., Norton, E. C., Konetzka, R. T., & Polsky, D. (2012). Do consumers respond to publicly reported quality information? Evidence from nursing homes. *Journal of Health Economics*, *31*(1), 50–61.
Xu, B. (2010). The sophistication of exports: Is China special? *China Economic Review*, *21*(3), 482–493.

Xu, X. P., & Sheng, Y. (2012). Productivity spillovers from foreign direct investment: Firm-level evidence from China. *World Development*, *40*(1), 62–74.

Yeaple, S. R. (2005). A simple model of firm heterogeneity, international trade, and wages. *Journal of International Economics*, *65*(1), 1–20.

Yu, M. (2010). Trade, democracy, and the gravity equation. *Journal of Development Economics*, *91*(2), 289–300.

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