CONTEMPORARY ECONOMIC POLICY

THE IMPACT OF EXPORTING AND FOREIGN DIRECT INVESTMENT ON PRODUCT INNOVATION: EVIDENCE FROM CHINESE MANUFACTURERS

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To understand the drivers of product innovation at the firm level, I compare the effects of foreign direct investment (FDI) and exporting on product innovation using a rich firm-level database of manufacturing and industrial enterprises. The article focuses on product innovation, as it is vital to economic development. Estimates from linear regressions and propensity score matching tests show that learning-by-exporting is a stronger predictor of product innovation. Firms that receive foreign investment also tend to engage in more product innovation, but not at the same level as the firms that export. Additional tests confirm that as they start and stop exporting, firms change their patterns of investment in the drivers of product innovation—fixed capital and research. (*JEL* D22, F14, F23, L25, O31)

Emerging countries are no longer content to be sources of cheap hands and low-cost brains. Instead they too are becoming hotbeds of innovation … They are redesigning products.… They are redesigning entire business processes to do things better and faster than their rivals in the West. Forget about flat—the world of business is turning upside down.

The Economist Magazine—(Masters of Innovation: 2010)

I. INTRODUCTION

Exporters and foreign-owned firms do more product innovation. The mechanism behind this pattern is not clear, nor is it clear that technology transfer through foreign ownership translates to more product innovation at the firm level compared to homegrown efforts. It is clear, however, that product innovation is vital to development. Economies that consistently create more varieties have better growth outcomes. Policymakers in developing economies charged with promoting innovation-driven private-sector led development typically consider two approaches—export promotion or foreign direct investment (FDI). I compare the relative efficacy of these two well-known approaches.[1]

China is an excellent case for this study: it has grown to be the world's largest exporter, is the number one FDI destination among developing economies while expanding the scope of its industrial output. Chinese exporters featured in 85% of U.S. imported manufactured goods categories in 2005 (up from 9% in 1972) (Schott 2008). Firm-level evidence buttresses the point. In the Chinese annual survey of manufacturing firms between 2005 and 2007, 13% of firms reported creating new product varieties and 10% by value of aggregate output in the data was from the product varieties that were new to the firms. In sum, one cannot ignore product innovation in the narrative of China's growth experience.

To understand the firm-level drivers of product innovation in China, this article uses a comparison-study of two firm categories—exporters and foreign-owned firms. The literature on product innovation motivated this approach.

ABBREVIATIONS

FDI: Foreign Direct Investment
GDP: Gross Domestic Product
HMT: Hong Kong, Macau, and Taiwan
OECD: Organization for Economic Co-operation and Development
OLS: Ordinary Least Squares
PSM: Propensity Score Matching
R&D: Research and Development
SOEs: Stateowned Enterprises
WTO: World Trade Organization

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1. Section II discusses the relationship between product innovation and economic growth briefly.

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Gorodnichenko, Svejnar, and Terrell (2010) and Damijan, Kostevc, and Polanec (2010) indicate that exporters tend to do more product innovation, while others attribute product innovation to foreign-ownership (Guadalupe, Kuzmina, and Thomas 2012). There are good reasons for both arguments, and the reverse could be true. Firms that start exporting may learn the methods required for product innovation, as may firms that receive foreign capital. Likewise, large, productive firms may be more likely to introduce new products, export, and find foreign owners.

I use a propensity score matching (PSM) approach to address concerns about endogeneity in estimating the effects of exporting and FDI. Effectively, I limit comparisons of product innovation by exporters or foreign-owned firms to firms with very similar observed characteristics. I used a set of control variables that was large enough that one could assume any difference between exporters and nonexporters with the same set of characteristics was close to random. For example, in comparing only firms in the same industry and with nearly the same size, the approach addresses concerns that larger more innovative firms in a particular sector are more likely to experience the exporting or foreign-ownership "treatment" (Abadie and Imbens 2009; Caliendo and Kopeinig 2008). I use Chinese firm-level data from the National Bureau of Statistics annual survey of industrial enterprises between 2005 and 2007.

I find that export participation leads to a higher likelihood of product innovation. The matching estimates show that new products are a greater share of output for exporters—20% for exporters, versus 14% for nonexporters with matched propensities. New products are 12.9% of the output of majority foreign-owned firms, compared to 19.0% for Chinese owned similar firms that were chosen to control for selection into FDI status (i.e., foreign ownership).[2] This raises an interesting contrast for papers that find statistically significant effects for FDI on product innovation in other contexts like Eastern or Western Europe (Commander and Svejnar 2011; Guadalupe, Kuzmina, and Thomas 2012). The differences suggest that context may determine the level of product innovation that foreign owners undertake.

2. Tables 1, 3, and Figure 1 below delve further into these comparisons. In the main results, I show that these differences in product do not depend on whether I measure the intensity or the incidence of product innovation.

I emphasize two causal mechanisms for product innovation—research and development (R&D) and investments in fixed capital. This builds on earlier articles that provide evidence of a positive correlation between exporting and R&D (Aw, Chung, and Roberts 2000; Aw, Roberts, and Xu 2008; Lileeva and Trefler 2010). I use difference-in-differences estimates to show that on average, both of these inputs to product innovation increase as firms start exporting, and decrease for the firms that stop exporting. The same pattern does not register for FDI.

I organize the rest of the article as follows: Section II discusses the related literature, while the subsequent section covers the methods, data, and results. The article concludes in Section V after several robustness checks in Section IV.

II. RELATED LITERATURE

This article focuses on the direct impacts of trade and FDI on firms that exported goods or received foreign capital, respectively. (I will not discuss spillovers from FDI and exporting; if these exist, they should bias my estimates toward zero and leave any main findings unchanged. High levels of innovation spillovers from other firms imply that the findings are imprecise, but it is reasonable to expect that the direct impacts of FDI and export participation vastly exceed the spillover effects.)

A. *Product Innovation*

Product innovation is vital to economic development. It is no accident that larger economies produce and consume greater numbers of product varieties, as documented by Hummels and Klenow (2005). This follows the Schumpeterian view of development (Schumpeter 1942); economies grow because firms successfully create new varieties as the old ones disappear. Madsen (2008) finds support for a Schumpeterian growth hypothesis that links R&D and the creation of new product varieties to economic growth. That article used international data from Organization for Economic Co-operation and Development (OECD) economies. The argument in that article builds on earlier work like Segerstrom (1991), that motivate an unambiguous positive relationship between promoting innovation and economic growth. Benhabib, Perla, and Tonetti (2014) also provide a model of firm-level growth that is driven by innovation in a related article. More recent articles provide formal models and evidence that link product innovation to welfare through consumers' love of variety (Broda and Weinstein 2006; Krugman 1980).

