Input Prices, Allocation of Resources and TFP Growth: Evidence from Chinese Imports in France

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Abstract

Productivity is the fundamental engine of economic growth. The literature has shown that a large part of productivity loss is due to resource misallocation. However, few studies have introduced traded intermediate inputs in their frameworks. I provide new evidence that decreasing prices of imported intermediate inputs foster aggregate productivity growth by improving resource allocative efficiency. I estimate a structural model with heterogeneous importers using a comprehensive dataset of French firms in manufacturing industries. I then implement a TFP decomposition to quantify the contribution of allocative efficiency in France between 1999 and 2012. One percentage point increase of sourcing goods from China rises annual French TFP growth by 0.2 percentage point. Allocative efficiency explains all aggregate TFP gains from increasing sourcing of intermediate goods in China.

JEL classification: D2, F1, F4, F6.

Keywords: Trade, Aggregate Productivity, Resource Allocation, Technical Efficiency, Allocative Efficiency, Firm-level Data.

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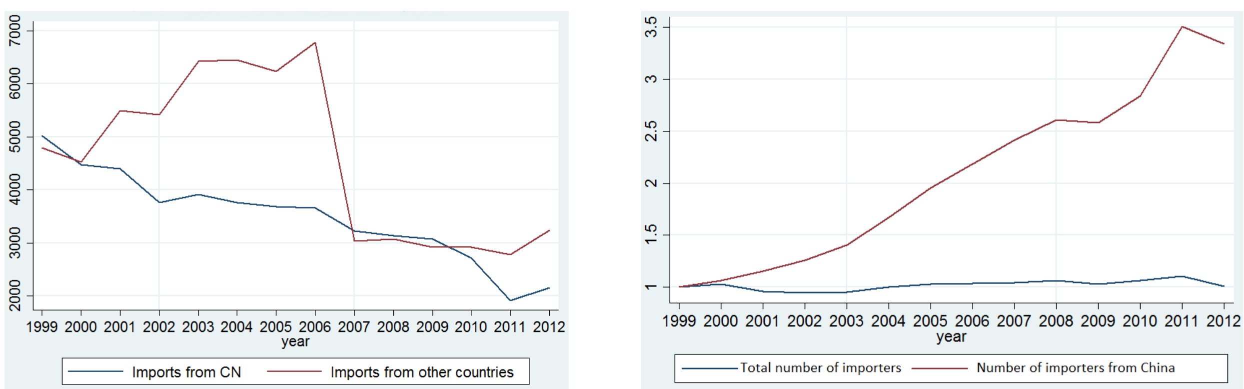
1. Introduction

Total factor productivity (TFP) is the main driver of GDP growth and depends on fundamentals and infrastructures such as trade policies, regulatory framework, institutional quality, *et cetera*. Country integration in global value chains is important for its competitiveness and directly impacts its productivity. Access to foreign inputs allows domestic firms to buy cheaper or higher quality intermediate inputs and induces modifications in their production functions. For instance, biggest French firms in the car industry have outsourced more intensively in China in early 2000s. They have gained market share from their domestic and foreign competitors by reducing their production cost. At the aggregate level, they weight more in the weighted average of firm-level TFP and generate aggregate productivity gains. Understanding how firm outsourcing strategy impacts aggregate productivity and resource reallocation across firms is then crucial in a globalized world.

Fig. 1. Evolution of traded intermediate inputs in France



(a) Average unit cost of French imports by origin country (in Euros)

(b) Number of importing firms by origin country (Based 1 = 1999)

Source: French customs data

Intermediate inputs represent more than fifty percent of trade flows in France in 2000s. A large part of intermediate inputs used by firms are imported and a growing share is from China. Chinese goods represent 1.7% of total imports of intermediate goods in 1999 and 7.4% in 2011. Moreover the annual growth rate of total imports of intermediate inputs is around 3%, against 15% for Chinese goods [1]. While the average unit cost of imported intermediate inputs from China falls between 2000 and 2007, the unit cost of imports from other countries increases (see figure 1a) and the number of firms importing from China almost doubled (see figure 1b).

[1]Source: WIOD database and author's computation

Nevertheless, firms are heterogeneous and do not benefit from Chinese trade liberalization in the same extent. Only the most productive are able to import goods. Moreover market frictions can prevent some firms to outsource their production in China. For instance, the French statistic institute (INSEE) survey provided by Fontagné and D'Isanto (2013) reveals that anxiety among employees and trade unions in France is one of the main reasons for planned but not carried out outsourcing (see Table 10 in appendix). Other barriers cited by French companies are legal or administrative barriers and uncertainty about quality of goods and services provided abroad. This survey clearly highlights some frictions that prevent access to foreign inputs for some firms regardless of their productivity. These firms lost market share and reduce their size due to market frictions. This generates resource misallocation and aggregate productivity loss.

The objective of the paper is to establish how the Chinese productivity shock in early 2000s has contributed to aggregate productivity growth in France between 2000 and 2012 in presence of market frictions. China's accession at the WTO in 2001 has boosted its competitiveness and considerably changed world trade environment. Guided by stylized facts, I show both theoretically and empirically that the declining marginal costs of Chinese imported inputs generated aggregate productivity gains in France by allowing the most productive firms to grow faster and correct resource misallocation.

