The Impact of Emerging Market Competition on Innovation and Business Strategy: Evidence from Canada

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Abstract

Does intensifying emerging market competition boost or inhibit innovation? We estimate how a representative panel of Canadian firms adjusts innovation activities, business strategies, and exit in response to large increases in Chinese import competition. Our analysis shows that the innovation response of firms depends on the type of innovation: on average, product innovation incentives are stimulated by competition while process innovation incentives decline. We develop a theory that combines these different innovation types with partially irreversible innovation strategy choices to derive novel performance implications in response to competition. Consistent with this theory, we find that firms that initially pursue process innovation strategies and survive have higher profits ex-post, but are ex-ante more likely to exit. In contrast, firms that initially pursue product innovation strategies have higher profits if they survive, without significant impact on exit. Both empirical patterns are consistent with our theory, which suggests that innovator performance depends on the balance of innovation incentive effects and competitive failure risk.

Keywords: Chinese competition, innovation, business strategy, commitment, exit, risk

JEL classifications: D2, F1, L2, L6, M2

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1. Introduction

What is the impact of trade integration with low-income countries on firm dynamics in high-income countries, including innovation activities and business strategy? A large empirical literature has documented that low-cost competition in the wake of China's entry into the WTO has led firms in North America and Europe to cut jobs, lose market share, or shut down altogether and has correspondingly highlighted the labor market consequences of Chinese competition; see Bernard, Jensen, and Schott (2006), Iacovone, Rauch and Winters (2013) and Autor, Dorn, and Hanson (2013).

Innovation adds an important dynamic dimension to the impact of Chinese competition on developed economies. Innovation might add significant dynamic costs for North American trading partners if it declines in response to Chinese competition or it might lead to significant dynamic gains if competition boosts innovation. At a deeper theoretical level, these different possible innovation responses to competition are linked to a long-standing theoretical debate on whether competition facilitates innovation or not (see Shapiro (2018)). On the one hand, traditional R&D-based models of endogenous innovation[3] follow Schumpeter (1943) and predict that competition tends to lower innovation and therefore profits and net job creation. On the other hand, a theoretical literature following Arrow (1962) predicts that intensifying competition will boost innovation, as in models of quality differentiation such as Sutton (2012) and Amiti and Khandelwal (2013), escape from competition models such as Aghion, Harris, Howitt and Vickers (2001) or trapped factor models such as Bloom, Romer, Terry, and Van Reenen (2014).

Previous empirical studies have found mixed results on how innovation responds to intensifying Chinese competition, with Bloom, Draca, and Van Reenen (2015) documenting positive innovation responses to Chinese competition in Europe, while Autor, Dorn, Hanson, Pisano, and Shu (2016) find that US publicly traded firms systematically reduced innovation. This paper contributes to both the ongoing theoretical debate on how competition affects innovation as well as the empirical debate on what drives differences in firm responses to Chinese competition. In our theory, the incentive to innovate in response to competition depends on the type of innovation pursued. We consider "product innovations" – in the form of novel and differentiated products – as more likely to shield firms from competition, such that competition may strengthen product innovation incentives, corresponding to the "Arrow Effect" in Arrow (1962) and Shapiro (2018). We consider "process innovations" – which are primarily aimed at reducing costs and improving technical efficiency – as likely to directly increase profitability without insulating firms from their competition. This will result in weakened innovation incentives in response to intensifying competition, corresponding to the "Schumpeterian Effect" in Schumpeter (1943), Homberg and Matray (2018) and Shapiro (2018). Our model highlights the potential limitations of a one-dimensional model of innovation and suggests that a richer model that distinguishes between types of innovations – such as product and process innovations – could provide a more unified framework for thinking about the innovation response to competition. This perspective can also potentially explain the different empirical results in the literature on innovation responses to

[3] Leading examples include Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992), Klette and Kortum (2004), and Atkeson and Burstein (2010).

Chinese competition if large and old US firms analyzed by Autor, Dorn, Hanson, Pisno and Shu (2019) primarily pursue process innovation strategies (consistent with evidence by Cohen and Klepper (1996)), while the mostly medium-sized and younger European firms analyzed by Bloom, Draca and Van Reenen (2015) primarily pursue product innovation strategies.

Our theory combines these different innovation types with a partially irreversible innovation strategy choice to make novel predictions about how Chinese competition impacts the performance of firms. We define business strategy as a long-term plan to pursue specific performance advantages based on novel products, more efficient processes, or lower costs, and we focus on innovation strategies. Such strategies are often costly to reverse, and manufacturing firms such as Intel, General Electric, Nucor, and Ford rarely decide to change innovation investments on a year-to-year basis but rather view such investments as part of a long-term commitment. But such long-term strategic commitments in turn imply the possibility of considerable risk, as firms that are stuck with a partially irreversible innovation strategy might suffer losses when the business environment changes rapidly, particularly if their innovation attempts fail. In other words, the choice of an innovation strategy and its interaction with rising Chinese competition involves important risk-return tradeoffs that have not been considered in the current literature. To understand our firm performance predictions, it is conceptually useful to separate three different types of firms based on their strategy choice and innovation outcomes. In particular, the data can be understood as consisting of firms that do not pursue an innovation strategy (henceforth "non-innovators") as well as firms with an innovation strategy, which in turn can be separated into successful and failed innovators. A novel feature of our model is the idea that the strategic choice to pursue an innovation strategy might involve taking on an additional risk especially in the context of intensifying competition. In particular, failed innovations might reduce firm profits disproportionally in the face of more competition. This additional "competitive failure risk" captures possibly significant additional costs of failed innovations, such as delayed implementation on other projects as well as shutdown costs of projects and has previously been used in theoretical studies such as Atkeson and Burstein (2010). In the context of comparing the performance of innovators to non-innovators, competitive failure risk will generate a selection effect: exit of failed innovators will be higher than exit of non-innovators. At the same time, the failed innovators with the lowest profits will exit, so that profits of surviving failed innovators will be higher than profits of non-innovators. These two key performance moments – exit and profits conditional on survival – are thus critical for measuring competitive failure risk. We show that the overall impact of intensifying competition on firm performance depends on the sum of this competitive failure risk effect and the innovation incentive effects, which differ by innovation type. As a result, our theory is able to make predictions about the differences in performance impact, depending on whether firms pursue a product innovation strategy, a process innovation strategy, or no innovation strategy.

We test our theory using rich Canadian firm-level panel data on strategy choices, innovation outcomes, exit and performance from 1999 – 2005. Our analysis uses unique self-reported measures of intended innovation strategies, which allow us to measure whether firms initially pursue process or product innovation strategies.[4] The lack of such data has prevented previous studies from considering how international competition could have differential effects on firm performance depending on a firm's strategic choices. Our measures of intended strategies have the additional advantage that they are not outcome variables like patenting or TFP, hence they do not confound the effect of intended strategic choices with the effects of luck and outcome-based selection. This allows us to analyze the risks associated with innovation activities. The data also provide many measures of self-reported innovation outcomes, including novel business processes protected by trade secrets or incremental product innovations. We use administrative tax records to validate these self-reported innovation outcomes, showing that they strongly correlate with reported revenues and operating costs that are consistent with firms' tax records. These rich measures of innovation outcomes also cover young and small firms, which typically do not yet own patents, do not have formal R&D expenditures and hence are often excluded from previous studies.[5]

Our identification strategy mirrors the empirical approach by Autor, Dorn, and Hanson (2013) and Bloom, Draca, and Van Reenen (2015), who utilize the massive expansion of Chinese exports in the wake of China's WTO accession as a natural experiment. Guided by our theory, we develop two sets of results. First, we analyze how Canadian firms adjust their innovation activities and business strategies to this "China shock." Consistent with our theory, we find that Canadian manufacturing firms systematically reduced process innovation activities, while they increased product innovation activities. Furthermore, we find evidence of increased adoption of product innovation strategies, while process innovation strategies do not systematically respond to Chinese competition.

We then move to test the new performance implications of our theory, which predicts exit and profit responses to competition as a function of initial strategy choices. We find that firms that pursue process innovation strategies exhibit higher profits if they survive, but they are more likely to exit in response to Chinese competition. In contrast, firms that produce product innovation strategies perform better if they survive with no notable change in exit probability. Both empirical patterns are consistent with our theory, which suggests that both types of innovation strategies carry competitive failure risk, but differ in their innovation incentive effects.

2. Theory and Hypothesis Development

2.1 Model setup

This section outlines our baseline theory, which serves two purposes. First, we formalize the idea of a partially irreversible strategy choice that allows us to clarify what type of information the new

[4] Yang, Kueng, and Hong (2015) provide a detailed analysis of firms' business strategy choices.