In the Chinese case, product innovation helped increase the scope, volume, and sophistication of aggregate exports (Amiti and Freund 2010; Schott 2008). For firms, the creation of new varieties adds new profit streams and increases the utilization of human and physical capital (Bernard, Redding, and Schott 2011; Eckel and Neary 2010). They can also help to diversify a firm's portfolio against potential adverse product-specific shocks. Given the importance of product innovation to growth, especially for China, this article tries to understand the factors driving the creation of new varieties, starting from its well-documented drivers—FDI and exporting.

This article contributes a novel comparison of these two drivers of product innovation in the Chinese context, to the literature on firm-level innovation and international participation. In considering exporting as a potential driver of product innovation, the article comes close to the learning-by-exporting literature, which I describe next.

B. *Exporting and Product Innovation*

Much of the work on learning-by-exporting focuses on revenue productivity (Clerides, Lach, and Tybout 1998; De Loecker 2007, 2013). These articles argue that in equilibrium exporters are more productive because firms learn to be more productive as they export, not just because the most productive firms self-select into exporting.

Few articles have tested learning-by-exporting with respect to product innovation. Notably, Damijan, Kostevc, and Polanec (2010) examine whether the higher level of product innovation by exporters is due to selection, or learning-by-exporting. That article found evidence in support of learning-by-exporting, using Slovenian data.

Gorodnichenko, Svejnar, and Terrell (2010) provide evidence that exporters engage more in new product innovation, identifying the causal mechanism as information exchange through vertical linkages to foreign firms. Their tests use 2002 and 2005 data from the World Bank's firm-level Business Environment and Enterprise Performance Survey in 27 transition economies from Eastern and Central Europe. Others have reported similar results for Italy (Bratti and Felice 2012; Castellani and Zanfei 2006) and Slovenia (Damijan, Kostevc, and Polanec 2010).[3] This article extends the research objective of Gorodnichenko, Svejnar, and Terrell (2010) to Chinese industrial enterprises, in combination with the question of foreign investment's impact on product innovation.

C. *FDI and Product Innovation*

Guadalupe, Kuzmina, and Thomas (2012) use propensity score methods to test for the effects of foreign investment on product innovation, but do include a comparison with exporting, like this article. Furthermore, their article does not test for a causal mechanism that drives product innovation in foreign-owned firms. Furthermore, we define product innovation differently: I define product innovation as a continuous measure of output share, while Guadalupe, Kuzmina, and Thomas (2012) use a dummy that indicates whether a firm introduced new products. Even with these differences, their conclusions are similar to what I find.

Several earlier works suggest that FDI or foreign ownership should lead to more product innovation (Girma, Gong, and Görg 2008; Girma et al. 2012; Iacovone et al. 2009; Lai 1998). The reasons offered by this literature include: (1) Foreign owners support subsidiaries' R&D efforts, (2) FDI enables access to needed credit or finance for innovation, (3) foreign multinationals transfer their innovations to subsidiaries to facilitate low-cost production. As a parallel to the learning-by-exporting literature, articles that link FDI to productivity have a history that goes back to Iacovone et al. (2009), Javorcik (2004), Djankov and Hoekman (2000), and Aitken and Harrison (1999).

D. *Exporting and FDI's Effects on Product Innovation*

This article's primary contribution is a direct comparison of the direct impact of exporting against FDI. The articles cited above generally examine the role of trade in product innovation, without exploring the effect of foreign ownership. The following articles argue that foreign

3. All these papers support the learning-by-exporting hypothesis. That said, one must emphasize the distinction between the product innovation and productivity dimensions of learning-by-exporting. Keller (2004) reviews the debate on learning-by-exporting for productivity. A related question, which this paper cannot address for lack of data, is learning-by-importing (Vogel and Wagner 2010).

investment promotes product innovation, also without providing a comparison to exporting (Girma, Gong, and Görg 2008; Guadalupe, Kuzmina, and Thomas 2012). Note that I use the term “foreign ownership” to describe FDI in most of the article; the term seems more relevant to firm-level descriptions.

Commander and Svejnar (2011) compare the effects of foreign ownership and exporting like this article, but for the ratio of sales to inputs. In their analysis, both exports and foreign ownership are associated with higher efficiencies or throughput ratios. However, the foreign ownership variable takes away the significance of the export variable in a regression model with both variables.

The tests that follow recognize that FDI and exporting are not orthogonal features of firm-level data. The prevalence of export-platform FDI implies that in many cases, exports happen because of FDI. Conversely, one can make the case for foreign investment that follows a successful exporting relationship. Examples of the first scenario include Kneller and Pisu (2007) who use aggregate data for Europe, and Sun (2009) who uses Chinese firm-level data to show that FDI increases exports as a share of total output.

III. METHODS, DATA, AND RESULTS

This section reports three sets of results: (1) ordinary least squares (OLS) regressions that test the effects of FDI and exporting on product innovation, (2) PSM tests that show the same idea more robustly, and (3) tests that show drivers of product innovation before and after export entry.

The baseline OLS exercise helps to establish that FDI and exporting as drivers of innovation are relevant to the Chinese context, as documented in the literature. It is a simple comparison of foreign-owned and exporting firms with all other firms in the data. Correlation between these categories and product innovation does not imply causation, so I use PSM to mitigate bias that may result if the firms most likely to introduce product innovations also happen to be foreign owned or exporters.

One may designate exporting or foreign-ownership as instrumental variables. In principle, being in these categories leads to product innovation because firms do things differently—using new methods, equipment, or processes. Therefore, in Section III.D, I further support the claim of a causal relationship between exporting and product innovation by testing whether firms that start exporting also change their pattern of spending on innovation drivers. The innovation drivers I use for this article are R&D and asset purchases. (I show before the aforementioned test that these variables are strong predictors of product innovation.)

A. Data

The data comprise all annual surveys of Chinese industrial firms from 2005 to 2007. China’s National Bureau of Statistics compiled these firm-level data. The sample approximates a census of all firms with revenues greater than 5 million Yuan (about $600,000), supplemented with a stratified random sample of firms below this threshold. The entire dataset is an unbalanced panel of 763,036 firm-year observations, covering over 329,000 unique firms. Fifty-five percent of the firms are present in all 3 years, while another 20% show up in at least two.[4]

I identify exporters from the reported sales and exports values for each firm-year. Foreign ownership is determined from the reported components of paid-up capital. The data cover a period of strong export participation and foreign investment for Chinese firms: this was after China’s World Trade Organization (WTO) accession in December 2001. To illustrate the significance of the timing, the number of firms in the data increased from 249,028 to 311,186 between 2005 and 2007, and the share of those numbers that were exporters in 2007 was 25%. Firms with majority foreign ownership were 8% of the sample in 2007.[5]

Only a minority of firms undertakes product innovation—90% of firm-year observations

4. Before these assessments, I dropped 12,293 observations with one or more of these issues: negative sales, negative paid-up capital, foreign capital that exceeded total paid-up capital, and exports that exceeded sales. (These observations accounted for 1% of the output observed in the data.) This was after I excluded observations for industries outside manufacturing, to avoid comparability issues. The relevant Chinese two-digit industry codes are between Food Manufacturing (14) and Instruments and Office Equipment Manufacturing (41).

