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# OPPOSING FIRM-LEVEL RESPONSES TO THE CHINA SHOCK: HORIZONTAL COMPETITION VERSUS VERTICAL RELATIONSHIPS?

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**ABSTRACT**

We decompose the "China shock" into two components that induce different adjustments for firms exposed to Chinese exports: a horizontal shock affecting firms selling goods that compete with similar imported Chinese goods, and a vertical shock affecting firms using inputs similar to the imported Chinese goods. Combining French accounting, customs, and patent information at the firm-level, we show that the horizontal shock is detrimental to firms' sales, employment, and innovation. Moreover, this negative impact is concentrated on low-productivity firms. By contrast, we find a positive effect - although often not significant - of the vertical shock on firms' sales, employment, and innovation.

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# 1 Introduction

The spectacular growth of China's exports following its accession to the WTO – the eponymous "China shock" – has induced substantial adjustments in the manufacturing sectors of developed economies. Most of the literature analyzing those adjustments starts with a measure of this shock (typically the growth rate of Chinese exports) at the sector-level. According to this measure, one of the most affected sectors is apparel. Consider two subsets of French firms classified in this sector from our sample in 1999. One set of firms produced women's jackets using woven polyester as intermediate input. The share of women's jackets imported from China (Chinese import penetration) increased by 30 percentage points (pp) between 2000 and 2007, whereas Chinese import penetration in woven polyester declined over the same period. Another set of firms produced embroidered clothes using women's trousers as intermediate input. Over that same 2000-07 period, Chinese penetration for embroidered clothes declined by 12pp, whereas Chinese penetration for women's trousers increased by 22pp. Both sets of firms were significantly impacted by the sharp rise in Chinese apparel, but in very different ways. The dominant component of the shock for the first set of firms is horizontal: a sharp increase in Chinese exports of products similar to those these firms are producing. On the other hand, the dominant component of the shock for the second set of firms is vertical: a sharp increase in Chinese exports of products used by this set of firms as an intermediate input. While the sales of the firms in the first set decreased markedly between 2000 and 2007, they increased for the firms in the second set over the same period.

In this paper, we disentangle the horizontal and vertical components of the Chinese import shock at the firm-level and analyze its effects on employment, sales, and innovation. We use French accounting records, customs, and patent information on a comprehensive firm-level panel dataset spanning the period 1994-2007 and show that those two components have opposite effects on French firms' outcomes in 2000-07. We find that exposure to horizontal trade competition is detrimental to firms' sales, employment and innovation. Moreover, this negative effect is concentrated among low-productivity firms. By contrast, we find a positive effect (although often insignificant) for the vertical component on firms' sales, employment and innovation.

Following the seminal work of Autor et al. (2013), a vast literature analyzes the effects of the China shock on those same employment, wage, and innovation outcomes.[1] Yet this literature relies almost exclusively on industry variation. Consequently, it confounds the horizontal impact of increased competition in output markets with the vertical impact of increased access to imported intermediates, thereby making it difficult to interpret its results. For instance, a positive effect of import shocks on domestic performance could be explained either by a positive escape competition effect from increased competition in output markets, or by an improved access to intermediate inputs. Moreover, at the industry-level, the horizontal shock and vertical shock are highly correlated, and regressions using only industry-level information confound these two shock components. Finally, using industry-level variation precludes a granular control for the trajectory of the entire industry, regardless of a firm's exposure to either the horizontal or the vertical component of the China shock.

Moving from industry- to firm-level analysis allows us both to disentangle the horizontal and vertical components of the China shock and to separately control for industry-level trends. On the employment side, we find that including a separate control for the vertical component increases markedly the negative impact of the horizontal shock. However, part of this impact could stem from an industry aggregate trend – which could be driven either by trade competition or other correlated industry-level changes. Directly accounting for these industry-level trends, we show that the (within-industry) horizontal competition from Chinese goods does trigger a precisely estimated downsizing of impacted French firms. On the innovation side and contrary to what we find for employment, no significant industry-wide trend emerges in the response of patenting to the China shock. After controlling for the vertical component of the shock, we do find a very strong and significant negative impact of increased horizontal competition on patenting by affected firms.

[1] In particular see Bloom et al. (2016); Iacovone et al. (2011); Autor et al. (2020a); Bombardini et al. (2017). Acemoglu et al. (2016) show that import competition from China has increased after 2000 and has depressed US manufacturing employment and overall job dynamics through input-output linkage. Mion and Zhu (2013) report that growth (resp. exit) rate of firms is negatively (resp. positively) associated with industry exposure to low-wage country imports, in particular because of China. Dauth et al. (2014) also document a negative impact on wage and employment in Germany due to the rising import competition with "the East" (China in particular). However, export oriented sectors experienced gains from trade liberalization. Hombert and Matray (2018) discuss how firms escape trade-induced competition thanks to innovation which allows them to increase product differentiation.

Our analysis relates to several strands of the literature. We already referred to the literature on the effects of the China shock on domestic performance. There is also a literature identifying a positive impact of increased access to imported intermediate inputs on firm performance. Amiti and Konings (2007) show that a 10 percentage points fall in input tariffs leads to a productivity gain of 12 percent for firms that import their inputs. In the same vein, Amiti and Khandelwal (2013) show that a reduction in import tariffs has a positive impact on product quality for varieties close to frontier and Gopinath and Neiman (2014) show that the devaluation of the Argentinian currency – which amounted to a negative shock for imported capital goods – had a negative impact on aggregate productivity.[2] We contribute to this literature by conducting a firm-level analysis on the impact of the vertical component of the China shock in regressions where we include the horizontal component of the shock and where we also control for industry-wide trends.