[5] Another advantage of using survey data on innovation rather than patent data is the increasing popularity of patenting as a strategic tool by incumbents vs. entrants (Boldrin and Levine, 2013) as well as a rent extraction tool by patent trolls (Tucker, 2014). From this perspective, a fall in patenting in response to more competition from China might just reflect the fact that domestic firms in high-income countries recognize that they cannot enforce domestic patents against Chinese competitors and therefore they reduce patent applications.

data on strategic choices helps capture. Second, the model allows us to introduce the distinction between process and product innovations, which in turn will guide our empirical analysis. We focus on the optimal decisions for a single firm, although it is straightforward to generalize the model to a monopolistic competition industry equilibrium. Demand, production technology, and choices give rise to expected profits $\Pi_\iota^s(c)$, which will be a function of the strategic choice s and indicator ι capturing successful innovations and the level of competition, given by c.[6]

The sequence of events in the model is as follows: in stage 0, we assume that firms initially make a partially irreversible strategy choice of whether to pursue innovation or not; this is captured by the indicator $s \in \{0,1\}$, which is 1 if they pursue innovation. If firms do not pursue innovation ($s = 0$), the expected profit will not depend on innovation outcomes and will simply be given by $\Pi^0(c)$ in stage 2. We will call such firms "non-innovators." On the other hand, if firms do pursue an innovation strategy ($s = 1$), then their profits will ultimately depend on whether they succeed at innovating. We use $\iota \in \{0,1\}$ as the indicator for a successful innovation and $p = Prob\{\iota = 1\}$ as the probability of successful innovation. In stage 1, firms that pursue an innovation strategy can increase their chances of successful innovations by investing in R&D, with a cost function given by $R(p) = \frac{1}{2}\kappa \cdot p^2$. After these investments, the probabilistic innovation outcome is realized in stage 2, at which point there will be successful innovators ($\iota = 1$) as well as failed innovators ($\iota = 0$). Regarding profits, we define $\pi_\iota(z,c) = \frac{z_\iota}{c}$ as the post-innovation profits, which depend on the level of competition c as well as the post-innovation firm level productivity index z_ι.[7] After innovations are realized, firms will be heterogeneous, depending on the productivity z_ι, and will only continue operating if they can cover overhead fixed costs f

$$\pi_\iota(z,c) \geq f \tag{1}$$

[6] Higher values of c denote more competition. For example, in a standard trade model with CES preferences, elasticity of substitution η, and P as the CES price index, competition would be captured by $c = P^{-(\eta-1)}$.

[7] Note that although our model abstracts from any initial heterogeneity, it is straightforward to extend the model in at least two ways to capture such initial heterogeneity. First, firms might differ with respect to initial productivities Z^A. Second, variation in κ could capture differences in innovation incentives or abilities for different types of innovation. These extensions allow the model to rationalize features of the data, e.g. larger/more productive firms are more likely to innovate, there are many large non-innovating and small innovating firms, some firms only undertake one type of innovation and others undertake both types. A less trivial extension we do not pursue here is to model the potential complementarity and/or substitutability of innovation strategies with each other, firm productivity and competition. Conceptually, our model captures the relevant economic intuition when comparing firms that differ only in terms of a single innovation strategy and competition shock, holding other factors constant. Theoretically, it is difficult to sign the selection bias when making an unconditional comparison between innovating and non-innovating firms because this is highly model dependent. For example, in a standard Melitz framework higher productivity firms are less likely to exit when faced with a competition shock, but surviving firms face a similar proportional decrease in profits regardless of productivity. Models with variable markups or with heterogeneous fixed costs (e.g. more productive firms have higher fixed operating costs) can have different implications for the relationship between productivity, competition, profit and survival. We discuss selection issues in detail in the empirical section but essentially our approach is to control for firm size/productivity and other strategic choices that could impact firm performance directly and when interacted with competition, to isolate the average treatment effect corresponding to our analysis of a single strategy choice and competition shock in this section.

Failed innovators that cannot cover these fixed costs exit. Exit rates are denoted as δ_1^1 for successful innovators, δ_0^1 for failed innovators and δ^0 for non-innovators.

We use a specific example of the model to facilitate the analysis:

- If innovations are successful, firms are assumed to generate a productivity z_1 that is sufficiently high for them not to exit (i.e. $\delta_1^1 = 0$).
- Similarly, we assume that exit probabilities for non-innovators (s=0) are constant and their productivity is given by $\bar{z}$.
- Failed innovators realize a productivity $z_0 \in [\underline{z}, \bar{z}]$ with $\underline{z} < \bar{z}$. We assume these productivity draws are continuously distributed with cdf $G(.)$. Together with the previous assumption, we therefore assume that failed innovators' productivity is typically lower than non-innovators. This assumption captures in a simple way the idea that failed innovation leads to significant costs, such as delayed implementation on other projects and shutdown costs of innovation projects, and has previously been used in theoretical work such as Atkeson and Burstein (2010). This assumption is necessary to generate the "competitive failure risk effect" discussed in section 2.3.

Exit for failed innovators is determined by whether productivity is above a cutoff that is influenced by competition, denoted $z^c(c)$. If $z_0 < z^c(c)$, then failed innovators exit. In general, for innovation strategy firms, the expected profit for successful innovation, is given by:

$$\Pi_\iota^1(c) = (1 - \delta_\iota(c)) \cdot \psi_\iota(c) \tag{2}$$

with $(1 - \delta_\iota(c)) = P(\pi_\iota(z,c) \geq f)$ as the survival probability and $\psi_\iota(c) = E[\pi_\iota(z,c) - f | \pi_\iota(z) \geq f]$ as the profits, conditional on survival. As a result, the optimal investment problem for innovation strategy firms at stage 1 is:

$$p(c) = \arg\max_{p} \Pi^1(p,c) = p \cdot \Pi_1^1(c) + (1-p) \cdot \Pi_0^1(c) - \frac{1}{2}\kappa \cdot p^2 \tag{3}$$

Anticipating the degree of competition and optimal investment choices, the optimal strategy choice is given by

$$s(c) = \arg\max_{s\in\{0,1\}} \{ (1-s) \times [\Pi^0(c) - F_X] + s \times \Pi^1(p(c),c) \} \tag{4}$$

where F_X formalizes a net adjustment cost for changing strategy from an innovation strategy to a non-innovation strategy. This adjustment cost will capture some of the partial irreversibility we can observe in the data and explains why using initial strategy before the competitive shock will still matter for firm performance after the competitive shock.

2.2 Innovation and Strategy Responses to Competition

The key feature of the model that allows us to incorporate different types of innovation responses can be formalized when looking at the optimal innovation investment decision $p(c)$ and its response to changes in competition:

$$p'(c) = \frac{1}{\kappa}\left(\frac{d\Pi_1^1(c)}{dc} - \frac{d\Pi_0^1(c)}{dc}\right) = \frac{\xi(c)}{\kappa} \tag{5}$$

where we define $\xi(c) = \left(\frac{d\Pi_1^1(c)}{dc} - \frac{d\Pi_0^1(c)}{dc}\right)$ as the differential marginal impact of competition on profit for successful versus failed innovators. We will call $p'(c)$ the innovation incentive effect, as it captures how firms change their innovation effort and therefore the probability and number of successful innovations, in response to competition.

Case 1: Process innovation, which we formalize as increasing firm productivity so that $z_1 > z_0$. In this case, $\xi(c) = \left(\frac{d\Pi_1^1(c)}{dc} - \frac{d\Pi_0^1(c)}{dc}\right) < 0$, so that $p'(c) < 0$.

<u>Hypothesis 1A</u>: *Process innovations exhibit "Schumpeterian Effects", i.e. the number of successful process innovations falls in response to intensifying competition, as the innovation incentive effect is negative.*

Case 2: Product innovation, which we formalize as $\frac{d\Pi_1^1(c)}{dc} = 0$, so that product innovations completely shield successful innovators from competition. This shielding effect captures the idea that successful product innovations reduce product substitutability between innovators and competitors. This can also be thought of as increased distance in the product market space of a Hotelling model. As a result, $\xi(c) = \left(\frac{d\Pi_1^1(c)}{dc} - \frac{d\Pi_0^1(c)}{dc}\right) > 0$ and $p'(c) > 0$, so firms have stronger incentives to pursue product innovations in response to competition.

<u>Hypothesis 1B</u>: *Product innovations exhibit "Arrow Effects", i.e. the number of successful product innovations increases in response to intensifying competition, as the innovation incentive effect is positive.*

Given the distinction between product and process innovations, we can now discuss the implications of competitive shocks on initial strategy choice. Note that firms will choose to pursue an innovation strategy according to (4) if $\Pi^1(p(c), c) - \Pi^0(c) - F_x \geq 0$. In other words, the greater the difference between profits of an innovation strategy and the profits of being a non-innovator, the more likely it is that firms will choose an innovation strategy. The impact of a competitive shock on initial strategy choice can therefore be summarized by

$$\frac{d\Pi^1(p(c), c)}{dc} - \frac{d\Pi^0(c)}{dc} = \left(\frac{d\Pi_0^1(c)}{dc} - \frac{d\Pi^0(c)}{dc}\right) + \left(\Pi_1^1(c) - \Pi_0^1(c)\right) \cdot p'(c) \tag{6}$$

$$if$$

The first term $\left(\frac{d\Pi_0^1(c)}{dc} - \frac{d\Pi^0(c)}{dc}\right)$ is typically positive as failed innovators have lower productivity than non-innovators $z_0(\omega) < \bar{z}$. The sign of the second term depends on the sign of the innovation incentive effect $p'(c)$, which we assume differs for product and process innovations as discussed above. However, it should be noted that since the condition for actually optimally changing strategy also depends on the adjustment cost F_X, some firms might optimally decide not to change their strategy, even though (6) describes how firms are moved on average towards strategic change.

Hypothesis 2: *In response to competition, firms systematically adopt product innovation strategies, while there is no clear prediction on the adoption of process innovation strategies.*

2.3 Performance Impact of Competition

We start with firm exit. The difference in exit rates between innovators and non-innovators in response to a competition shock is given by

$$\frac{d\left(\delta^1(c) - \delta^0(c)\right)}{dc} = \left(1 - p(c)\right) \cdot \left(\delta_0^{1'}(c)\right) + p'(c) \cdot \left(\delta_1^1 - \delta_0^1(c)\right) \tag{7}$$

where δ^s is the exit rate, conditional on strategy $s \in \{0,1\}$, and $\delta_1^1 \geq 0$ is the exogenous exit rate for successful innovators, while $\delta_0^1(c)$ is the endogenous exit rate for failed innovators based on selection equation (1). The first term of (7) is positive, as the chance of failed innovation is positive and increased competition will increase exit rates of failed innovators, which is the competitive failure risk effect. As before, the overall impact of competition on exit rates for firms with different strategies depends on the balance of this competitive failure risk effect and the innovation incentive effect $p'(c)$[8], which differs across product and process innovations.