5. The dataset reports firms’ ownership capital in each of six source categories—individual, collective, national, other corporations/legal persons, non-Chinese foreign, and Chinese-foreign, that is, Hong Kong, Macau, and Taiwan. The first four categories correspond to private and state-owned sources of funds from mainland China. I define foreign-owned firms as those with majority stakes from non-Chinese sources, that is, outside mainland China, Hong-Kong, Macau, and Taiwan. Sections IV.B and A.4 (Appendix S1) report estimates with alternative definitions of foreign ownership.

registered zero new products. The nearly 76,000 observations with positive values of new products belong to 45,340 firms that count for 115,315 of the total firm-year observations. (The firms that undertook product innovation between 2005 and 2007 did so in only 2 of 3 years on average).

To preview whether product innovation co-occurs more with foreign ownership or exporting, one could sort the data into four groups that combine the two sets of categories: from Chinese-owned nonexporters to Chinese-owned exporters and from foreign-owned nonexporters to foreign-owned exporters. A nonparametric comparison of average innovation intensities for these groups may provide the first hint of what to expect in the results.

Table 1 summarizes the differences in levels of product innovation for the four exclusive subgroups created by the two categories of interest. New products as a share of total output value vary significantly between these groups, with the exporting subgroups having higher averages. Foreign-owned firms do not appear to undertake product innovation significantly above the mean according to the table, although they are larger and more likely to export than the average firm, which fits the pattern documented elsewhere in the literature (Commander and Svejnar 2011; Gorodnichenko, Svejnar, and Terrell 2010; Guadalupe, Kuzmina, and Thomas 2012).

The numbers in Table 1 imply that the two sets of categories are meaningfully distinct, that is, foreign-ownership is not nearly a perfect predictor of export participation and vice versa. The distinction is necessary for any meaningful comparison of the nature proposed by this article.

Table 1 also provides the first hint of a reasonable overlap between exporters and nonexporters, as well as firms with and without foreign-ownership. (The overlap is necessary for the tests that match on observed characteristics in subsequent sections of the article.) Twenty-four percent of exporters have foreign capital, more than a third of foreign-invested firms do not export, and more than a quarter of wholly Chinese-owned firms participate in the export market. As foreign-owned firms and exporters are larger than average, these numbers imply that the odds of finding large nonexporters as a comparison group for exporters of any ownership are not ignorable—several large foreign-owned firms should help to populate the counterfactual category. Similarly, large foreign-owned firms would have no small measure of comparably large Chinese-owned firms as a comparison group. (To illustrate output per firm comparisons: exporters being 29% of firms, accounted for 55% of output in 2005 and the 8% of firms that were foreign-owned in the same year accounted for 17% of output.)[6]

Some firms switched categories between 2005 and 2007. These "transition firms" help with the estimation procedures that follow the OLS regressions and propensity score estimation in the next two subsections.

B. Baseline Estimates—OLS

The simple OLS approach below provides the first formal test of the paper's main question. It is easy to interpret. The specification below reports the conditional mean share of output due to new products, or the likelihood of undertaking product innovation with exporting and foreign ownership as competing explanatory factors.

Formally,

(1)
$$Product\ Innovation_{it} = \alpha + \beta Exporting_{it} + \gamma FDI_{it} + \delta Exporting_{it} * FDI_{it} + FE_{pst} + \varepsilon_{it}.$$

Product Innovation measures the share of output represented by products each firm produced only for the first time that year. It could also be a dummy to indicate the incidence of product innovation for each firm-year.[7] *Exporting* is a dummy variable equal to one for firm-years with nonzero exports. By comparison, *FDI* indicates whether the share of a firm's capital owned by entities outside China, Hong Kong, Taiwan, and Macau exceeds 50%.[8] Desai, Foley, and

6. From the group estimates, one may deduce that 4% of total output in all years was new to the producing firms. Related summary statistics not present in the table include: 27.4% of firm-years involved exporting, 8% involved foreign-ownership, and the hypothetical average firm employed 193 persons to produce 102.840 million Yuan of output per year.

7. Being tax-irrelevant, this measure comes with fewer concerns about misreporting. Nevertheless, the definition is firm specific—one firm's new product may be another firm's staple. The official guidance advises firms to report only substantially new products under this heading.

8. The data report the ownership capital for each firm as well as the components of that capital that come from Chinese and non-Chinese sources. I do not consider capital from Hong Kong, Taiwan, and Macau as foreign. The strong historical ties and similar business cultures suggest that these locations should be considered Chinese—an issue I address in the robustness checks section. An additional rationale for defining foreign capital as I do is round tripping. Xiao (2004) suggests that, to avoid regulation, some persons invest funds from mainland China through entities in these locations, so that ownership is only nominally from outside mainland China.

TABLE 1
Group Summaries

Group	Attribute	2005	2007
Chinese-owned nonexporter	Product innovation	.058	.056
	Group share of total output	.41	.448
	Number of firms	151,975	205,033
	Group of share of total number	.677	.719
Chinese-owned exporter	Product innovation	.173	.207
	Group share of total output	.421	.38
	Number of firms	54,134	57,156
	Group of share of total number	.241	.201
Foreign-owned nonexporter	Product innovation	.054	.043
	Group share of total output	.031	.033
	Number of firms	5,966	7,911
	Group of share of total number	.027	.028
Foreign-owned exporter	Product innovation	.13	.135
	Group share of total output	.138	.14
	Number of firms	12,264	14,966
	Group of share of total number	.055	.053

Hines (2004) motivated the choice of majority-ownership as the threshold for indicating foreign ownership. Their article argues that majority- or wholly owned foreign affiliates experience more technology transfer from parent companies than minority-owned affiliates. ε_{it} is the error term.

Other control variables include industry, year, and province: the FE_{pst} term represents fully interacted province p, industry sector s, and year t fixed effects. The default level of product innovation is usually industry-specific. For example, makers of cotton yarn are not expected to introduce new product varieties at the same rate as the firms that turn the yarn into clothing. Hering and Poncet (2010) also describe the persistent and large differences between Chinese provinces in terms of economic development and R&D. These, and the possibility of year-to-year changes in the investments that support product innovation motivated this specification. I leave out other variables to avoid clutter in this first-stage comparison of the firm categories.[9]

Table 2 reports positive relationships between product innovation and *Exporting*. A similar pattern shows up for *FDI*. The conclusions do not depend on whether one measures product innovation as a share of output, or with a dummy variable. Column 1 of the table suggests that new products as a share of exporters' output will be twice the average for firms in the same sector, province, and year. To interpret this term, consider that product innovation's mean value in the data is 3.9%, while 28% of firms export in the average year. Column 4 reports nearly identical predictions: firms that export are 13% more likely to introduce a new product on average, compared to nonexporters. By comparison, 10% of firm-years in the data register product innovation, which implies that exporters have about twice the rate of the average firm.