Other firm-level analyses on trade and innovation include Lileeva and Trefler (2010); Bustos (2011); Aw et al. (2011); Aghion et al. (2018, 2021). With French firm-level data, Aghion et al. (2018) show how an exogenous increase in the export market size induces innovation, in particular at the most productive firms; Aghion et al. (2021) further highlight the knowledge spillovers generated by exporting French firms on firms in the export destination countries. Here we analyze how the China import shock impacts employment and innovation, distinguishing between the horizontal and vertical components of the increased competition induced by that shock.[3]

Our paper is also connected with the theoretical literature on trade, innovation and growth (see Grossman and Helpman, 1991a,b, Aghion and Howitt, 2009, chapter 13) which analyzes the role of innovation decision in explaining firm dynamics in global economies. More recently, Burstein and Melitz (2013) reviews a rich literature that studies how firms' innovation responds to trade liberalization and Akcigit et al. (2018) develops a dynamic general equilibrium growth model with endogenous innovation in an open economy. The theoretical literature has also considered the heterogeneous

[2]See also Goldberg et al. (2010); Topalova and Khandelwal (2011); Bas and Strauss-Kahn (2014, 2015) and Bas (2012).

[3]The literature has also explored the reverse channel of how domestic technology adoption can generate import shocks. Malgouyres et al. (2019) shows for example how access to broadband internet has led to an increase in firm-level import.

impact of the China shock: Caliendo et al. (2019) builds a theoretical model allowing for both a horizontal component and a vertical component, which they calibrate using industry-level measures of the shock and of input-output connections.

The remaining part of the paper is organized as follows. Section 2 describes our data, shows some descriptive statistics, and outlays our estimation equations. Section 3 presents our results. Section 4 concludes.

# 2 Data, measurement, and empirical strategy

## 2.1 Data

We merge different sources of information at the firm-level. First, the administrative and tax dataset *FICUS* from Insee-DGFiP provides us with sales, employment, profit, and detailed sector information for the universe of French firms from 1994 to 2007. Second, the French Customs database provides us with firm-level information on exports and imports over a range of more than 5000 product categories (HS6 product-level). This information is completed by *BACI*, from Cepii, which provides us with product level bilateral trade information for all country pairs. Finally, *PATSTAT* from the European Patent Office provides us with patenting information, which we match with firms' administrative identifiers using the matching algorithm developed by Lequien et al. (2019). This firm-level matching provides us with very precise information on total patent applications and the subset of triadic applications.[4]

Our various data sources run from 1994 to 2007. We use information over 1994-1999, our pre-sample period, to construct firms' exposure measures (the "share" part of our "shift-share" variables) as well as firm-level controls; and information over the 2000-2007 period to construct our shocks (the "shift" part of our shift-share shocks) and analyze their impacts on firm-level outcomes. We restrict our firm sample to privately managed manufacturing firms: (i) which record positive sales in 1999; (ii) which have 10 employees or more at least once over our whole sample period; (iii) which report export sales or imports to customs prior to our base year 1999.

[4]Triadic patent applications are patent applications filled at the European Patent Office (EPO), the United States Patent and Trademark Office (USPTO) and the Japan Patent Office (JPO).

Table 1 shows the mean values for our main outcome variables in 1999. Going from left to right in the table, we increasingly restrict the set of French firms we consider. The first column covers all privately owned firms. The second column focuses on manufacturing firms. The third column restricts attention to the subset of manufacturing firms which report exports or imports to customs in 1999. And the fourth column further restricts our sample to firms with at least one patent between 1993 and 2007. Moving from the universe of privately owned firms to the subset of manufacturing firms that both trade and patent, we see that average firm size, whether measured by sales, employment, or value added, systematically increases. In addition to showing larger sales and employment, patenting firms also display above average levels of value-added per worker, patent flows, export to sales ratios, and of the number of exported and imported products, while showing a slightly lower than average labor share.

These findings are consistent with the export and innovation premia reported in Aghion et al. (2018). They are also consistent with existing studies emphasizing a negative correlation between firms' productivity and labor share (see e.g. Autor et al., 2020b; Aghion et al., 2019), and a positive correlation between firm size and the extensive margin of trade (number of exported products, e.g. Bernard et al., 2014, 2019b for the U.S. and Mayer et al., 2014 for France).

As of 2007, 51% of manufacturing firms present in our sample in 1999 have disappeared from our fiscal files. This amounts to a yearly attrition rate of 8.5%. This rate most likely overestimates the true exit rate due to the death of the firm. If we restrict our exit count in year $t$ to firms with either negative recorded value added in $t-1$ or with a drop of more than 30% in employment between $t-2$ and $t-1$, the yearly average exit rate of manufacturing firms falls down to 3.5% (25% over the entire sample period). The exit rate of manufacturing firms is twice as high as that of the average French firms reported in column (1). Finally, columns (3) and (4) show that, among manufacturing firms, those that trade and/or patent exhibit lower exit rates (e.g. Bernard et al., 2006).

In the remaining part of the paper, we will focus our attention on firms that engage in international trade, i.e. on the subset of firms described in the last two columns of Table 1. Those are the firms for which we are able to construct our firm-level trade shocks.