Hypothesis 3: *Exit rates of process innovators systematically increase in response to competition, compared to non-innovators, while exit rates of product innovators can have an ambiguous response to competition, compared to non-innovators.*

While the predicted response of exit to competition is clear for process innovation strategies and ambiguous for product innovation strategies, the reverse is true for the predictions of profits conditional on survival. These profit responses are given by

$$d \ln \Pi^1(c) - d \ln \Pi^0(c) = p'(c) \cdot \left(\ln \psi_1^1 - \ln \psi_0^1(c)\right) + \left(1 - p(c)\right) \cdot d \ln \psi_0^1(c) \tag{8a}$$

For process innovators, the first term is negative as the innovation incentive effect for process innovations is negative. This is partially countered by the second effect, which captures the competitive failure risk effect, which forces out the lowest-productivity firms so that productivity (and hence profits) conditional on survival is higher.

While the profit predictions for process innovators are ambiguous, they are unambiguous for product innovators:

$$\begin{aligned} & d \ln \Pi^1(c) - d \ln \Pi^0(c) \\ & \quad = p'(c) \cdot (\ln \psi_1^1 - \ln \psi_0^1(c) + \ln c) + \left(1 - p(c)\right) \cdot d \ln \psi_0^1(c) + p(c) \cdot \frac{1}{c} \end{aligned} \tag{8b}$$

In this case, $p'(c) > 0$, because the innovation incentive effect for product innovators is positive so that both the innovation incentive and competitive failure risk effect increase average profits.

Hypothesis 4: *In response to competition, average profits of surviving product innovators will increase compared to non-innovators, while average profits of surviving process innovators can increase or decrease compared to non-innovators.*

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[8] Note that exit rates for failed innovators are higher than for successful innovators: $\delta_1^1 - \delta_0^1(c) < 0$.

We summarize our theoretical predictions in figure 1.

[Figure 1]

3. Data and Methodology

3.1 Data overview

Our confidential firm-level data come from Canada's Workplace and Employment Survey (WES), a random stratified sample conducted by Statistics Canada with the universe of Canadian firms as the sampling frame.[9] The survey is stratified by industry, firm size, and region, and we use the population weights provided for all summary statistics and regressions. We use data from the 1999, 2001, 2003, and 2005 waves of the survey.[10] The data are a panel with re-sampling to replenish the sample after firm exit or attrition. We restrict our attention to manufacturing firms (NAICS industry codes with 3 as the first digit) since Chinese exports are heavily concentrated in manufacturing, with over 80% of exports in the manufacturing sector during our sample period; see Autor, Dorn, and Hanson (2016). This gives us a starting sample of 1,370 firms, of which about 900 survive until the end of the sample period depending on which outcomes we examine.

Note that although the number of firm-observations is moderate, the application of sampling weights makes our analysis representative for all manufacturing firms with at least one employee – in total more than 57,000 firms. Our consideration of the universe of firms is important, as many previous studies of innovation responses to competition focus on the largest public and private firms, which are typically less likely to exit in response to competition shocks.

A unique aspect of the WES data set is that it contains detailed measures of firms' initially intended strategies to deal with competition as well as firms' realized outcomes, such as innovation and performance. Table 1 presents summary statistics for our main variables, which we now describe in detail. Note that the sample contains a good mix of small, medium, and large firms.

Firms' business strategies are measured in Section G of the WES. Firms are asked to rate the importance of 15 different strategies on a five-point scale from "Not important'" to "Crucial,'" with strategies ranging from expansion to new markets, new products, quality management, and cost reductions. We focus on three sets of strategies. We are mainly interested in two types of innovation strategies, but we also consider low-cost strategies as controls.

Innovation strategies differ by whether they pursue product or process innovations. These strategies are measured as follows. First, the product innovation strategy corresponds to the two factors of "Undertaking research and development" and "Developing new products/services,'" while the process innovation strategy corresponds to "Undertaking research and development" and

[9] See \url{http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=2615} for the WES questionnaire.
[10] The survey was conducted every year from 1999 to 2006. Information about business strategies was asked every other year.

“Developing new production/operating techniques.” *Low-cost strategy* corresponds to two different items: “Reducing labor costs” and “Reducing other operating costs.”

An important measurement issue we face is that respondents are asked to assign a numerical value from 1 to 5 to the importance of factors like “improving quality” or “lowering cost,” with higher values reflecting higher strategic importance. These numerical values by themselves seem problematic, especially when comparing responses across respondents. Specifically, it seems that some respondents systematically rate all strategic factors higher on average, considering everything as important, while others rate all factors particularly low. These different reference points make a direct comparison of numerical Likert-scores across respondents – and therefore across firms – potentially problematic.

To deal with this issue, we construct a measure of the firm’s top strategic priorities. These are defined as indicator variables equal to one if the firm considers the strategy to be more important than, or at least as important as, any other strategy listed. We also require a strategy be considered at least “important” (a score of 3) to be considered a strategic priority. This strategic priority variable has the advantage that it extracts information on the relative priorities of the firm. Table 1, panel A, reveals that innovation strategies were rarely a top strategic priority in Canadian manufacturing in 1999.

Section G of the WES also contains several questions measuring perceptions of competition. Firms are asked “To what extent do these firms offer significant competition to your business?” and respond based on a similar five-point importance scale (with “don’t know” as an additional category), with separate items for locally-owned firms, Canadian-owned firms, US-owned firms, and other internationally-owned firms. This allows us to assess whether the increase in Chinese import competition we measure in the data is salient to Canadian firms, which is useful to empirically test hypothesis 2 (which says that firms can change their strategic priorities in response to anticipated competition). As revealed in table 1, panel B, among firms that survived from 1999–2005, the increase in perceived competition from “Other internationally-owned” firms is over three times as large as the increase in perceived competition by US-owned firms (1.6% vs. 0.5%).

Number of innovations. The WES also asks detailed questions about innovation outcomes which is the basis of our measure of successful innovation. Section H asks whether the firm introduced new or improved products during the previous year and whether it introduced new or improved processes. Based on the response, we construct distinct measures of the number of product- versus process innovations for each firm by taking the cumulative number of years the firm innovated over the period we examine (1999–2005). In constructing our innovation measures, we count “new” and “improved” in the same year as two separate innovations since doing so increases the correlation of our innovation measures with performance in Table 2.

[Table 1]

Note that the average firm in our data innovates quite frequently based on this variable. Table 1 reveals that for the average firm that survived the six-year period from 1999 to 2005, new or improved products were introduced on 4.4 out of 12 possible occasions while new or improved processes were introduced on 2.9 out of 12 possible occasions.. There are several reasons why the number of innovations is so high in our data. First, product and process innovation need not correspond to a patent or world-first innovation. The survey explicitly recognizes that an innovation could be a world-first but could also be a Canada first or a local market first, which may simply involve adoption of existing ideas and technologies. Second, firms often pursue product and process innovations together: on average firms report only 0.82 years with some product innovation (new or improved) but no process innovation and only 0.386 years with some process innovation but no product innovation. Although the mean innovation is high, the standard deviation is also high, consistent with a wide variance of innovation outcomes across firms.

The WES contains several variables that can be used to assess firm performance. Firms are asked to report their revenues, total employment, gross payroll, and operating profits (defined as revenues minus operating expenses) from the previous year. [11] We use and report these variables in log changes except for operating profits (due to negative values), for which we calculate the change, normalized by initial revenues. The average Canadian manufacturing firm that survives from 1999 to 2005 sees substantial growth of revenue, payroll, and profits over the period (from 15–25% total over a six-year period) but very low employment growth (under 4% over a six-year period).

It is worth emphasizing that special care was taken to ensure that our firm exit variable captures either bankruptcy or plant shutdown but not events such as non-response or M&A. In particular, the protocol that analysts at Statistics Canada followed in case of non-response was to first re-contact establishments and in case of persistent non-response to check in administrative tax data whether the firm had declared bankruptcy or the plant had shut down. Only in these circumstances is our variable recording an "exit."[12]

3.2 Validating innovation measures

Since our study relies on self-reported innovation outcomes that are not verified by outside observers such as patent officers, we first provide corroborating evidence that these potentially noisy measures affect firm performance. First, we offer additional evidence from a related innovation survey, in which respondents have been directly asked about the economic significance of the self-reported innovation outcomes. In particular, the Survey of Innovation and Business Strategy (SIBS), which is a repeated cross-section with data for 2009 and 2012, asked respondents who reported process or product innovations about the quantitative importance of these innovations for costs and sales. Firms reporting successful process innovations in the last 3 years claim that new or improved processes led to an average unit cost reduction of 7.3%. In contrast, firms reporting successful product innovations in the last 3 years claim that new or improved products account for an average of 5.2% of revenue.

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[11] We cross checked the reported revenue and cost data from the WES against balance sheet and cash flow data from the General Index of Financial Indicators (GIFI), which itself is based on corporate tax disclosures. Additionally, we cross checked WES revenue data for all manufacturing firms against reported revenues in the Annual Survey of Manufacturing (ASM).

[12] Appendix A provides additional supplemental information on strategic choices and innovation behavior across industries, documenting that all industries have a large degree of within-industry variation in strategic choices and innovation behavior.