Column 2 reports on the *FDI* term, yielding a lower R^2, and a coefficient that indicates new products are 0.3% higher as a share of output for foreign-owned firms, relative to firms in the same sector, province, and year. The direction and size of the coefficient agree with prior works (Girma, Gong, and Görg 2008; Guadalupe, Kuzmina, and Thomas 2012). The 8% of firm-years fall in this majority foreign-owned category. Column 5 suggests that 0.5% more of the foreign-owned firm-years report product innovation.

Columns 3 and 6 include *FDI* and *Exporting* in the same regression. The point estimates strongly suggest that exports had a much bigger impact on innovation, and the FDI variable's contribution changes signs to negative. A comparison with Commander and Svejnar (2011) is interesting: In that article, the coefficient of the export variable effectively became zero when an FDI variable was added to the regression. The reverse is observed here. Differences in the role of export-platform FDI as well as the nature of the transition to trade in Eastern Europe may be responsible for this difference—which invites a separate study to compare drivers of product innovation in China and Eastern Europe.

9. I also consider using a dummy variable to capture differences between private enterprises and SOEs. The results do not change substantially—suggesting that by 2005, one could observe the results of policy reform that promoted innovation for Chinese SOEs. Girma, Gong, and Görg (2009) also showed that SOEs in China, which were generally not innovative in the last century, embraced product innovation after they started exporting.

TABLE 2
Comparing Innovation: Exporting vs. FDI

	(1)	(2)	(3)	(4)	(5)	(6)
	Product Innovation			**Product Innovation > 0**		
Exporter	0.039***		0.041***	0.126***		0.133***
	(0.000)		(0.000)	(0.001)		(0.001)
FDI		0.003***	−0.012***		0.005***	−0.045***
		(0.001)	(0.001)		(0.001)	(0.001)
Exporter*FDI			−0.018***			−0.080***
			(0.001)			(0.003)
Constant	0.029***	0.040***	0.030***	0.065***	0.099***	0.064***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	760,777	760,777	760,777	762,883	762,883	762,883
R-squared	0.081	0.072	0.081	0.141	0.110	0.142

Notes: Product innovation measures new products as a share of total output. This is the dependent variable in columns 1–3. In columns 4–6 the dependent variable is a dummy that indicates whether product innovation is greater than zero. The Exporting and FDI variables indicate exporting and majority-ownership by foreign entities, respectively. Not shown are fully interacted fixed effects for two-digit industry, province, and year. Standard errors in parentheses.

***$p < .01$, **$p < .05$, *$p < .1$.

This exploratory step is highly informative, but comes with many caveats: province, year and sector-fixed effects are the only controls, and the observed correlation does not clearly account for the possibility that the most innovative firms may self-select into exporting or foreign ownership. The PSM test addresses these concerns.

C. Tests that Control for Selection into Exporting or FDI

To mitigate concerns about self-selection, I repeat the estimations in Table 2 using PSM.[10] Some definitions are in order: The causal effect of exporting on product innovation is the difference between the average performance of firms given the export treatment and comparable nonexporters. PSM relies on contrasts between exporters and nonexporters that are similar on just about every other measure. The approach relies on having a sufficiently large set of descriptors for the firms, such that any difference not captured by the matching variables should be essentially random, that is, the Conditional Independence Assumption.

I use 12 variables for this matching process: These include firm size, age, research, financing cost ratios, stateowned enterprises (SOEs) dummies that indicate whether the firm is state-owned or private, and a dummy that indicates the firm's province. Two variables measure firm size—total assets and employee numbers.[11] I also include a categorical variable to capture firms' four digit industry groups. (There are 445 of these.) Section A.1 in Appendix S1, Supporting Information, describes these variables further and provides summary statistics. While evaluating the propensity to export, I include a variable to capture the fraction of paid-up capital owned by foreign entities. Similarly, the test step for FDI includes a measure of export intensity.

I match exporters and FDI recipients to their nearest neighbors. Nearest neighbors are the counterfactual items whose propensity scores are most similar to the reference observation. The propensity score is the predicted value of the exporting or FDI dummy in a first-stage probit regression using the instrumental variables that I describe in the next paragraph. Table 3 presents the PSM estimates, which show the effects of export participation and foreign ownership in columns 1 and 2, respectively, corrected for the average likelihood of selection into a treatment.[12]

10. Leuven and Sianesi (2012) explains this method and tools for implementing it.

11. Using total assets may create a capital-intensive bias in the measure of size, and using total employees might do the reverse; using both variables attempts to alleviate both concerns.

12. The simple nearest-neighbor match suits this author's purpose. The number of observations is large, with many firms in the control and treatment categories sharing similar observable attributes. Therefore, one expects counterfactuals that roughly approximate each tested firm-year. If the overlap between control and treatment items was worse or observations fewer, one could have considered kernel matching or other N-neighbor matching to average out the control observations used.

TABLE 3
Innovation vs. Exports and FDI: Propensity Score Matching

	Product Innovation		Product Innovation > 0	
Dependent Variable:	**(1)**	**(2)**	**(3)**	**(4)**
Exporting	0.062***		0.186***	
	(0.004)		(0.007)	
FDI		−0.061***		−0.1121***
		(0.006)		(0.009)
Constant	0.138***	0.190***	0.262***	0.355***
	(0.002)	(0.04)	(0.002)	(0.002)
Observations on common support	90,461	78,499	82,932	73,337

Notes: Product innovation—the dependent variable measures new products as a share of total output. Columns 3 and 4 use a dummy as the outcome variable. The reported effects are the estimated average treatment effects on treated observations. Standard errors in parentheses.
***$p < .01$, **$p < .05$, *$p < .1$.

The exporting and FDI variables indicate exporting and majority-ownership by foreign entities, respectively. Section A.2 of Appendix S1 describes the variables used to correct for self-selection.

This matching estimate of the treatment effects shows that export participation predicts an additional 6.1% of outputs that are new products (19.9% for exporters vs. 13.8% for comparable nonexporting firms). Firms with majority foreign-ownership under-perform relative to their peers. New products account for 12.9% of their output, compared to 19.0% for Chinese-owned firms with similar propensities. Understandably, foreign-owned firms are larger and more likely to do R&D, so the innovation benchmark is set higher than for exporters.

To address the possibility that only foreign-owned exporters account for the estimated effects of exporting, I repeat the propensity score tests on the subset of the data that is foreign-owned only. (This gives 7,527 observations on the common support, much less than the 90,461 used in column 1 of Table 3.) Among foreign-owned firms, exporters enjoy product innovation advantage that is comparable but less than that in the full sample (5.0%); suggesting that this subset's average cannot account for all the export treatment effect in Table 3 (see Section A.3 for these results). Section A.2 in Appendix S1 supports these results by showing that the sample selected for matching is balanced in terms of the observed covariates, and graphically illustrates the common support on the propensity score for firms that received the export or foreign-ownership treatments.