Table 1: Descriptive statistics

| | All mean | Manufacturing mean | Trading mean | Patenting mean |
|---|---|---|---|---|
| Sales | 8,358 | 9,171 | 17,265 | 60,223 |
| Employees | 40.4 | 41.1 | 81.2 | 259.3 |
| VA | 2,220 | 2,187 | 4,450 | 15,881 |
| VA/worker | 44.26 | 37.90 | 45.62 | 54.42 |
| Labor share | 0.58 | 0.58 | 0.59 | 0.52 |
| Export intensity | 0.05 | 0.13 | 0.13 | 0.21 |
| Exported products | 1.23 | 3.46 | 7.87 | 19.14 |
| Imported products | 1.99 | 5.60 | 12.25 | 27.90 |
| Patent applications | 0.00 | 0.17 | 0.37 | 2.96 |
| Triadic patents | 0.00 | 0.01 | 0.02 | 0.15 |
| Exit | 0.25 | 0.51 | 0.27 | 0.10 |
| Death | 0.13 | 0.25 | 0.14 | 0.06 |
| Observations | 243,056 | 86,408 | 37,958 | 4,710 |

**Notes**: Unweighted mean of descriptive variables by firm group in 1999. All columns exclude firms recorded with less than 10 employees over all our sample period. Going from left to right we step by step restrict the set of French firms. The first column covers privately owned firms, regardless of their industry. The second column only keeps privately owned manufacturing firms. The third column only keeps all privately owned manufacturing firms that can be matched to customs data in 1999. Finally the fourth column further restricts our sample to firms that are observed in patent data at least once between 1993 and 2007. Sales and value added are expressed in thousands of euros, value added per worker in thousands of euros per worker. We use a fractional count to define firms' total patent applications and triadic patent applications in 1999. Firm exit stands for missing fiscal identifiers as of 2007 while death stands for exit combined with negative recorded value added prior to exit and/or a 30% drop in firm employment in the 2 years preceding exit. Observations provide the number of firms.

## 2.2 Measuring trade shocks

For each firm, we construct both a horizontal trade shock and a vertical trade shock. The horizontal shock is constructed using the firm's export data at the detailed product-level to measure its exposure to increased Chinese import penetration on its *outputs* markets. The vertical shock is constructed using the firm's import data at the same detailed product-level to measure its exposure to the same Chinese import penetration on its *inputs* markets.

Formally, let $x_{f,i,t_0}$ and $m_{f,i,t_0}$ denote firm $f$'s exports and imports of product $i$ in our base year $t_0 = 1999$. And let $S_{i,t}$ denote the share of total French imports of good $i$ originating from China in year $t > t_0$. Our baseline empirical specification will regress firm $f$'s outcome on long differences in the firm's horizontal and vertical exposures to Chinese import penetration. These are defined respectively by:

$$H_{f,t} = \sum_i \frac{x_{f,i,t_0}}{\sum_j x_{f,j,t_0}} S_{i,t} \quad \text{and} \quad V_{f,t} = \sum_i \frac{m_{f,i,t_0}}{\sum_j m_{f,j,t_0}} S_{i,t}.$$

We then define the shift-share long-run differences corresponding to measured changes in horizontal and vertical exposure to Chinese import competition as:

$$\Delta H_f = \sum_i \frac{x_{f,i,t_0}}{\sum_j x_{f,j,t_0}} \Delta S_i \quad \text{and} \quad \Delta V_f = \sum_i \frac{m_{f,i,t_0}}{\sum_j m_{f,j,t_0}} \Delta S_i$$

where $\Delta S_i$ is the 2007/2000 long run difference in the share of total imports of good $i$ originating from China.[5] In order to match trade flows to customs data, we translate all product-level variables into the HS2002 classification at the 6-digit level.

Figure 1 plots the long-run differences over the 2000-2007 period for the horizontal and vertical exposure variables; at the industry-level in Figure 1(a), and at the firm-level controlling for industry fixed effects in Figure 1(b). The horizontal and vertical exposures to Chinese import penetration are clearly correlated at the industry-level. This in turn implies that the firm-level variation displayed in Figure 1(b) is key for identifying the separate effects of horizontal and vertical trade competition for firm-level outcomes (controlling for industry trends). A simple variance decomposition of our firm-level horizontal and vertical shocks shows that only 10% of the overall variance can be explained by the 2-digit industry variation. The remaining variation is exhibited across firms *within* those industries.

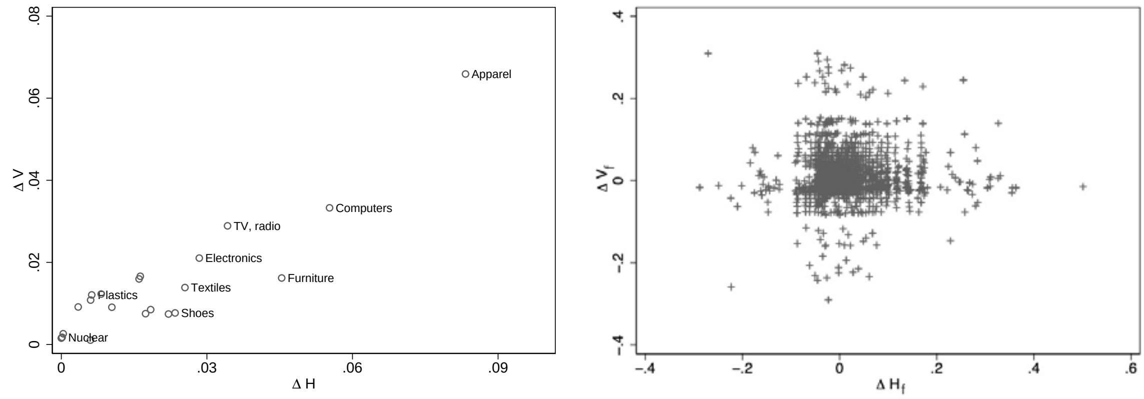
Even though firm-level measures of exposure to horizontal and vertical trade competition improve upon industry-level measures, Figure 1(b) also displays a positive correlation between $\Delta H_f$ and $\Delta V_f$.[6] In our data this correlation arises from the fact that firms tend to export and import within the same detailed product category. This echoes Bernard et al. (2019a)'s finding that firms often export products that they did not themselves produce. To take into account this positive correlation between ex-