Second, while the WES survey does not directly ask respondents about the economic significance of reported innovation outcomes, the panel nature of our data does allow us to validate our innovation outcomes using other observable outcomes. In particular, the data include information on operating revenue and operating costs, which we cross-checked with the corresponding revenue and cost reports of the same firms in administrative tax data. If our self-reported innovation measures are indeed related to real effects on revenues and costs, as claimed by companies responding to the SIBS, then we would expect them to be significantly correlated with reported revenues and costs that we know are consistent with administrative tax data.

[Table 2]

Table 2 reports our results of regressing revenue and operating cost growth on our measures of product and process innovations for the sample of continuing firms. As these regressions are based on changes in log revenue or costs within firms, these results are not driven by the fact that larger firms are more likely to innovate. We also include 4-digit NAICS industry controls so the results hold when comparing firms within an industry. Consistent with our expectations, we see a significant impact of product innovations on revenue growth. Product innovations also significantly increase operating cost growth, presumably because they lead to an increase in the number of offered products and therefore increased demand for inputs to produce these new products. Process innovations have a significantly negative impact on operating cost growth, as expected.[13]

3.3 Identification and empirical strategy

Our main objective is to estimate the causal effect of increases in Chinese import competition on innovation strategy, innovation outcomes, and performance for Canadian firms. We measure the strength of Chinese import competition using the share of Chinese imports over total imports within a 4-digit NAICS industry. Between 1999 and 2005, the average 4-digit NAICS manufacturing sector experienced a rise in Chinese import share from 2.9% to 7.9%, but for some industries the increase was much larger. Figure 2 plots the initial share of Chinese imports in 1999 for each of the 85 4-digit NAICS industries against the subsequent change, revealing a wide dispersion across industries that serves as our main source of identifying variation. For instance, China's contribution to Canadian imports in 1999 was particularly high in "apparel accessories" and "footwear," with shares of about 25%. Accordingly, in the six-year period from 1999 to 2005, in which China's exports increased dramatically, these shares increased by another 13–15%. On the other hand, industries like "dairy product manufacturing" or "printing" had low Chinese import shares in 1999 and experienced only modest increases over the subsequent six years.

[Figure 2]

Our estimation strategy is a difference-in-difference strategy: we use cross-industry differences in the change in Chinese import shares to identify the effects of competition on Canadian firms, while

[13] Ideally, we would have used unit costs, but these are not reported in the WES, which also lacks information on output quantities.

effectively controlling for firm fixed effects by differencing firm-level outcomes. That is, we estimate specifications like equation (1):

$$\Delta y_{i,k} = \alpha + \beta \cdot \Delta c_k + \epsilon_{i,k} \quad (9)$$

where $\Delta y_{i,k}$ is the change in the firm-level outcome of interest, and Δc_k is the change in Chinese import share in industry k. We would not expect the impact of Chinese competition on strategy, innovation and performance to be significant in the short run, and therefore we focus on long-run outcomes, similar to specifications of Bloom, Draca, and Van Reenen (2015)[14] and Autor, Dorn, Hanson, Pisano, and Shu (2019)[15]. Our main specification uses a long-differenced version of equation (9) where we take differences from 1999 to 2005 within each firm for the set of firms that survive throughout the period. For regressions where firm exit is the outcome of interest, we simply use a dummy variable equal to one for firms that exited by 2005 and zero otherwise.

One potential concern about estimating equation (9) by OLS is that the changes in Chinese import share that we observe are correlated with industry-level Canadian demand shocks or industry-level Canadian technology/supply-side shocks. For instance, Canadian demand for Chinese textiles relative to Canadian textiles might have increased in this six-year period, which could have led to an increase in China's import share in this industry and a change in Canadian firm performance. Alternatively, suppose better value-chain management by Canadian firms makes it less costly to off-shore production to China. This better technology makes textiles cheaper and hence increases sales for Canadian firms. At the same time, it also makes off-shoring to China more likely and thus increases import shipments of textiles from China to Canada.[16]

Our main solution for this problem is to use the initial Chinese share of imports in 1999 as an instrument for future Chinese import growth at the industry level, following Bloom, Draca, and Van Reenen (2015). The idea behind the IV strategy is that WTO accession and productivity growth in China were plausibly exogenous and unrelated to unobserved domestic Canadian industry-level shocks. At the same time, comparative advantage arguments suggest that a reduction in overall trade barriers towards China should increase Chinese export growth the most in sectors with the highest comparative advantage. This initial comparative advantage in turn can be measured by initial industry exports from China to Canada, see Balassa and Noland (1965) and Bloom, Draca, and Van Reenen (2015). Consequently, initial 1999 Chinese exports to Canada should be a valid instrument to predict sectoral growth of Chinese exports to Canada during this period, while at the same time being unrelated to domestic demand or supply shocks that simultaneously drive changes in Chinese imports and Canadian firm performance. Figure 2, which plots the growth of Chinese import shares against the initial Chinese import share for each NAICS 4-digit industry, shows that this correlation is high, and we generally find F-statistics above 10 in the first stage of our instrumental variable regressions. In Appendix B we show that results are similar if we use Chinese import shares for countries other than Canada as an instrument – this

[14] Specifically, we use the Bartik instrument which Bloom, Draca and Van Reenen introduce in section 5.2 of their paper.

[16] We explicitly analyze potential offshoring effects in section 5.2 below.

alternative indicator of Chinese comparative advantage does not use Canadian trade patterns at all in the spirit of Autor, Dorn and Hanson (2013).

Our baseline specification (9) allows us to characterize average changes in the outcomes we analyze. To capture moments conditional on strategy, we use the following interaction regression:

$$\Delta y_{i,k} = \alpha + \beta \cdot \Delta c_k + \gamma \cdot \Delta c_k \times s_i + controls_{i,k} + \epsilon_{i,k} \tag{10}$$

where s_i is an indicator for an initial strategy in 1999, such as product innovation strategy or process innovation strategy. With the dependent variable being either exit $y = \delta$ or profits $y = \ln \Pi$, the interaction coefficient identifies the performance response to Chinese competition, contrasting firms with an innovation strategy to non-innovators within the same 4-digit industry.

For $controls_{i,k}$, we include the uninteracted initial strategy variables to estimate the direct impact of strategic choice on the outcomes and focus on the interaction between strategy and competition. We also include low-cost strategies and initial size (domestic revenues) as additional controls, on their own and interacted with the trade shocks, to be able to fully account for the effects of these factors on performance. Firm size is a central determinant of innovation and exit responses to competition across a range of heterogeneous firm models; while firm size is correlated with strategic choice, we try to isolate the independent effect of strategic choice in these specifications. Alternatively, we also use initial firm TFP and initial firm TFP interacted with Chinese competition as controls for firm productivity effects.[17]

At this point, it is instructive to consider other potential identification issues in equation (10). Specifically, following the potential outcomes framework of Rubin (1974), let $\frac{\Delta y_i^s}{\Delta c_k}$ denote the possible responses to Chinese competition for firm i with initial strategy $s \in \{0,1\}$. Note that in this general notation responses $\frac{\Delta y_i^s}{\Delta c_k}$ are allowed to be heterogeneous across firms i. Then, the estimated treatment effect in (10) can be decomposed in the following way

$$\begin{aligned} & E\left[\frac{\Delta y_i^1}{\Delta c_k}\middle| s_i = 1\right] - E\left[\frac{\Delta y_i^0}{\Delta c_k}\middle| s_i = 0\right] \\ &= \underbrace{E\left[\frac{\Delta y_i^1}{\Delta c_k}\middle| s_i = 1\right] - E\left[\frac{\Delta y_i^0}{\Delta c_k}\middle| s_i = 1\right]}_{\text{Strategy Treatment Effect}} + \underbrace{E\left[\frac{\Delta y_i^0}{\Delta c_k}\middle| s_i = 1\right] - E\left[\frac{\Delta y_i^0}{\Delta c_k}\middle| s_i = 0\right]}_{\text{Strategy Selection Effect}} \end{aligned} \tag{11}$$

In other words, the difference in responses of firms with innovation strategies compared to the control group of non-innovators, can be decomposed into an average strategy treatment effect and

[17] Following Levinsohn and Petrin (2003) and Ackerberg, Caves and Frazier (2015), these TFP estimators identify output elasticities of inputs by assuming that variable cost inputs contemporaneously respond to unobserved firm-level productivity shocks, while dynamic inputs such as capital stock exhibit no current impact of unobserved firm-level productivity shocks. We use intermediate inputs, such as electricity and materials as variable cost inputs in our production function estimation and then calculate TFP as residual from the difference of revenue and output-elasticity-weighted inputs.

an effect from endogenous selection into innovation strategy. The strategy selection effect potentially complicates identification, as firms selecting into innovation strategies initially before China's WTO entry, might be systematically different from non-innovators in terms of both their unconditional performance outcomes and the implications of competition shocks for their performance outcomes, rendering the strategy selection effect non-zero. We cannot completely rule out potential selection effects without explicit randomization or quasi-randomization of strategic choices, see Hamilton and Nickerson (2003). It is therefore useful to explicitly state how selection concerns will affect our analysis and the interpretation of our results in the light of (11).

The first type of selection effect – initial strategy selection based on heterogeneous benefit – is that firms which anticipate future competitive shocks systematically select into innovation strategies. To ensure that this selection concern is mitigated, we take two additional steps. First, we focus on initial strategy choices in 1999, at least two full years before China's official entry into the WTO at the end of 2001. During 1999, uncertainty about China's entry into the WTO was high, due to difficulties during negotiations as well as the accidental bombing of the Chinese embassy in Belgrade on May 7, 1999 by the US[18]. Second, we utilize data on perceptions of international competition to ensure that the initial strategy choices are not systematically correlated with competitive perceptions.