Comparing the results of this set of tests with the baseline OLS estimates, the 6.0% difference obtained from the matching step is more than the 3.8% from the OLS regression for exporters. It is nice to see the two tests yield coefficients with the same sign.

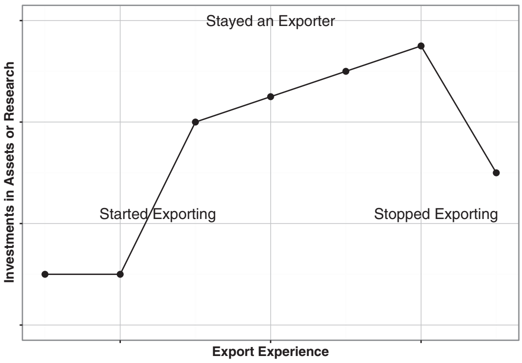
D. Learning Mechanisms for Product Innovation

Given the findings that link higher levels of product innovation to exporting, this section explores possible mechanisms that enable product innovation. The logic that drives the next steps is as follows: intangible factors associated with exporting or foreign ownership may drive the decision to create new products, but the act of creating new products must require measurable changes to the factors of production. Examples of those tangible changes could be investments in R&D to develop or improve products. It could also be investments in equipment to change production processes and methods.

I focus on these two potential mechanisms: R&D spending could represent the homegrown dimension of innovation inputs. Aggregate R&D as a share of gross domestic product (GDP) in China was growing throughout this period. At the firm level, investing in R&D clearly indicates a commitment to learning, which could translate into product innovation. In the same vein, asset purchases could reflect technology diffusion through the acquisition of assets with embodied knowledge, as is well documented for China

Unreported results using N-nearest neighbor matching yield results that are largely similar. Abadie and Imbens (2009) and Caliendo and Kopeinig (2008) explain the advantages of N-nearest neighbor matching over simple nearest-neighbor matching.

FIGURE 1
Illustrative Export-Driven Innovation Pattern



Note: This graph is purely illustrative. It was not created from real data.

(Augier, Cadot and Dovis 2013; Brahmbhatt and Hu 2010). A large number of Chinese producers import their production equipment, which usually embody associated production methods (Woo 2012).[13]

To the extent that exporting is causal to product innovation, it should also be causal to these changes in production, observed and unobserved. In other words, if firms learn to undertake actions like R&D necessary for innovation as they export, the observed measures of these mechanisms should increase when firms begin to export, grow as firms continue to export, and decline for firms that stop exporting. Figure 1 illustrates this pattern of learning-by-exporting. (In contrast, the selection hypothesis would predict small increases on transition into the treatment, and no changes thereafter.) Following the argument in De Loecker (2007), R&D and new assets could be mechanisms that firms learn as they export, and in learning, become more productive.

Formally, for a set of mechanisms that lead to product innovation X:

$$X_{ist} = \gamma_s + \lambda_t + \beta S_{st} + \bar{\varepsilon}_{ist}. \tag{2}$$

S represents the exporting or foreign ownership treatment status; γ helps to address selection—it is the average difference between exporters and nonexporters (or foreign- vs. domestically owned firms). β is the parameter of interest, it measures the extent to which firm i changes X because its ownership or exporting status changed. X represents the set of causal factors like R&D, and investment in fixed capital. Firms may not report all elements of X in the data.

$\beta = E(X_{after,treated} - X_{before,treated} + X_{after,untreated} - X_{before,untreated})$ is the identifying assumption in Equation (2), i.e., $E\left(\bar{\varepsilon}\right) = 0$. This is reasonable, especially if one includes firm fixed effects.

In other words, R&D spending and asset purchases should experience a positive shock right about when a firm starts to export, the positive trend should continue on a reduced scale for firms that keep exporting, and one should see an incomplete reversal of the increased patterns of investment for firms that stop exporting. The reversal should be incomplete because those that stopped learned from their export experience.

Testing this idea is a regression model that extends the specification used by Bernard and Jensen (1999) and De Loecker (2007). The primary differences in this case are: (1) I test for innovation drivers, not productivity on the left hand side, and (2) I include lagged values of the dependent variable to reduce concerns about endogeneity.

Formally:

$$lnX_{it} = a + \beta_0 ln\left(X_{it-1}\right) + \beta_1 Start_{it} + \beta_2 Stay_{it} + \beta_3 Stop_{it} + \beta_4 Size_{it} + e_{it}. \tag{3}$$

Start, *Stay*, and *Stop* capture all the possible treatment status options for a firm in Equation (3). For the exporting treatment, *Start* indicates firms that do not export in year $t-1$ but export in year t and *Stay* shows firms that export in year $t-1$ and continue to export in year t. *Stop* flags firms that exported in year $t-1$, but failed to register exports in year t. X is a placeholder for the matrix of firm characteristics that include size, industry, and location. To interpret the regression, one should consider that only observations in 2006–2007 are usable: of these, 4% of observations fit the *starting exports* category, 25% fall in the *Stay* category, and 4% are observations corresponding to firm-years where exporting stopped. Firm-years unrelated to exporting make up the remaining 67% of observations.

Given a causal relationship between exporting or foreign ownership and R&D for example, one must still show R&D is causally linked to product innovation. Correlation would be sufficient if reverse causation was impossible. In this case, it is possible that firms undertake R&D or asset

13. Other causal drivers of product innovation may exist outside the two that are central to this section of the paper. The approach to estimating the causal relationship addresses the possibility of other unobserved causes.

TABLE 4
Changes at the Export and FDI Transitions

	Before Exporting	After Exporting	Before FDI	After FDI
Variables	**Group Averages**			
Product innovation	.049	.077	.044	.050
I(Product innovation > 0)	.104	.206	.094	.106
R&D	475.93	773.75	464.47	632.10
I(R&D > 0)	.133	.165	.113	.127
Log(Original asset value)	8.858	9.084	9.333	9.518
I(Δ original asset value > 0)	.762	.770	.785	.753
N	15,726		5,688	

purchases after embarking on a course of product innovation for another reason.

Formally:

$$\text{(4)} \quad \text{Product Innovation}_{it} = \alpha_i + \alpha_2 X_{it} + \widehat{\varepsilon}_{it}.$$

Firms fixed effects α_i help to identify the relationship in Equation (4) as causal. (This approach also mitigates bias due to omitted elements of X that are firm specific.) If $\alpha_2 > 0$ and $\beta > 0$, one could argue that the variables in X_{it} are the causal mechanisms through which exporters or foreign-owned firms undertake product innovation. The rest of this section focuses on estimating Equations (3) and (4).