[5] The validity of this specification comes from an identification based on the exogenous assignment of the shocks. Borusyak et al. (2018) discuss at length the case of the China shock and argue that the associated specification can indeed reasonably be viewed as leveraging exogenous shock variations.

[6] The correlation between $\Delta H_f$ and $\Delta V_f$ when controlling for 2-digit industry fixed effects is 0.26 in our sample.

Figure 1: BETWEEN AND WITHIN INDUSTRY EXPOSURE TO TRADE COMPETITION

(a) industry-level exposure (b) firm-level exposure




**Notes:** Panel (a) displays a scatter plot of the average long difference of the horizontal ($\Delta H$) and vertical ($\Delta V$) shocks by 2-digit manufacturing industries. Panel (b) displays a scatter plot of the residual long difference of firm-level horizontal ($\Delta H_f$) and vertical ($\Delta V_f$) once 2-digit industries fixed effects have been controlled for. For statistical secrecy reasons we discretize each shock's residuals into 100 bins and plot mean values of our residualized shocks for 2,997 groups each containing at least 5 firms. All long differences are taken over the 2000/2007 period.

ports and imports at the firm-level, a second empirical specification developed in the Appendix splits our horizontal and vertical shocks between: (i) a net export shock on exports that are not imported; (ii) a net import shock on imports that are not exported; (iii) a common export/import shock. Our results are robust to using this alternative specification.

## 2.3 Empirical specification

Our baseline specification seeks to separately identify the causal impact of increased firm-level exposure to Chinese imports along the horizontal ($\Delta H_f$) and vertical ($\Delta V_f$) dimensions. The regression equation is:

$$\tilde{\Delta} Y_f = \alpha + \beta_H \Delta H_f + \beta_V \Delta V_f + \gamma' X_{f,t_0} + \eta_{s(f)} + \varepsilon_f, \qquad (1)$$

where (i) $\tilde{\Delta} Y_f$ is the growth rate of firm $f$'s outcome of interest between 2000 and 2007; (ii) $X_{f,t_0}$ is a collection of firm-level pre-$t_0$ controls, with $t_0 = 1999$; and (iii) $\eta_{s(f)}$ are 2-digits industry fixed effects. The time window 2000-2007, which corresponds to the spectacular increase in China's influence in international trade, is very commonly used and allows our results to be comparable with previous studies of the effects of the China shock.

In all our specifications, $X_{f,t_0}$ includes pre-1999 firm-specific levels and 5-years trends in employment and sales, as well as the dummies for the firm's export/import status.[7] Our regressions with patenting as the outcome variable further control for pre-1999 initial stocks and average yearly patenting rates in the relevant patent category.

We treat our raw dependent variables $Y_f$ in three different ways. First, when $Y_f$ is a flow variable such as sales or employment we use its "Davis-Haltiwanger" (DH) growth rate between $t-k=2000$ and $t=2007$ defined as:

$$\tilde{\Delta}Y_f = 2\frac{Y_{f,t} - Y_{f,t-k}}{Y_{f,t} + Y_{f,t-k}}.$$

Second, when looking at patenting outcomes, we first compute firm's $f$ 1993-1999 and 2000-2007 average yearly flows of patents. We then define our dependent variable of interest $\tilde{\Delta}Y_f$ as the DH growth rate of these two average yearly patent flows. Third, we treat binary outcomes such as industry switching or firm exit using a simple linear probability model.

We address potential biases on the estimated $\beta_H$ and $\beta_V$ coefficients arising from unobservable domestic shocks by instrumenting $\Delta H_f$ and $\Delta V_f$ by their counterparts constructed using product-level Chinese import penetration measures aggregated over six advanced countries excluding France.[8]

# 3 Results

## 3.1 Comparing industry- and firm-level evidence

Before presenting our full results, we show in Table 2 how the measured responses to increased trade competition of employment and patenting vary when: (a) we move from industry-level shocks to firm-level shocks; (b) we move from the overall universe of manufacturing firms to the subset of trading firms with available customs data.

[7]Controlling for export/import dummies amounts to controlling for the sum of "shares" in our shift-share shocks, which in turn is required when using an incomplete shift-share setting as explained in Borusyak et al. (2018).

[8]Our instrument are the counterparts of our horizontal and vertical shocks computed with import penetration measures from Canada, Germany, Italy, Japan, the United Kingdom and the United States.