However, even if firms were able to perfectly forecast Chinese competition, the potentially resulting biases in (11) can be signed in an informative way. Specifically, our theory suggests that the firms that select into these innovation strategies are likely to either benefit the most from innovation strategies or to be insulated the most from Chinese competition. As a result, firms that self-selected in 1999 into innovation strategies should be less likely to exit and more likely to generate high profits after China's WTO entry. Econometrically this translates into a positive strategy selection effect for profit regressions, $\mathrm{E}\left[\frac{\Delta \mathrm{y}_\mathrm{i}^0}{\Delta c_k}\middle|\mathrm{s}_\mathrm{i}=1\right]-\mathrm{E}\left[\frac{\Delta \mathrm{y}_\mathrm{i}^0}{\Delta c_k}\middle|\mathrm{s}_\mathrm{i}=0\right]>0$ and a negative strategy selection effect for exit regressions, $\mathrm{E}\left[\frac{\Delta \mathrm{y}_\mathrm{i}^0}{\Delta c_k}\middle|\mathrm{s}_\mathrm{i}=1\right]-\mathrm{E}\left[\frac{\Delta \mathrm{y}_\mathrm{i}^0}{\Delta c_k}\middle|\mathrm{s}_\mathrm{i}=0\right]<0$, as firms with higher profits are less likely to exit. As we will discuss in the context of our results, the direction of these biases cannot explain the combination of our performance results which makes it unlikely that our performance results are completely driven by this type of strategy selection effects.

The second type of selection effect – initial strategy selection based on firm-level characteristics that independently affect a firm's performance response to unanticipated competition shocks – is more general and harder to rule out directly. There are many plausible dimensions of firm heterogeneity that might affect a firm's optimal strategy choice and its response to competition shocks such as firm size, productivity, differences in innovation capabilities (Acemoglu, Akcigit, Alp, Bloom, and Kerr ,2018), and differences in organizational practices (Yang, Kueng and Hong, 2015). In our analysis we control for the most obvious characteristics such as firm size, productivity, and other strategy choices that could affect performance directly or could affect the performance response to competition shocks.

[18] See: https://en.wikipedia.org/wiki/United_States_bombing_of_the_Chinese_embassy_in_Belgrade

The impacts of selection on unobserved firm characteristics can again be signed for the most plausible cases. If firms selecting into innovation strategies are more likely to have capabilities that allow profits to be shielded from Chinese competition, we again have $\mathrm{E}\left[\frac{\Delta y_i^0}{\Delta c_k}\middle|\mathrm{s_i}=1\right]-\mathrm{E}\left[\frac{\Delta y_i^0}{\Delta c_k}\middle|\mathrm{s_i}=0\right]>0$ for profit regressions and $\mathrm{E}\left[\frac{\Delta y_i^0}{\Delta c_k}\middle|\mathrm{s_i}=1\right]-\mathrm{E}\left[\frac{\Delta y_i^0}{\Delta c_k}\middle|\mathrm{s_i}=0\right]<0$ for exit regressions. On the other hand, if firms selecting into innovation strategies are less likely to be shielded from Chinese competition, one would expect the opposite predictions, i.e. a stronger fall in profits, accompanied with a stronger rise in exit of innovators compared to non-innovators. Again, we will see that this combination of biases is unlikely to fully explain our results.

4. Results

4.1 Nature of the Chinese Competition Shock

We begin our analysis with perceptions of competition by Canadian firms. This analysis addresses the fact that many countries were simultaneously affected by Chinese competition, which potentially poses an identification problem. For a small open economy like Canada, it is possible that the main competitive effects of China's WTO entry were not related to direct competitors from China, but were instead the consequence of an indirect effect through US competition. From this perspective, Chinese competition might affect US firms, which in turn compete more intensively with Canadian firms. Additionally, other countries such as Mexico might see a surge in export competition to Canada at the same time as China, so that our analysis might potentially conflate these trade competition effects.

[Table 3]

To address both concerns, we utilize the unique perception data on competitors by location in the WES data. We measure changes in the perception of foreign (non-US) competition by taking the perceived importance of competition from "Other internationally-owned" firms and subtracting the mean importance of competition from all four sources (local, Canadian, US, non-US foreign), which normalizes our measure to capture changes in the *relative* importance of competition from this source within a firm.

As table 3 shows, Chinese exports had a strong impact on perceived competition by Canadian manufacturing firms that remained in the sample from 1999 to 2005. At the same time, no significant effect can be shown at any level of confidence for perceived US competition, confirming that our results reflect direct effects from Chinese competitors. Additionally, columns 5 and 6 in table 3 include import competition from either Mexico (the country with the largest increase in exports to Canada other than China) or the top-4 Southern hemisphere countries (Mexico plus Brazil, Chile, Peru) and top-4 Northern hemisphere countries (South Korea, Germany, Italy, Ireland) with the largest increase in exports to Canada. These columns show that neither of these international competitors affected the perception of "Other internationally-owned" competition for Canadian firms significantly, which is not surprising given that 56% of the increase in Canadian manufacturing imports between 1999-2005 was due to China. Changes in perceived international competition by Canadian firms is mostly driven by intensifying Chinese competition.

Even as the Chinese competition shock was clearly perceived by Canadian firms, a natural question is whether this increase in competition was substantial enough to merit a response. In the last columns of table 3, we find a large effect of Chinese competition on firm exit. The coefficient implies that the 5-percentage-point increase in industry-level Chinese import share between 1999 and 2005 for the average firm led to the exit of 4.2% of the firms sampled in 1999 over that period, which relative to the 17% overall exit rate of these firms means that exit increased by around 25%. This large effect of Chinese competition on firm exit is consistent with empirical work on the large employment impact of Chinese competition in Canada. For example, Murray (2017) finds that Chinese competition explains around 20% of the manufacturing job losses in Canada from 2001-2011.

On the profit side, IV specifications are consistent with negative effects of rising import competition on the profits of surviving firms, even as the standard errors are too large to reject a zero effect. This is likely due to selection effects: survivors are likely to be the best-performing firms, which would lead to an upward bias that could partially offset the negative effect of increased Chinese import competition. It is important to keep these selection effects in mind as we further analyze the performance consequences of increased Chinese competition.

4.2 Average Effects of Chinese Competition on Innovation and Strategy

4.2.1 Arrow vs Schumpeterian Innovation Incentive Effects

To explore hypothesis 1, we analyze whether the number of product and process innovations was affected by Chinese competition.

[Table 4]

Table 4 shows the impact of Chinese competition on product and process innovation. Our IV results for process innovation are consistent with Schumpeterian effects stated in hypothesis 1A, in that they show a strongly negative response of process innovation. The average surviving firm had a total of 4 process innovation observations (the sum of the number of years with a new process and number of years with an improved process) out of a potential 12 in the 6 years between 1999 and 2005, but the average effect of Chinese import competition lowers this by about 0.6.

The results are at first seemingly inconsistent with hypothesis 1B, which predicted that product innovations increase in response to Chinese competition. However, one possible explanation is that in the data, a large fraction of product innovations require process innovations, as evidenced by the fact that 64% of firms in the SIBS survey report that a process innovation was required for their reported product innovation. To investigate this possibility, we construct exclusive measures of the number of process and product innovations, which only count innovations for years in which either only a process or only a product innovation is reported. Columns 3 and 4 of table 4 confirm that for these exclusive innovation measures, product innovations exhibit a significant positive innovation incentive effect, as predicted by hypothesis 1B.

The product innovation results also address a potential concern with our identification strategy. This approach relies on the use of initial industry exposure to Chinese competition in 1999. But if initially less innovative industries continue to further decline, a systematic reduction in innovation might be driven not by Chinese competition but by unobserved industry innovativeness. However, the exclusive product innovation results in table 4 show that product innovation was in fact stimulated by Chinese competition, which is inconsistent with the view that these industries with intensifying Chinese competition were inherently less innovative.[19]

4.2.2 Innovation Strategy Response to Competition

The last two columns of table 4 test hypothesis 2 on the strategic response of firms to intensifying competition. Consistent with our theory, we separate innovation strategies in process innovation strategies and product innovation strategies. Our baseline specification focuses on continuing firms from 1999 to 2005 in the WES. Consistent with hypothesis 2, we find that firms systematically shift towards product innovation strategies, a result significant at the 10% level. In contrast, the strategic response of process innovation strategies to Chinese competition is more ambiguous.

Along with our findings on the innovation incentive effects in table 3, this difference in strategic responses to competition can be understood through the lens of our theory. As our derivations around hypothesis 2 in section 2.2 showed, product innovation strategies become more attractive in the wake of intensifying competition, since increased innovation incentives make successful innovations more likely. Consistent with this theory, we find both positive innovation incentive effects and systematic shifts towards product innovation strategies. On the other hand, hypothesis 2 also predicted that the effect of competition on the adoption of process innovation strategies can be ambiguous. The theory predicted that the innovation incentive effect for process innovations is negative, as shown in table 3, and that this negative effect is partially countered by the fact that intensifying competition has a more negative profit impact on non-innovators as compared to failed innovators.

4.3 Performance Effects of Chinese Competition

4.3.1 Initial strategy and selection concerns

As described in section 3.3, identifying innovator performance moments in response to a competition shock requires that initial strategy choices be predetermined. Our main concern is that the firms that benefitted the most from an innovation strategy in response to growing import competition from China were able to forecast this (e.g. anticipating Chinese productivity growth and WTO entry) already in 1999. The consequence would be self-selection into optimal strategic response, which would lead to a downward bias in the exit coefficient and an upward bias in the profit coefficient relative to a true “shock.”