I rely on a Tobit empirical specification for Equation (2) as relatively few firms undertake R&D. R&D expenses are greater than zero for only 83,176 of the 763,036 firm-year observations in the data. These expenses are attributable to 45,340 firms. Even these firms do not spend on R&D in every year (they account for 127,883 observations, which suggests that for them, R&D expense occurs in about 2 of 3 years). Asset purchases are more common—they are positive for 70% of observations with two consecutive firm-years, although they tend to be higher for exporting firms.[14]

Table 4 presents some nonparametric comparisons before the regression exercises. It shows differences in exporting, R&D, and asset purchases for firms that changed exporting or FDI status. Only 15,700 and 5,700 firms fit each of these categories, but those numbers are large enough to be instructive in this summary table format. As the dataset is a short 3-year panel, no distinction is made between firms that started exporting in 2006 or 2007. The table provides suggestive evidence of a strong relationship between the transition to exporting and product innovation, with exporting having the stronger relationship. Twenty percent undertake product innovation in the year of exporting, compared to 10% for the same firms before exporting. (The comparable numbers are 4.4% and 5% for foreign-ownership.) The share of output due to new products also increases, while an additional 3% of firms start spending on R&D in the year of exporting relative to year before exporting. About 12.7% of firms that received foreign capital undertake R&D; in the year before receiving foreign capital the fraction is 11.3%—so the incidence of R&D increases with foreign ownership, just not as much as with exporting.

Asset purchases were measured using the original purchase value of assets before depreciation, as recorded in the data.[15] The alternative—using changes in the net value of assets—is problematic given the difficulty of accounting simultaneously for asset purchases, disposals, and depreciation on old and new assets. Comparing the original purchase value of a firm's assets in one year with the prior year gives the lower bound of its assets purchases that year. The question of interest here is whether positive values of asset purchases are correlated with product innovation and exporting.

Table 5 shows that product innovation increases for firms with R&D and new assets, status notwithstanding. The two key predictor

14. Using Tobit means relying on assumptions of normally distributed errors. Future work could consider alternative approaches. The Tobit approach appears adequate for the basic goal of showing a link between exporting and R&D or asset purchases.

15. Say a hypothetical firm A owns a widget worth 100 Yuan in year 1. If it buys a second widget worth 150 Yuan in year 2, its original assets value increases to 250, even if the value of assets on the books is smaller due to depreciation. The main challenge with using this variable to measure asset changes is that when firms dispose of assets in the same year that purchase new ones, purchases are underreported by the value of the disposals. (If the firm sold the first widget at the same time that it upgraded to another, the reported value would be 150.)

TABLE 5
R&D and Asset Purchases Increase Product Innovation

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Log(New Product)			I(Product Innovation)		
Log(R&D)	0.134***		0.106***	0.011***		0.009***
	(0.005)		(0.009)	(0.001)		(0.001)
I(R&D)	−0.223***		−0.235***	−0.006*		−0.012**
	(0.028)		(0.051)	(0.003)		(0.006)
Log(Asset purchase)		−0.000	−0.001		−0.000	−0.000
		(0.003)	(0.003)		(0.000)	(0.000)
I(Asset purchase)		0.006	0.004		0.001	0.000
		(0.025)	(0.025)		(0.003)	(0.003)
Log(Total assets)	0.072***	−0.036*	−0.045**	0.004***	−0.009***	−0.010***
	(0.008)	(0.019)	(0.019)	(0.001)	(0.002)	(0.002)
Log(Employees)	0.046***	0.077***	0.070***	0.003***	0.006***	0.006***
	(0.006)	(0.018)	(0.018)	(0.001)	(0.002)	(0.002)
Constant	0.219	4.299***	4.258***	0.056	0.480***	0.472***
	(0.543)	(1.524)	(1.522)	(0.062)	(0.172)	(0.172)
Observations	762,883	358,035	358,035	762,883	358,035	358,035
R-squared	0.790	0.893	0.893	0.755	0.870	0.870
Firm FE	Y	Y	Y	Y	Y	Y
Prov. FE	Y	Y	Y	Y	Y	Y
Ind.-year FE	Y	Y	Y	Y	Y	Y

Notes: The product innovation measure represents the log of new products' value for a firm-year. Columns 4–6 use a dummy as the outcome variable. Logged values of R&D and Asset Purchase for each firm year are the key control variables (with 1 added before taking logs to avoid losing zero-valued observations). Dummy variables that indicate when these variables are nonzero were included to address possible bias due to so many zeros in the RHS variables. These are the *I*() items. I also include size controls—the log of total assets and the log of total employee numbers. The number of observations is markedly less for observations that use asset purchases as a control variable. There were only 358,000 usable observations with two consecutive firm-years, as needed to calculate year-to-year changes in original asset values. To interpret these OLS estimates, it helps to know that the mean values of the Log(New Product), I(Product Innovation), Log(R&D), and Log(Assets Purchase) variables are 0.92, 0.09, 0.71, and 5.78, respectively. 90% and 60% of the observations had a value of zero for R&D and Asset Purchases. Standard errors in parentheses

***$p < .01$, **$p < .05$, *$p < .1$.

variables were measured in logs (after adding 1). Most nonzero values of R&D and assets are large enough that adding 1 should not bias the estimated effects in any meaningful way. The step allows the use of the many zero observations, while maintaining an appropriate scale that recognizes the skewed distribution of these variables on a linear scale. I include a dummy variable for nonzero R&D expense in the OLS regression to address potential bias from the prevalence of zeros. This is less of an issue for asset purchases, but I use a similar dummy as a precaution. I also controlled for size—measured as the log of total asset values and employee numbers. I also kept the usual dummies for fully interacted 2-digit industry year, as well as a province dummy.

Column 1 of the table indicates that conditional on having positive R&D expense, firms that do more R&D also tend to do more product innovation. For example, if the average firm increases its R&D spending by one standard deviation (1.9), it would increase its output of new products by 25% and its likelihood of product innovation by 2%. Firm fixed effects help to address concerns about endogenous R&D or reverse causality. Interestingly, the set of firms that do not report any R&D at all tend to engage in more product innovation after controlling for firm size. This supports the argument that firms may have other approaches to product development like staff training that are not reported in a separate cost category like R&D. (If the regression was run without the *I*(*R&D*) dummy, the coefficient on the *Log*(*R&D*) variable remains positive, statistically significant and about two-thirds of its size in Table 5.) In summary, the evidence suggests a causal relationship between R&D and product innovation, with other factors also playing a part in product innovation for firms that do not report R&D expenses. Column 4 mimics the pattern in column 1 on a smaller scale for the product innovation dummy.