Table 2: Comparing industry- and firm-level shocks

| | Employment | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Industry | | | | | Firm | | Placebo |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Horizontal | -0.728*** | -0.467* | -1.012*** | -2.310*** | -2.703*** | -0.872*** | -0.367** | -0.0130 |
| | (0.213) | (0.272) | (0.386) | (0.792) | (0.765) | (0.197) | (0.167) | (0.0311) |
| Vertical | | | | 1.868* | 1.833* | -0.0214 | 0.136 | -0.0208 |
| | | | | (1.075) | (1.003) | (0.189) | (0.179) | (0.0312) |
| F | | 131.6 | 119.6 | 17.66 | 14.00 | 160.1 | 142.2 | 142.2 |
| Mean | -0.0657 | -0.0657 | -0.0657 | -0.0657 | -0.108 | -0.108 | -0.108 | 0.0416 |
| N | 42323 | 42323 | 42323 | 42323 | 27884 | 27884 | 27883 | 27883 |
| | Triadic patents | | | | | | | |
| | Industry | | | | | Firm | | Placebo |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Horizontal | -0.195 | -0.781 | -1.074 | -1.564 | -1.589 | -1.513*** | -1.312*** | 0.210 |
| | (0.560) | (0.735) | (0.775) | (1.572) | (1.565) | (0.494) | (0.487) | (0.374) |
| Vertical | | | | 0.748 | 0.844 | 0.114 | -0.179 | -0.335 |
| | | | | (2.209) | (2.161) | (0.490) | (0.482) | (0.359) |
| F | | 165.4 | 84.84 | 20.90 | 20.40 | 131.4 | 141.8 | 96.39 |
| Mean outcome | 0.101 | 0.101 | 0.101 | 0.101 | 0.100 | 0.100 | 0.100 | 0.0960 |
| N | 5005 | 5005 | 5005 | 5005 | 4710 | 4710 | 4710 | 4710 |
| Firm controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Industry FE | | | | | | | ✓ | ✓ |
| Sample | All Mfg | All Mfg | All Mfg | All Mfg | Trading Mfg | Trading Mfg | Trading Mfg | Trading Mfg |
| Shocks | 3-dgt industry | 3-dgt industry | 4-dgt industry (from customs) | 4-dgt industry (from customs) | 4-dgt industry (from customs) | Firm (from customs) | Firm (from customs) | Firm (from customs) |

**Notes:** This table compares different specifications and sources of identification when taking the 2000/2007 DH growth rate of employment and the 1993-1999 versus 2000-2007 DH growth rate of average yearly triadic patent flows as the outcome variables of interest. Columns (1) to (4) look at the universe of privately owned manufacturing firms with more than 10 employees while columns (5) to (8) restrict this sample to firms with available trade data. Columns (1) and (2) use trade shocks directly defined at the 3-digit industry. Columns (3) to (5) use product information aggregated from firm-level data to construct 4-digit industry shocks. Finally columns (6) to (8) use our preferred firm-level shocks. Column (8) is a placebo test which takes the pre-1999 DH growth rate of employment and triadic patents as our dependent variables. The detail of each specification is given in the main text. Standard errors clustered at the 4 digit industry-level are in parentheses. ***, ** and * indicate p-value of the Student state of null coefficient below 0.01, 0.05 and 0.1 respectively.

Our dependent variables are the 2007/2000 DH long difference of employment and DH growth rate of yearly average triadic patent flows over the 2007-2000 period versus the 1993-1999 period. The first industry shock is defined as the increase in Chinese import penetration in each firm's initial 3-digit NACE industry. We report the OLS and shift-share IV estimates associated with this first industry shock in columns (1) and (2), respectively. As reported in several previous studies using comparable sources of identification (see Autor et al., 2016), the employment effect of increased industry-level competition appears to be large and negative.

To assess the differences that may exist between direct industry-level measures of trade competition and our product-level approach, we build a second industry shock by aggregating our firm-level weights within each 4-digit industry. This aggregation procedure allows us to compute both a horizontal and a vertical measure of industries' exposures to increased trade competition. We start in column (3) by reporting the shift-share IV estimate of the horizontal component without controlling for its industry level vertical counterpart. The difference between columns (2) and (3) shows that compared to product-based measures, direct industry-level measures of exposure to trade competition miss an important part of the negative horizontal effect on employment growth. This can be attributed both to measurement error in the pure industry-level specification of column (2) and to the fact that industry-level measures tend to aggregate the vertical and horizontal components of trade competition. The difference between columns (3) and (4) indeed shows that failing to account for the positive effect of vertical relationships leads to an upward bias on the coefficient associated to horizontal trade competition (omitted variable bias).

Before switching to our preferred firm-level specification, we check in column (5) that the employment effects from both vertical and horizontal shocks measured in column (4) on the universe of manufacturing firms do not change significantly when we restrict our sample to the subset of trading manufacturing firms. Those are the firms for which we can compute our firm-level shocks.

From column (6) onward, Table 2 reports firms' responses to those firm-level shocks on that subset of trading manufacturing firms. The estimated negative effect of the horizontal shock is divided by 3 when we switch from the industry trade measure (column (5)) to the more accurate firm-level trade measure (column (6)) on that same sample of firms. In addition there are other potential industry-level characteristics that are correlated with a high Chinese export growth rate. We account for these industry trends in column (7) by adding 2-digit industry fixed effects to our baseline specification. Column (7), which is our preferred specification, shows the within-industry impact of horizontal and vertical China shocks. Controlling for industry trends is particularly important if we try to isolate the impact of horizontal competition on employment: this impact is reduced by more than half when moving from column (6) to column (7), yet it remains economically and statistically significant. All regressions in the remaining part of the paper reproduce the setting of column (7) and include 2-digit industry fixed effects as well as the usual firm-level controls. Finally, the placebo test in column (8) shows no response from the pre-1999 employment growth rate to both shocks.