[19] We also explicitly control for initial industry differences in innovativeness and firm productivity in appendix C.

To investigate the plausibility of this strategy selection effect, we again utilize the competition perception data we previously used in section 4.1.1. Data on perceptions of competition by ownership of competing firms highlights the salience of Chinese import competition for Canadian firm executives, while not being systematically related to other foreign competitors. Another key advantage of this data is that it is available at the firm level. If firms that successfully anticipated the growth of Chinese competition did systematically select into innovation strategies, we should see a strong correlation of perceived non-US international competition and strategy choices. Appendix D shows that there is no significant relationship between innovation strategies and initial perceptions of non-US international competition in 1999. Furthermore, we show that neither changes in perceived non-US international competition between 1999 and 2005 nor future perceptions of non-US international competition (in 2005) are significantly correlated with initial strategy choices in 1999. These results are inconsistent with the innovation strategy choices of firms in 1999 being driven by current or forecasted Chinese competition.

4.2.2 Exit

The first column of table 5 follows hypothesis 3 and estimates the effect of Chinese competition on exit as a function of different initial innovation strategies. The results are consistent with our theoretical discussion in section 2.3, which predicted that exit rates of process innovators should clearly increase, while predictions on exit rates of product innovators were ambiguous. As we discussed in that context, the overall exit effect due to a competition shock can be understood to consist of the sum of two separate effects. First, the innovation incentive effect, which is negative for process innovators and positive for product innovators. Second, "competitive failure risk", which captures possibly significant additional costs of failed innovations, such as delayed implementation on other projects as well as shutdown costs of projects, and is negative for both types of innovators. In the context of comparing the performance of innovators to non-innovators (the control group), competitive failure risk lowers the profit of failed innovators and generates a selection effect: exit of failed innovators will be higher than exit of non-innovators.

Since process innovations will exhibit a negative innovation incentive effect, the implied lower number of successful innovations will tend to reduce average profits and increase exit rates. Combining innovation incentive effect and competitive failure risk can explain the systematically higher exit rates of process innovators as documented in table 5. In contrast, since product innovations will exhibit a positive innovation incentive effect, the higher number of successful innovations will tend to raise average profits while reducing exit rates. Combining this positive innovation incentive effect with the negative competitive failure risk effect implies that the effect of a competition shock on exit rates is ambiguous, consistent with column 1 of table 5.

The theory is particularly helpful in understanding these results and the role played by competitive failure risk. Our theory suggests that without competitive failure risk, exit rates of product-innovators relative to non-innovators should systematically decline in response to competition, due to the positive innovation incentive effect. The degree to which exit rates of product innovators do not decline relative to non-innovators is therefore indicative of competitive failure risk, even for product innovators.

It should also be noted that the exit effects of initial strategies – and performance effects of initial strategies in general – are supportive of the view that strategic choices are at least partially irreversible, as indicated by the presence of a strategy adjustment cost in equation (4). Indeed, if strategic adjustment were completely costless, one would expect initial process innovators to exhibit the same exit rates as non-innovators.

Column (1) of table 5 uses domestic revenue as a measure of initial firm productivity, as well as the interaction of Chinese competition with domestic revenue. These controls ensure that our results are not biased by the fact that firms with innovation strategies tend to be larger and are therefore less likely to exit in response to Chinese competition. Column (3) uses TFP as an alternative measure (estimated using a timing-based GMM estimator following Ackerberg, Caves and Frazier (2015)) as a direct control and interacted with Chinese competition, yielding similar results.

4.2.3 Profits, conditional on survival

With respect to the effect of a competition shock on profits for firms with different innovation strategies, hypothesis 4 predicts that profits should increase for surviving product innovators, while the impact of competition on profits for surviving process innovators can be ambiguous. Table 5 shows that these predictions hold in the data.

Again, our theory is helpful in understanding these profit results. Let us start with process innovation strategies and the impact of competition on profits for surviving firms. The theoretical prediction in hypothesis 4 is ambiguous, since the innovation incentive effect is negative, which will then reduce the probability of successful process innovations, reducing average profits. But at the same time, the competitive failure risk effect will tend to increase observed average profits, conditional on survival, as the most unprofitable firms – often failed innovators – will tend to exit. Our empirical finding of higher average profits for surviving firms with initial process innovation strategy therefore tells us that competitive failure risk forces dominate the innovation incentive effects for process innovation strategies.

The opposite logic applies with respect to product innovation strategies, following hypothesis 4. On the one hand, product innovators exhibit a positive innovation incentive effect, as they innovate to try to shield themselves against competition, which will tend to increase average profits. At the same time, the competitive failure risk effect will also tend to increase average profits, as unprofitable and failed firms will exit, thereby leading to a clear prediction of higher profits in response to competition for product innovators.

At this point it is also useful to return to our discussion of potential strategy selection effects mentioned in section 3.3 and 4.3.1. Recall that our concern is that firms either choose an innovation strategy in anticipation of greater benefits in the face of future Chinese competition or that more capable firms select into innovation strategies. This should tend to bias coefficients for interactions of strategy and Chinese competition down for exit and up for profit as shown in equation (11) of section 3.3. But these biases are not able to fully explain the results in table 5. For example, if this bias is at work, then the unbiased exit effect of Chinese competition for process innovators is likely even more positive as exit in response to Chinese competition is more likely for firms that are not self-selected in terms of their strategic choice. In other words, if we could take out the firms that selected into process innovation strategies because they anticipated not facing much bankruptcy risk, then the exit rates of the remaining firms must be even higher. Similarly, if more capable firms selected into process innovation, then exit effects of remaining firms must be higher than the ones we measure. But this would imply that the underlying competitive failure effects are even stronger than indicated by our results. A similar argument can be made for product innovators. We therefore conclude that even if we cannot provide randomization of strategy choices, the biases from strategy self-selection are likely to work against us finding significant competitive failure risk effects.

We also note that in all specifications we control for low-cost strategies as well as the interaction of Chinese competition with low-cost strategies. This is important as process innovations are sometimes argued to mainly reflect cost-saving innovations. Our results highlight that process innovation strategies have their own distinct effects from other cost cutting measures that do not require R&D. Additionally, note that the profit regressions in columns (2) and (4) use initial TFP as well as the interaction of initial TFP with instrumented Chinese competition, to rule out that productivity differences across firms might drive our results.

5. Robustness

This section provides additional evidence to more closely connect our analysis to the literature in at least two respects. First, a number of studies, such as Bena and Simintzi (2015) and Branstetter, Chen, Glennon, Yang, and Zolas (2017), have used China's entry into the WTO as an outsourcing shock, rather than as a direct competitive shock. The outsourcing channel has potentially different implications for firm performance and welfare, which is why separating product market competition from outsourcing effects is important.

Second, although the differences in process vs product innovations can potentially explain the difference in findings between Autor, Dorn, Hanson, Pisano, and Shu (2016), Bena and Simintzi (2015), Gong and Xu (2017), and Li and Zhou (2017) for the US on the one hand and Bloom, Draca, and Van Reenen (2015) for Europe on the other hand, another difference between the US and Europe might be the initial extent of product market competition. The question here is whether initial domestic competition could help us understand how and why the North American responses differ from the European responses to Chinese competition. Our discussion follows each of these issues in this sequence.

5.1 Outsourcing and processing trade

In this section, we analyze whether outsourcing effects are an alternative mechanism that can explain the negative process innovation effects in response to Chinese trade. Outsourcing would have different implications in terms of firm profits and welfare. If firms optimally outsource activities to China, then the fall in process innovation would not capture horizontal competitive effects, but would instead reflect the fact that outsourcing is a substitute for process innovations. The implications for firm profits under the outsourcing mechanism would be very different, as outsourcing firms would just replace cost-saving process innovation with cost-saving outsourcing practices. Hence, firm profits might still increase, even under intensive use of outsourcing.

To analyze whether our results are indeed driven by outsourcing, we utilize aggregate trade data on processing trade. If outsourcing is indeed a major factor for manufacturing, then one would expect this to be related to trade of intermediates, or processing trade. However, our analysis in appendix E shows that the share of processing trade in China's exports to Canada has been systematically falling since China's entry into the WTO. These aggregate trends already foreshadow some of our empirical analysis.

[Table 6]

The first column of table 6 shows that controlling for processing trade share does not substantially affect the negative impact of Chinese competition on process innovation.

5.2 Initial competition and product differentiation

The basic idea of this section follows the insight of Aghion, Bloom, Blundell, Griffith, and Howitt (2005) that the impact of competition on innovation might follow an inverted U relationship. If the initial level of competition in Europe was relatively low, then one would expect increased Chinese competition to lead to increased innovation. In contrast, the initial level of competition in the US and Canada might be considered relatively high, so that a further competitive shock from China leads to a negative effect on innovation.

A full cross-country investigation of this hypothesis is beyond the scope of this paper. However, we can analyze the implications of the inverted U hypothesis within Canada. Specifically, if correct, the inverted U hypothesis would predict that firms or sectors with more intense initial competition should exhibit significantly more negative effects of Chinese competition on innovation. We investigate this hypothesis using measures of product differentiation, based on elasticities of substitution from Broda and Weinstein (2006). We interpret low differentiation (high elasticity) as related to more intense initial competition, along the lines of Syverson (2004).

[Table 7]

Table 7 documents the results of sample splits according to product differentiation for the performance effects of Chinese competition, conditional on initial strategy. The table shows that our baseline results of the effects of Chinese competition on innovation strategy firms are driven by sectors with high product homogeneity.