Columns 2 and 5 suggest that purchasing fixed assets may not predict product innovation as well as R&D. This is especially after controlling for firm size. The estimated coefficients on this variable and its nonzero dummy are not statistically significant. Another interesting result from this set of estimates is that large firms in terms of assets do not appear to be most likely to introduce product innovations—if they are also not large employers. Otherwise, there is no indication that a statistically significant relationship exists in general between asset purchases and product innovation. Columns 3 and 6 combine the two key variables and their dummy indicators and yield estimates that are consistent with the other specifications in Table 5. Firms that undertake R&D tend to do product innovation; purchasing assets is not a clear predictor of product innovation although the estimates suggest that firms that do not report R&D spending may undertake other efforts to create new products.

Table 6 links exporting and foreign ownership to R&D and asset purchases. Column 1 shows R&D, while column 2 shows asset purchases. The annual survey dataset reports both the depreciated and original or purchase values of fixed assets. Therefore, it is possible to track net asset purchases using their reported original values for fixed assets in 2006–2007. I use these data to estimate Equation (3).[16]

Firms' patterns of spending on innovation inputs change as they start exporting. The Tobit specification in Table 6 shows that R&D for the average firm increases by about 132% when a firm starts exporting and by 73% for firms that remain exporters. (To compute these, I use the average value of 0.92 for the R&D variable and apply the e^{coeff_mean} transformation to the difference.) That group, in turn, invests more than firms that stop exporting. The firms that stop exporting still do better than those with no export record, having learned from their experience, their R&D spending is 62% above average. Capital purchase patterns do not follow the trend exactly, but remain broadly consistent: firms that start exporting invest more than the average nonexporter, those that stop exporting invest less than the average new exporter but more than nonexporters—which suggests learning from the export experience. Experienced exporters invest in equipment at below-average rates for exporters, arguably because most investments required were made at the beginning of the export experience. Long-run investment trends cannot be deduced from the 3-year panel data. The size controls behave as expected, firms that are larger in terms of assets or employees also undertake more R&D and investments in fixed assets.

In contrast, firms that start FDI do not spend on R&D more than the average firm. Their asset purchases are larger than those of the average domestically owned firm, but the increase of 0.4% over the mean remains less than the 0.5% increased associated with starting exporting. (I compute these with the average value of 5.74 for asset purchases and apply the e^{coeff_mean} transformation to the difference.) After controlling for firm size and lagged values, R&D expense is actually 74% lower for firms that started to be majority foreign-owned. The estimated effect of the change in ownership status is statistically significant. Similar patterns obtain for remaining majority foreign-owned or reverting from foreign-owned to domestic ownership. Asset purchases are higher than average—actually higher than for the comparable export status, but spending on R&D is less than average. The pattern of lower R&D spending by foreign-owned entities is consistent with the literature—multinationals generally prefer to keep R&D centralized where they have stronger intellectual property protection (Branstetter, Fisman, and Foley 2006; Fernandes and Tang 2012). In contrast, locally owned exporters generally do not have the option to outsource their R&D. Their spending on R&D and new assets therefore reflects their efforts to update production processes as they compete in global markets.[17]

The pattern of R&D growth experienced by these exporters may lend some credence to the *Economist* magazine's claim: Exporters in developing economies are staking their claim on the innovation terrain.

16. Approximating asset purchases to net asset purchases assumes ignorable asset sales, which is consistent with the rarity of negative asset purchases in the data: if asset sales were usually large, then there would be many instances where net purchases are negative because sales exceed purchases. If small amounts of asset sales were the norm, then the dependent variable will be biased towards zero. This calls for the reasonable assumption that disposals of assets are not unusually low for exporters or foreign-owned firms. If they were upgrading equipment, which requires the disposal of old assets, one expects these firms to have higher-than average disposals, which reduces the estimated value of asset purchases in these regressions.

17. This pattern may be consistent with the foundational work of Vernon and Wells (1966), that with product innovation, most of the resources and R&D required are drawn from local sources. By that reasoning, R&D expenses may decline for affiliates of multinationals trying to replicate products using know-how from their home-countries.

TABLE 6
Innovation Drivers by Stage of Export/FDI Participation

Dependent Variables:	(1) Log(R&D)	(2) Log(Asset Purchases)	(3) Log(R&D)	(4) Log(Asset Purchases)
Started_Exports	0.988***	0.474***		
	(0.079)	(0.027)		
Stayed_Exports	0.398***	0.101***		
	(0.040)	(0.013)		
Stopped_Exports	0.238***	0.138***		
	(0.086)	(0.028)		
Started_FDI			−0.606***	0.332***
			(0.138)	(0.044)
Stayed_FDI			−0.655***	0.248***
			(0.061)	(0.020)
Stopped_FDI			−0.416***	0.170***
			(0.145)	(0.046)
Log(R&D), Lagged	1.643***		1.641***	
	(0.007)		(0.007)	
Log(Assets), lagged		−0.000***		−0.000***
		(0.000)		(0.000)
Constant	−16.708***	−7.134***	−17.059***	−7.122***
	(0.208)	(0.070)	(0.208)	(0.070)
σ	5.897***	2.964***	5.898***	2.964***
	(0.022)	(0.004)	(0.022)	(0.004)
Observations	437,736	358,035	437,736	358,035
Size controls	Y	Y	Y	Y
Province FE	Y	Y	Y	Y
Ind.-year FE	Y	Y	Y	Y

The dependent variable is the logged value of asset purchases or R&D undertaken in each firm-year. The main explanatory variables are firms' foreign-ownership or export status. I also use lagged values of the dependent variable to mitigate concerns about endogeneity. The σ captures the Tobit specification's equivalent of the square of residual variance. Compare with 2.06 and 3.09—the standard deviations of the dependent variables. Standard errors in parentheses.

***$p < .01$, **$p < .05$, *$p < .1$.

IV. ROBUSTNESS CHECKS

A. Learning with Corrected Biases

Bernard and Jensen (1999) did not need to prove that learning mechanisms work, unlike this article. To address concerns that the regression coefficients in Table 6 are biased upwards because of self-selection, the next two paragraphs present the results of tests that use the PSM method.

Table 7 presents results consistent with the findings of the OLS step. Each "treatment condition" is tested separately. The control group was selected to match each treatment: Observations with the *Start* treatment were matched to others who were similarly not exporters in the previous period. *Stay* was matched against new exporters and those that had stopped exporting, while those with the *Stop* treatment were compared with firms that had no exporting history.

As in Table 6, firms that start exporting invest more in R&D and fixed production capital than their nonexporting peers. (1.00 for exporters vs. 0.864 for nonexporter peers). The estimates are statistically significant for both Exporting and FDI, but with opposite signs. In the first year that a firm becomes majority foreign-owned it invests less in R&D than comparable Chinese-owned firms. This is consistent with Table 6, and supports the suggestion that when firms start exporting, they learn to do R&D. Chinese firms that become foreign-owned may actually reduce their R&D efforts if the parent company opts to locate R&D efforts elsewhere, to retain better control over intellectual property rights. While both sets of "starters" out-invest peers in terms of fixed production capital, the estimates are only statistically significant for firms that started exporting.