The bottom half of Table 2 shows that moving from the industry-level to our new firm-level measures of the China shocks also makes a big difference when assessing the impact of the China shock on innovation (new firm patents). The negative response of innovation to the horizontal competition shock only becomes significant once we use our firm-level shock and separately control for the vertical shock. On the other hand, controlling for the industry-level trends does not have a major impact on the negative economic magnitude of the innovation response to the shock: this response is only slightly reduced when these controls are introduced. We view this result as a strong argument in favor of switching to firm-level evidence whenever possible, and separating out the horizontal and vertical components of the China shock.

## 3.2 Main firm-level outcomes

Table 3 extends our preferred column (7) specification from Table 2 to additional left-hand-side firm outcome variables. The first set of variables captures additional dimensions of the firms' "current" status beyond employment: sales, the labor share (in value added), exit from manufacturing (firm remains active), and firm death. We also add a broader measure of innovation captured by the average flow of all patent applications (not just triadic patent applications). Lastly, we add a set of variables that capture changes to the firms' exported product mix (we do not observe product-level details for domestic sales). We measure the fraction of new and discontinued products (entry/exit of an exported HS6 product between 1999 and 2007). And we quantify the extent to which French firms in our sample shift their production towards products where France had a comparative advantage relative to China in 1999.[9] This variable is only defined for firms with available export data for both 1999 and 2007.

Our main findings can be summarized as follows: Only the horizontal shock negatively and significantly affects sales, employment, the firm's labor share, and patenting; the vertical shock has no significant effect on these variables; moreover, the vertical shock induces exit from manufacturing, conditional on the firm's survival. This last result suggests that the access to cheaper inputs allows firms to move away from production tasks and concentrate instead on service activities outside of manufacturing. For those firms that maintain their manufacturing activities in France, the

[9] We compute this firm-level measure of relative comparative advantage as an average across the set of exported products. For each HS6 product, we measure France's comparative advantage relative to China as the 1999 ratio of France's exports to the world over China's exports to the world. We then define firm-level comparative advantage as the average product-level comparative advantage over a firm's product mix, at all dates $t \geq 1999$.

vertical shock induces them to stick with their current set of products: these firms are far less likely to introduce new products. On the other hand, the horizontal shock induces a strong response in firms' product mix: the affected firms switch to products where France's relative comparative advantage is stronger. Evidently, firms that benefit from increased access to Chinese imported inputs find it profitable to continue producing/exporting products where France's comparative advantage is weak.

Our findings are consistent with Autor et al. (2020a) and Pierce and Schott (2016) who both find that increased exposure to trade competition leads U.S. firms to reduce sales, employment and to shift their production away from labor intensive and high labor share production tasks into service activities. Our contribution is to show that the negative impact of the increased Chinese exposure on sales, employment, labor share, and domestic innovation is tightly linked to the horizontal component of the trade shock. Finally, the direction of the effects of the shock on almost all firm-level outcomes is reversed when moving from the horizontal to the vertical component of the shock.

Table 3: Main firm-level outcomes

| | Main outcomes | | | | | Patents | | Products | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| | Sales | Employment | Labor share | Exit mfg | Death | Triadic | Appln | Discontinued | New | Comp Adv |
| Horizontal | -0.417** | -0.367** | -0.255** | 0.0104 | 0.0707 | -1.312*** | -1.488* | 0.196* | 0.191 | 0.637*** |
| | (0.197) | (0.167) | (0.106) | (0.0751) | (0.0798) | (0.487) | (0.854) | (0.117) | (0.161) | (0.155) |
| Vertical | 0.0653 | 0.136 | 0.136 | 0.301*** | -0.0765 | -0.179 | 0.412 | -0.133* | -0.488*** | -0.288* |
| | (0.186) | (0.179) | (0.114) | (0.0890) | (0.0931) | (0.482) | (0.945) | (0.0738) | (0.112) | (0.151) |
| F | 142.2 | 142.2 | 133.2 | 142.2 | 169.9 | 141.8 | 141.8 | 131.3 | 162.0 | 148.2 |
| Mean outcome | 0.0704 | -0.108 | -0.0236 | 0.0745 | 0.160 | 0.100 | 0.289 | 0.815 | 0.472 | 0.00161 |
| N | 27883 | 27883 | 24999 | 27883 | 33203 | 4710 | 4710 | 24232 | 17307 | 16090 |

**Notes:** This table reports our main results when regressing firm-level outcomes on our firm-level horizontal and vertical shocks. Columns (1) to (5) gather results for variables taken from French fiscal and administrative files. Columns (6) and (7) present results for triadic patents and patent applications. Columns (8) to (10) use exported products to construct measures of changes in a firms' product scope. We use DH growth rate for continuous variables and a simple linear probability model for dummy variables in columns (4) and (5). The share of discontinued products (8) is defined for firms with export data in 2000. The share of new products (9) is defined for firms with export data in 2007 and the DH growth rate of the relative comparative advantage content of a firm's exports (10) is defined for firms with available exports both in 2000 and 2007. The baseline sample includes all manufacturing firms with positive sales in 1999, which can be matched to customs data in 1999 and are recorded with at least 10 employees once between 1994 and 2007. Columns (6) and (7) restrict this sample to firms observed with at least one patent in our time window while columns (8) to (10) are by construction restricted to exporting firms. All models control for initial 5-years trends and level of sales and employment, export/import dummies as well as 2-digit industry fixed effects (NAF rev. 1 classification). We add 1999 stock of patents and pre-1999 trend in patenting activity for models involving patenting outcomes. Standard errors clustered at the 4 digit industry-level are in parentheses. ***, ** and * indicate p-value of the Student test of null coefficient below 0.01, 0.05 and 0.1 respectively.