6. Conclusion

To our knowledge this is the first representative multi-industry study that finds evidence for the effects of innovation strategy. The limitations of this study provide several promising avenues for further research. First, we did not offer any direct evidence for the factors that determine adjustment costs of specific innovation strategies. Different types of innovation strategies might involve different types of adjustment costs, e.g. horizontal product differentiation could involve different adjustment costs from vertical quality differentiation. More detailed direct evidence on the nature of such adjustment costs would further our understanding of the degree of strategic commitment for different types of innovation strategies.

Second, our performance results indicate that superior performance of innovators in response to competitive shocks can be interpreted as compensation for increased competitive failure risk. It is worth re-emphasizing that the underlying shock – in the form of a competition shock – is common to all firms in an industry, but that firms can differ in terms of their exposure to this common or systematic risk. This mechanism is reminiscent of basic theories of finance, such as CAPM, where common or systematic risk in the stock market is the basis of risk compensation and individual firms can have different risk exposures, or different "betas". Our results suggest that the "beta" for "competitive failure risk" is significantly higher for firms with innovation strategies. Our study therefore provides a natural link between innovation economics and finance.

Third, our results provide suggestive evidence on why the innovation responses to Chinese competition found in Autor, Dorn, Hanson, Pisno and Shu (2019) for the US might differ from the results in Bloom, Draca and Van Reenen (2015) for Europe. In particular, our analysis provides two potential explanations. On the one hand, the US might be considered initially more competitive than Europe, so that the additional increased Chinese competition lead to more innovation in Europe while it depressed innovation in the US, consistent with the evidence we provided in section 5.2. On the other hand, large and old US firms analyzed by Autor, Dorn, Hanson, Pisno and Shu (2019) might primarily pursue process innovation strategies, consistent with the findings in Cohen and Klepper (1996), while the mostly medium-sized and younger European firms analyzed by Bloom, Draca and Van Reenen (2015) might primarily pursue product innovation strategies. In this case, our theory and our empirical evidence on the differential innovation responses of product and process innovators suggests that product innovators have a more positive innovation incentive effect than process innovators. While highly suggestive, we leave the analysis of this hypothesis for the differing findings between Bloom, Draca and Van Reenen (2015) and Autor, Dorn, Hanson, Pisano and Shu (2019) for future research.

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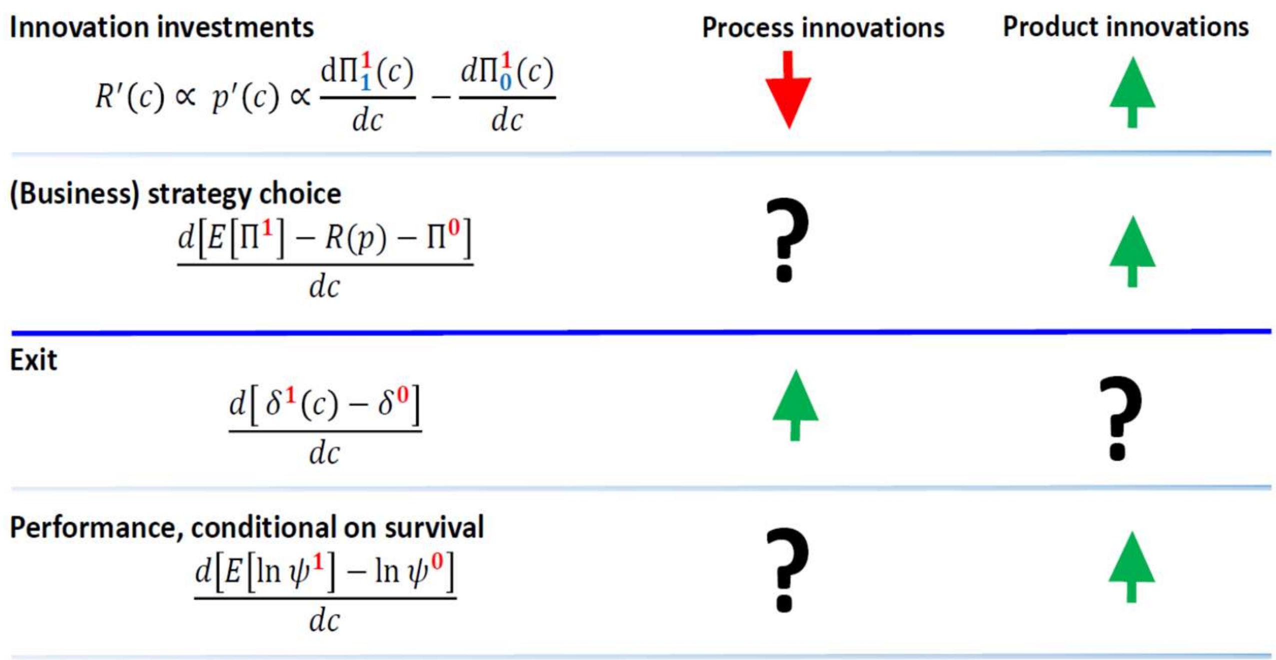

Figure 1: Theoretical predictions of risky innovation model with endogenous exit. The superscript $s = 1$ denotes firms with an initial innovation strategy, while firms with an $s = 0$ superscript denote non-innovators. The first two rows capture unconditional moment predictions, while the last two columns capture performance predictions conditional on strategy choice.

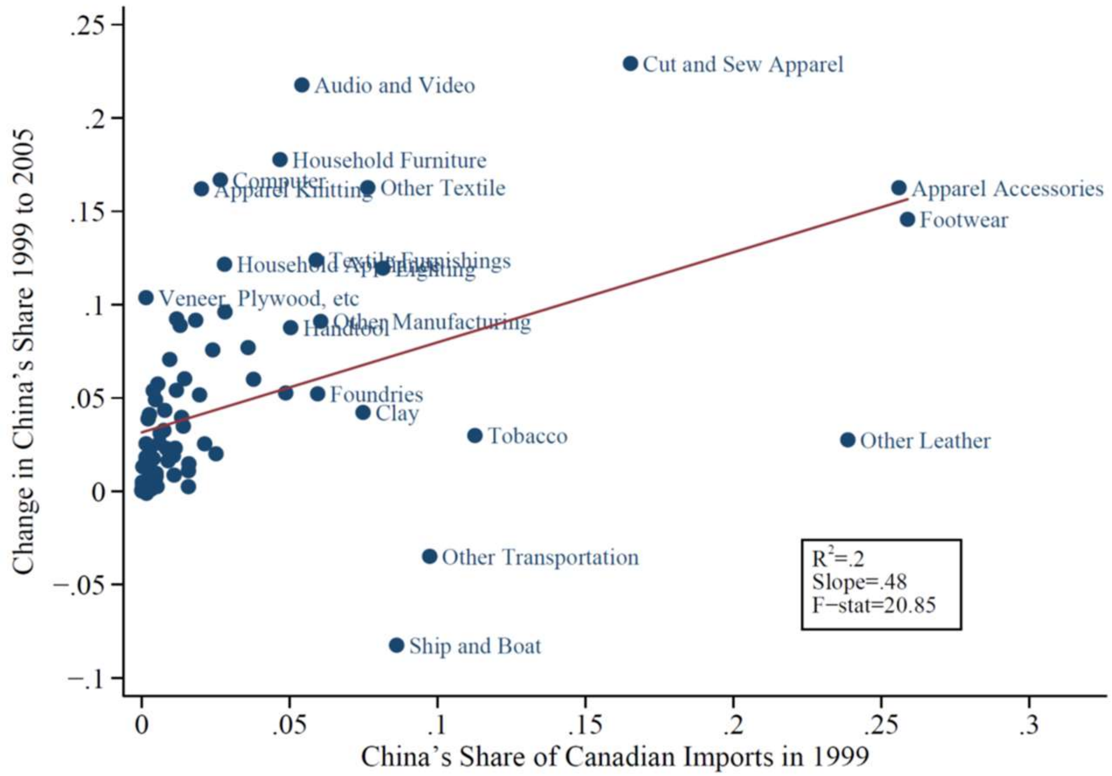

Figure 2: Graphical validation of first stage of IV estimation based on revealed comparative advantage, following section 5.2 in Bloom, Draca and Van Reenen (2015). Each point in the figure is a different four digit industry.

Table 1: Summary Statistics

Panel A: Initial levels in 1999	N	Population-weighted Mean	Population-weighted S.D.
Process innovation strategy top priority	1370	0.117	0.321
Product innovation strategy top priotity	1370	0.152	0.359
Low-cost strategy top priority	1370	0.181	0.385
Exit by 2005	1370	0.169	0.375
Chinese share of Canadian imports	1359	0.029	0.047

Panel B: Changes from 1999-2005	N	Population-weighted Mean	Population-weighted S.D.
Perceived non-US foreign competition	868	0.016	1.573
Perceived US competition	868	0.005	1.363
Cumulative number of years with product innovations	913	4.436	3.263
Cumulative number of years with process innovations	913	3.917	3.287
Cumulative number of years with product innovations only	908	0.823	1.053
Cumulative number of years with process innovations only	908	0.386	0.727
% change in revenue	864	0.256	0.704
% change in employment	868	0.036	0.578
% change in gross payroll	868	0.275	0.654
Change in gross profits/1999 revenue	864	0.142	1.039
Chinese share of Canadian imports	1222	0.050	0.063

Table 2: Validating self-reported innovation measures

Dependent variable	Revenue growth	Operating cost growth
	(1)	(2)
Number of Product Innovations	0.022	0.045
	(0.011)	(0.012)
Number of Process Innovations	0.001	-0.031
	(0.011)	(0.012)
Population sampling weights	YES	YES
4-digit NAICS dummies	YES	YES
Observations	871	875
R-squared	0.160	0.165

Notes: Dependent variable in column (1) is operating revenue growth; column (2) uses operating cost growth. Independent variables are the count of years (between 1999 and 2005) with product or process innovations (summing new and improved). Standard errors are clustered by 4 digit NAICS.