Firms that remained as exporters do not appear to spend more on R&D than new exporters and firms that stopped exporting—the comparison group for this exercise. The difference for R&D is not statistically significant, as is the observed mean difference for assets purchases. Firms that remained majority foreign-owned, compared with new or formerly foreign-owned also do not register any statistically significant difference in their spending on R&D and asset purchases.

TABLE 7
Matching Estimates by Stage of Export Participation

Variables	Log(R&D)	Log(Asset Purchases)
Started_Exports	0.139***	0.193**
	(0.028)	(0.072)
Stayed_Exports	0.012	−0.031
	(0.023)	(0.059)
Stopped_Exports	−0.037	−0.092
	(0.024)	(0.070)
Started_FDI	−0.158***	0.047
	(0.045)	(0.114)
Stayed_FDI	−0.015	0.034
	(0.041)	(0.100)
Stopped_FDI	−0.098**	0.275**
	(0.043)	(0.116)

Notes: The reported effects are the estimated average treatment effects on treated observations. For these propensity score matching exercises, the counterfactual for each row was limited to comparable firm-years as follows: *Started_** was matched to observations not foreign-owned or an exporter, and *Stayed_** to observations with a history of exporting or foreign ownership, but currently not in a second consecutive year in that status. *Stopped_** was matched to either nonexporters or firms with no foreign-ownership in that year. The dependent variables are logged values of R&D and asset purchases (plus 1 to avoid losing zeros). The number of treated observations was 15,713, 110,260, and 17,100, respectively for Exports in rows 1–3 of column 1. Rows 4–6 of column 1 had 3,784, 35,947, and 5,211. The numbers vary by column because the match was limited to items on the common support. The matching variables include firm size, output per assets and employee, as well as 4-digit industries. Further detail on the mean outcomes for treated and untreated items, the control items on common support and balancing tests for the matching variables are available on request from the author. Standard errors in parentheses

***$p < .01$, **$p < .05$, *$p < .1$.

Firms that stop exporting invest less in R&D and new capital than other nonexporting peers. The difference is small enough to be that it is not statistically significant, however. This may imply that characteristics like output per-employee or other matching variables drive the learning suggested by Table 6. It does not invalidate the claim altogether, just how it is interpreted. Firms that changed from majority foreign ownership report split pattern of estimated effects. While these firms spend less on R&D than comparable Chinese-owned firms, they spend more on asset purchases. Both estimates are statistically significant at the 95% level.

B. Other Empirical Specifications

The definition of foreign capital excluded funds from Hong Kong, Macau, and Taiwan (HMT) throughout this article. This definition was motivated by the similarity of business cultures, technology, and connections in the region.

Nevertheless, I show below in Table 8 that the coefficients of the OLS tests in Tables 2 and 6 would remain mostly unchanged if foreign capital were redefined to include funds from HMT. (The implication is that the two categories of foreign capital sources in the data are not inherently associated with different propensities for product innovation.) For the PSM tests, matching coefficients for both versions of the model are broadly similar, showing that firms increase R&D and asset purchases when they enter the export market, invest more as they remain exporters, and reduce the pattern if they stop exporting, but not to the level of firms that never exported.

Table 8 only indicates that the conclusions of this article should not change, even if the definition of foreign capital had been more expansive from the start. In fact, I expect any other definition of foreign capital to enhance the contrast between the effects of trade and foreign investment presented in Tables 3 and 6.

Appendix S1 includes tests of the match quality for all the propensity score-based tests in the previous section.

V. CONCLUSIONS

This article compares the direct impacts of exporting and FDI on product innovation. FDI and export promotion are the two main channels that developing economies have adopted to lead private sector growth; hence the motivation to evaluate their relative merits in promoting product innovation. Firms with an interest in stimulating product innovation may also consider the same question as a matter of strategy.

Using PSM methods and rich firm-level data, this article shows that exporting causes firms to engage in greater levels of product innovation, lending support to the "learning-by-exporting" hypothesis (Bratti and Felice 2012; Damijan, Kostevc, and Polanec 2010; De Loecker 2007). FDI does not give the same level of new product creation, either in terms of incidence or intensity. In some specifications, foreign ownership actually leads to less innovation and less spending on items like R&D. In a developing economy like China, the absence of a positive relationship between FDI and innovation may be due to foreign owners' efforts to protect intellectual capital by moving R&D abroad (Branstetter, Fisman, and Foley 2006; Fernandes and Tang 2012). Those firms could also be reducing innovation

TABLE 8

Comparing Coefficients for FDI with and without HMT

	(1)	(2)	(3)	(4)	(5)	(6)
	Product Innovation			**Product Innovation > 0**		
Exporter	0.039***		0.044***	0.126***		0.145***
	(0.000)		(0.000)	(0.001)		(0.001)
FDI with HMT		−0.001	−0.019***		−0.007***	−0.065***
		(0.001)	(0.001)		(0.001)	(0.001)
Constant	0.029***	0.040***	0.031***	0.065***	0.101***	0.070***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	760,777	760,777	760,777	762,883	762,883	762,883
R-squared	0.081	0.072	0.082	0.141	0.110	0.146

Notes: The dependent variable in columns 1–3 is new product's share of total output, while columns 4–6 use a dummy that is 1 if new products represent a positive share of outputs. FDI with HMT is a categorical variable that switches from zero to 1 if more than 50% of ownership is from outside mainland China, Hong Kong, Macau, and Taiwan (HMT). In sign and significance, the results are comparable to Table 2. Standard errors in parentheses.

***$p < .01$, **$p < .05$, *$p < .1$.

efforts in the developing-economy subsidiary to avoid effort duplication.

I further explore the causal nature of the relationship between exporting and innovation, through the use of potential innovation inputs like R&D and asset purchases, as R&D causally predicts new product innovation in this context. Exporting or foreign ownership may drive the decision to create new products, but the act of creating new products must require measurable changes to these or other innovation inputs. Estimates from that exercise indicate that firms that start exporting undertake more R&D and invest more in new production assets. These results also suggest that firms learn from exporting—firms that stop exporting spend more on R&D and new assets than the average nonexporter, even if less than new or continuing exporters. In all specifications, firms that change from Chinese to foreign ownership reduce R&D spending on average. Their asset purchases are higher than average, but less than the comparable number for new exporters.

These findings suggest that context may matter for whether foreign investment leads to product innovation. On the other hand, exporting consistently predicts higher levels of innovation efforts like R&D and better product innovation outcomes. In a context where a foreign owner only wants the low production cost of a location like China, foreign ownership may actually lead to lower levels of product innovation. The owners' priorities determine whether the firm undertakes costly innovation efforts.

Relating these findings to papers like Commander and Svejnar (2011) and Guadalupe, Kuzmina, and Thomas (2012) that find a positive relationship between product innovation and foreign ownership in European contexts holds the potential for additional work on how context, property rights, and economic development influence technology transfer through ownership.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Variables used for PSM