## 3.3 Introducing firm heterogeneity

The average firm behavior as described in Table 3 may hide heterogeneous responses across different groups of firms. Therefore we group the firms according to their *initial* *labor productivity* measured as sales per worker in 1999. More specifically, we introduce below-median ($q = 1$) and above-median initial productivity ($q = 2$) dummies, which we interact with the vertical and horizontal shocks. Table 4 reproduces the results from Table 3 but separating the response of each of these two groups of firms to the horizontal and vertical China trade shocks.

Table 4: Evidence of heterogeneous response

| | Main outcomes | | | | | Patents | | Products | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| | Sales | Employment | Labor share | Exit mfg | Death | Triadic | Appln | Discontinued | New | Comp Adv |
| Horizontal*(q=1) | -0.409$^{*}$ | -0.489$^{**}$ | -0.244$^{*}$ | -0.0326 | 0.0349 | -1.259$^{**}$ | -1.888$^{*}$ | 0.0189 | -0.0368 | 0.578$^{***}$ |
| | (0.247) | (0.206) | (0.127) | (0.0648) | (0.116) | (0.516) | (1.058) | (0.0926) | (0.192) | (0.208) |
| Horizontal*(q=2) | -0.403 | -0.0778 | -0.263 | 0.117 | 0.0442 | -1.159 | -0.904 | 0.411$^{**}$ | 0.377$^{**}$ | 0.694$^{***}$ |
| | (0.264) | (0.204) | (0.168) | (0.127) | (0.0888) | (0.838) | (1.372) | (0.184) | (0.178) | (0.178) |
| Vertical*(q=1) | 0.0185 | -0.207 | -0.0181 | 0.220$^{***}$ | 0.126 | -0.0668 | 0.255 | -0.0925 | -0.415$^{**}$ | -0.327 |
| | (0.204) | (0.200) | (0.128) | (0.0740) | (0.110) | (0.481) | (1.139) | (0.0853) | (0.172) | (0.213) |
| Vertical*(q=2) | 0.117 | 0.488$^{*}$ | 0.348$^{*}$ | 0.371$^{**}$ | -0.322$^{**}$ | -0.341 | 0.428 | -0.224$^{*}$ | -0.577$^{***}$ | -0.264 |
| | (0.328) | (0.282) | (0.188) | (0.162) | (0.143) | (0.901) | (1.622) | (0.120) | (0.156) | (0.194) |
| F | 70.32 | 70.32 | 66.66 | 70.32 | 83.93 | 32.23 | 32.30 | 65.32 | 51.80 | 49.59 |
| Mean outcome | 0.0704 | -0.108 | -0.0236 | 0.0745 | 0.160 | 0.100 | 0.289 | 0.815 | 0.472 | 0.00161 |
| N | 27883 | 27883 | 24999 | 27883 | 33203 | 4710 | 4710 | 24232 | 17307 | 16090 |

**Notes:** This table reproduces the exact specifications described in Table 3 but interacts our horizontal and vertical shocks with below ($q = 1$) and above ($q = 2$) median dummies of sales per worker as measured in 1999. In addition to the controls described in Table 3 all models also control for the direct effects of the above/below median dummies. All models control for pre-1999 5-years trends and level of sales and employment, export/import dummies as well as 2-digit industry fixed effects (NAF rev. 1 classification). On the patent side we further add the initial stock of patents, the pre-1999 average patenting rate in the relevant patent category. Standard errors clustered at the 4 digit industry-level are in parentheses. $^{***}$, $^{**}$ and $^{*}$ indicate p-value of the Student test of null coefficient below 0.01, 0.05 and 0.1 respectively.

The negative effects of the horizontal shock highlighted in Table 3 on sales, employment, the labor share, triadic patents, and patent applications turn out to be concentrated on "laggard" firms with below median initial productivity. Consistent with this finding, the existing literature on competition and innovation points to a more negative effect of competition on innovation in firms far behind the technological frontier (Aghion et al., 2005).

Columns (2) and (3) also show that the effects of the vertical shock on employment and the labor share are positive and significant for the initially most productive firms: these firms appear more able to enhance their competitive advantage following an increase in Chinese penetration on their inputs markets. Consistent with this observation, these more productive firms have a lower probability of exit (column (5)).

Columns (8), (9), and (10) document how firms also respond to the China shock through product turnover and shifts in their product mix. When facing higher competition on their output markets, frontier firms adjust their product mix: they stop exporting some of their products and start exporting new ones (columns 8 and 9). In contrast, when facing more intense competition in their input markets, both frontier and laggard firms introduce fewer new products. This suggests that improved access to cheaper inputs offsets the need to switch to new products. Finally, column (10) shows that both frontier and laggard firms respond to increased horizontal competition by strongly shifting their product mix towards products where France has a comparative advantage relative to China.[10]

# 4 Conclusion

We use comprehensive firm-level panel data to analyze the effect of Chinese import shocks on sales, employment and innovation. We separately identify firms' responses to the horizontal and vertical components of the China shock. The horizontal shock is detrimental to firms' sales, employment, and innovation. Moreover, this negative effect turns out to be concentrated in low-productivity firms. The horizontal shock also strongly induces firms to switch their product mix towards products where France's comparative advantage relative to China is stronger. In contrast, the direction of those responses are reversed regarding the vertical shock.