Table 3: Average responses of Canadian firms to Chinese competition

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	Change in Chinese competition		Change in perceived non-US competition	Change in perceived US competition	Change in perceived non-US competition	Change in perceived non-US competition	Future Exit	Change in profits
	IV First Stage	IV First Stage	IV	IV	IV	IV	IV	IV
Change in Chinese competition			6.110	1.884	4.694	5.459	0.842	-0.725
			(2.195)	(1.416)	(1.604)	(1.998)	(0.354)	(0.713)
Initial Chinese import share X aggregate change in Chinese imports to CAN	1.169	1.204						
	(0.358)	(0.204)						
Change in Mexican competition					0.819			
					(5.397)			
Change in competition of non-Chinese, emerging economies						5.303		
						(3.350)		
Change in competition of top developed economies						-2.915		
						(2.916)		
Population sampling weights	YES	YES	YES	YES	YES	YES	YES	YES
Observations	863	1,354	863	863	863	863	1,354	859
R-squared	0.409	0.554	0.0261	0.00156	0.035	0.041	0.00579	0.000410

Notes: Column (1) displays IV first stage for firms that survive until 2005, while column (2) is the IV first stage for all initial firms in 1999. Column (3) shows impact of Chinese competition on perceived non-US international competition, while column (4) shows the impact on US international competition. Column (5) controls for Mexican competition in both the first and second stages of the IV, wile column (6) controls for international competition from from 4 Southern and Northern countries, excluding China, in both the first and second stages of the IV. Change in Chinese competition measures change in Chinese import penetration in Canada, defined as the market share of Chinese imports in total Canadian imports by 4 digit NAICS sector. Future exit measures either firm bankruptcy or plant shutdown in the years after 1999 but neither survey attrition nor M&A activity. Profits are defined as operating revenue minus operating cost relative to initial profits. Perceived competition measures as 1-5 Likert scales of the perceived intensity of competition. All regressions use population sampling weights, which make estimates representative of approximately 57,000 Canadian manufacturing firms. Robust standard errors in parentheses are clustered by 4-digit NAICS industry.

Table 4: Average innovation and strategy responses of Canadian firms to Chinese competition

	(1)	(2)	(3)	(4)	(5)	(6)
	Number of Process Innov.	Number of Product Innov.	Number of exclusive Process Innov.	Number of exclusive Product Innov.	Change in Strategy: Process innovation	Change in Strategy: Product innovation
Dependent variable	IV	IV	IV	IV	IV	IV
Change in Chinese competition	-12.012	-1.748	-1.171	4.447	0.270	0.442
	(3.799)	(4.288)	(0.737)	(1.427)	(0.353)	(0.252)
Population sampling weights	YES	YES	YES	YES	YES	YES
Observations	908	908	908	908	863	863
R-squared	0.0311	0.00551	0.000	-0.009	0.004	0.007

Notes: Change in Chinese competition measures change in Chinese import penetration in Canada, defined as the market share of Chinese imports in total Canadian imports by 4 digit NAICS sector. Number of innovations are counts of the number of years that firms reported either process or product innovations (summing across "new" and "improved"). Exclusive number of innovations is the number of years in which there were product or process innovations (new or improved) but excluding years in which both types of innovations occurred. Process or product innovation strategy is measured as relative priority of product or process innovation for business strategy in survey responses. All regressions use population sampling weights, which make estimates representative of approximately 57,000 Canadian manufacturing firms. Robust standard errors in parentheses are clustered by 4-digit NAICS industry.

Table 5: Heterogeneous performance impact of Chinese competition for innovation strategies

	(1)	(2)	(3)	(4)
Dependent Variable:	Future exit	Change in Profits	Future exit	Change in Profits
	IV	IV	IV	IV
Change in Chinese competition	5.04	-3.200	9.165	1.237
	(2.212)	(4.750)	(10.536)	(30.960)
Change in Chinese competition x(Process Innovation Strategy)	1.675	3.078	1.857	3.473
	(0.628)	(1.265)	(0.804)	(1.396)
Change in Chinese competition x(Product Innovation Strategy)	-0.176	3.079	0.087	3.34
	(0.476)	(1.100)	(0.490)	(1.282)
Population sampling weights	YES	YES	YES	YES
Controls for: initial size and interaction of initial size with Chinese competition	YES	YES	NO	NO
Controls for: initial TFP and interaction of initial TFP with Chinese competition	NO	NO	YES	YES
Additional controls	see table notes		see table notes	
Observations	1,320	840	1,125	714
R-squared	0.024	0.009	0.027	0.011

Notes: Change in Chinese competition measures change in Chinese import penetration in Canada, defined as the market share of Chinese imports in total Canadian imports by 4 digit NAICS sector. Profits are defined as operating revenue minus operating cost relative to initial profits. Future exit measures either firm bankruptcy or plant shutdown in the years after 1999 but neither survey attrition nor M&A activity. Process or product innovation strategy is measured as relative priority of product or process innovation for business strategy in survey responses. Columns (1) and (2) include controls for initial size, measured as initial domestic revenue and interaction of initial size with instrumented Chinese competition. Columns (3) and (4) include controls for initial TFP and interaction of initial TFP with instrumented Chinese competition. TFP is measured using timing-based GMM estimation as is Ackerberg et al, 2015. Additional controls include main effects for innovation strategies, and low-cost strategy and interactions of instrumented Chinese competition with low-cost competition. All regressions use population sampling weights, which make estimates representative of approximately 57,000 Canadian manufacturing firms. Robust standard errors in parentheses are clustered by 4-digit NAICS industry.

Table 6: Controlling for Outsourcing

	(1)	(2)	(3)
Dependent Variable:	Change in number of Process Innov.	Future exit	Profits
	IV	IV	IV
Change in Chinese competition	-11.29	5.39	-2.642
	(3.547)	(1.915)	(4.530)
share	1.400	-0.141	-1.850
	(1.191)	(0.471)	(1.504)
Change in Chinese competition x(Process Innovation Strategy)		1.97	3.262
		(0.584)	(1.656)
Change in Chinese competition x(Product Innovation Strategy)		0.139	2.448
		(0.481)	(1.814)
Change in Chinese processing trade share x(Process innovation strategy)		0.144	0.597
		(0.264)	(0.965)
Change in Chinese processing trade share x(Product innovation strategy)		-0.368	0.025
		(0.156)	(0.362)
Population sampling weights	YES	YES	YES
Additional controls	NO	see table notes	
Observations	908	1,320	840
R-squared	0.037	0.053	0.025

Notes: Change in Chinese competition measures change in Chinese import penetration in Canada, defined as the market share of Chinese imports in total Canadian imports by 4 digit NAICS sector. Processing trade share is defined as market share of Chinese imports that are intermediate instead of final goods, by 4 digit NAICS sector. Number of innovations are counts of the number of years in the past 3 years that firms reported. Future exit measures either firm bankruptcy or plant shutdown in the years after 1999 but neither survey attrition nor M&A activity. Profits are defined as operating revenue minus operating cost relative to initial profits. Process or product innovation strategy is measured as relative priority of product or process innovation for business strategy in survey responses. Additional controls for colums (2) and (3) include main effects for innovation strategies, initial size and low-cost strategy, interactions of instrumented Chinese competition with initial size and low-cost strategy as well as interactions of innovation strategies, low-cost strategy and initial size with Chinese processing trade share. All regressions use population sampling weights, which make estimates representative of approximately 57,000 Canadian manufacturing firms. Robust standard errors in parentheses are clustered by 4-digit NAICS industry.

Table 7: Initial Competition Intensity

	(1)	(2)	(3)	(4)
	Product Differentiation		Product Differentiation	
	LOW	HIGH	LOW	HIGH
Dependent Variable:	Change in Profits		Future exit	
	IV	IV	IV	IV
Change in Chinese competition	-1.364	-12.530	6.617	-3.065
	(5.071)	(15.359)	(2.151)	(4.309)
Change in Chinese competition x(Process Innovation Strategy)	5.749	0.507	1.944	1.508
	(1.250)	(5.043)	(0.607)	(2.896)
Change in Chinese competition x(Product Innovation Strategy)	2.609	4.296	-0.614	1.036
	(0.836)	(4.745)	(0.386)	(2.797)
Population sampling weights	YES	YES	YES	YES
Additional controls	see table notes		see table notes	
Observations	447	393	656	664
R-squared	0.037	0	0.126	0.004

Notes: Change in Chinese competition measures change in Chinese import penetration in Canada, defined as the market share of Chinese imports in total Canadian imports by 4 digit NAICS sector. Profits are defined as operating revenue minus operating cost relative to initial profits. Future exit measures either firm bankruptcy or plant shutdown in the years after 1999 but neither survey attrition nor M&A activity. Process or product innovation strategy is measured as relative priority of product or process innovation for business strategy in survey responses. As measure of initial competition intensity, we use product differentiation, defined as size of demand elasticities calculated for Canadian imports by Broda and Weinstein (2006). Additional controls include main effects for innovation strategies, initial size and low-cost strategy and interactions of instrumented Chinese competition with initial size and low-cost strategy. All regressions use population sampling weights, which make estimates representative of approximately 57,000 Canadian manufacturing firms. Robust standard errors in parentheses are clustered by 4-digit NAICS industry.