At the industry-level, the horizontal and vertical shocks are highly correlated. Our results confirm that to correctly identify the impact of import competition, these two components must be disentangled at the firm-level and industry-wide trends must be controlled for.

[10]This echoes the findings of Bernard et al. (2006) for the U.S.

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# ONLINE APPENDIX: NOT FOR PUBLICATION

## A Controlling for the common component of firms' export/import flows

In this Appendix we split our horizontal and vertical shocks between: (i) a net export shock on exports which are not imported; (ii) a net import shock on imports which are not exported; (iii) a common export/import shock. More formally:

- let $\widetilde{x}_{f,i,t_0}$ denote firm $f$'s **net exports** of product $i$ in base year $t_0$ :

$$\widetilde{x}_{f,i,t_0} = \max(x_{f,i,t_0} - m_{f,i,t_0}, 0)$$

- let $\widetilde{m}_{f,i,t_0}$ denote firm $f$'s **net imports** of product $i$ in base year $t_0$ :

$$\widetilde{m}_{f,i,t_0} = \max(m_{f,i,t_0} - x_{f,i,t_0}, 0)$$

- let $\widetilde{c}_{f,i,t_0}$ denote firm $f$'s **import/export intersection** of product $i$ in base year $t_0$ :

$$\widetilde{c}_{f,i,t_0} = \min(m_{f,i,t_0}, x_{f,i,t_0}).$$

We shall then define firm $f$'s horizontal, vertical, and common Chinese shift-share shocks, respectively, by:

$$\Delta\widetilde{H}_f = \sum_i \frac{\widetilde{x}_{f,i,t_0}}{\sum_j \widetilde{x}_{f,j,t_0}} \Delta S_i, \quad \Delta\widetilde{V}_f = \sum_i \frac{\widetilde{m}_{f,i,t_0}}{\sum_j \widetilde{m}_{f,j,t_0}} \Delta S_i \text{ and } \Delta\widetilde{C}_f = \sum_i \frac{\widetilde{c}_{f,i,t_0}}{\sum_j \widetilde{c}_{f,j,t_0}} \Delta S_i.$$

Our extended specification which splits our horizontal and vertical shocks between a net export shock on exports which are not imported, a net import shock on imports which are not exported, and a common export/import shock, is summarized by the regression equation:

$$\Delta_{t-k}^t Y_f = \alpha + \beta_H \Delta_{t-k}^t \widetilde{H}_f + \beta_V \Delta_{t-k}^t \widetilde{V}_f + \beta_C \Delta_{t-k}^t \widetilde{C}_f + \gamma' X_{f,t_0} + \eta_{s(f)} + \varepsilon_f. \qquad \text{(A)}$$

Table A1 reports the results of this exercise and confirms the main messages conveyed in Table 3.

Table A1: Main outcomes controlling for the common export/import component

| | Main outcomes | | | | | Patents | | Products | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| | Sales | Employment | Labor share | Exit mfg | Death | Triadic | Appln | Discontinued | New | Comp Adv |
| Horizontal | -0.403** | -0.374** | -0.336*** | 0.0385 | 0.0512 | -1.240** | -1.967* | 0.279*** | 0.243 | 0.462*** |
| | (0.195) | (0.175) | (0.108) | (0.0710) | (0.0890) | (0.553) | (1.029) | (0.102) | (0.164) | (0.167) |
| Vertical | 0.205 | 0.322* | 0.0808 | 0.269*** | 0.0159 | -0.560 | -1.040 | 0.0297 | -0.225* | -0.00775 |
| | (0.202) | (0.191) | (0.119) | (0.0828) | (0.0929) | (0.457) | (0.799) | (0.0736) | (0.129) | (0.141) |
| Common | -0.215 | -0.215 | 0.140 | 0.0113 | -0.0563 | -0.0744 | 1.104 | -0.278*** | -0.288** | -0.0332 |
| | (0.222) | (0.186) | (0.134) | (0.0968) | (0.112) | (0.420) | (0.935) | (0.0714) | (0.131) | (0.168) |
| F | 88.05 | 88.05 | 79.67 | 88.05 | 118.6 | 71.79 | 71.79 | 105.4 | 123.2 | 125.9 |
| Mean outcome | 0.0704 | -0.108 | -0.0236 | 0.0745 | 0.160 | 0.100 | 0.289 | 0.815 | 0.472 | 0.00161 |
| N | 27883 | 27883 | 24999 | 27883 | 33203 | 4710 | 4710 | 24232 | 17307 | 16090 |

**Notes:** This table reproduces the results of Table 3 but adds the common shock to the original specification. Because we add the common component of the horizontal and vertical shocks, all results contained in this table control for a dummy indicating whether the firm both exported and imported in at least one HS6 product category. The definition of dependent variables and the exact specifications are otherwise unchanged. All models control for 2-digits industry fixed effects. Standard errors are clustered at the 2-digit industry-level. Standard errors clustered at the 4 digit industry-level are in parentheses. ***, ** and * indicate p-value of the Student test of null coefficient below 0.01, 0.05 and 0.1 respectively.