According to Jones (2013), one of the most important developments in growth literature of the last decade, is the enhanced appreciation of resource misallocation across firms and sectors. In Hsieh and Klenow (2009), firm distortions on capital and final good markets create resource misallocation and explain the productivity gap observed between US, China and India. They use a closed-economy model of monopolistic competition with heterogeneous firms. Bellone et al., 2014), Fontagné and Santoni (2015) and Libert (2017) show that misallocation is also important in France in 2000s. Benkovskis (2015) introduces intermediate inputs in this framework and finds that misallocation of intermediate inputs is the major source of TFP loss in Latvia, but he also uses a closed-economy model without imported intermediate inputs.

In the trade literature, improved access to foreign suppliers of intermediate inputs directly increased firm-level productivity (Amiti and Konings (2007), Kasahara and Rodrigue (2008), Goldberg et al. (2010), Lileeva and Trefler (2007), Halpern, Koren, Szeidl, et al. (2015)). Trade liberalization for intermediate inputs also boosts firm productivity thanks to within-firm reallocation (Vandenbussche and Viegelahn, 2016) or by decreasing firm marginal cost (Gopinath and Neiman (2014), Blaum, LeLarge, and Peters (2015), Bernard, Moxnes, and Ulltveit-Moe (2014)). A new potiential channel is the reallocation of resources across firms. Few papers provide evidence of reallocation effect (Bloom, Draca, and Van Reenen (2014), Berthou et al. (2017),Tito and Wang (2017)), but they do not show how decreasing marginal cost of imported inputs reallocate resources across firm in an open-economy model with heterogenous firms and input market frictions.

Using Hsieh and Klenow (2009) framework, I develop a model where firms face specific distortions on each input market. I suppose firms maximize their sales and use three types of inputs: capital, labour and intermediate inputs. I suppose that firms face distortions on capital, labour and intermediate inputs and do not observe them. Distortions disproportionately increase or reduce firms' sales.

The contribution of the paper is three folds. My first contribution is to introduce imported inputs in Hsieh and Klenow (2009) framework. Many firms in France have seen their marginal cost decrease as new Chinese varieties of intermediate goods were cheaper. In addition to market frictions, I suppose that firms have to pay a fixed cost to import foreign varieties (Gopinath and Neiman, 2014). The fixed cost is proportional to the number of varieties after profit maximization. Increasing the number of imported varieties decreases firm marginal product of inputs and rises firm size. This allows the most productive firms, which are able to import a larger set of inputs, to reduce their cost of production and to increase their size faster than the least productive ones. Rising size of the most productive firms correct resource misallocation and contributes positively to the aggregate TFP growth.

Secondly, I rework the decomposition of aggregate TFP proposed by Osotimehin (2016) with a third production factor: intermediate inputs. The objective is to quantify TFP gains from resource reallocation across firms after Chinese trade shock. Aggregate TFP growth captures variations of within-firm TFP (called technical efficiency) and variations of firm size measuring resource reallocation (called allocative efficiency). This decomposition is crucial as it defines allocative efficiency gains and not just market share reallocation across firms. The allocative efficiency is defined relatively to the optimal allocation of resources from the point of view of the social planner. The allocation is optimal if marginal products of each input are equalized across firms within a sector and there is no market friction.

Finally, I estimate the impact of Chinese trade shock on aggregate productivity growth and allocative efficiency in France. I compute the decomposition on French firm-level data in manufacturing sectors between 1999 and 2012. I find that one percentage point increase in intermediate inputs imported from China is associated with 0.2 percentage point increase of annual aggregate TFP growth in France. All these TFP gains are coming from higher allocative efficiency of resources across firms. By looking at different trade margins, the increasing number of firms importing form China is the main channel for higher allocative efficiency and TFP growth.

The rest of this paper is organized as follow. Section 2, I develop a model of producers and derive the decomposition of aggregate TFP growth. Section 3, I describe data, estimation methods and results to quantify the impact of raising Chinese intermediate inputs in aggregate productivity in France. Section 4 concludes.

2. Theoretical Framework

In this section, I show in a simplified framework how traded intermediate inputs affect aggregate productivity. I use a standard model of monopolistic competition with heterogeneous firms to illustrate gains from trade coming from variations of allocative efficiency. I present the discussion from the point of view of the home country.

2.1. Technology and firm behaviors

I assume an economy with a single final good Y_t produced each year t by a representative firm in a perfectly competitive market. Final firm combines sector output Y_{st} by using a Cobb-Douglas technology :

$$Y_t = \prod_{s=1}^{S} Y_{st}^{\rho_{st}} \tag{1}$$

with $\sum_s \rho_{st} = 1$ and $\rho_{st} = P_{st}Y_{st}/P_tY_t$ is the share of industry s in total nominal value-added. These share are allowed to vary over time. P_{st} is the price of industry production Y_{st}. Final good Y_t is assumed to be the numeraire and $P_t = 1$.

Sector output is given by the CES aggregate: :

$$Y_{st} = n_{st}^{\frac{\theta-1}{\theta}} \left(\sum_{i \in N_{st}} Y_{it}^{\theta} \right)^{1/\theta} \tag{2}$$

Where n_{st} is the number of firms in each sector s and the elasticity of substitution within sector s equals $1/(1-\theta)$ with $0 < \theta < 1$ [2].

Sector s is composed by firms indexed by $i = \{1, ..., n\}$. Sector inputs are denoted by $L_{st} = \sum_{i \in N_{st}} L_{it}$, $K_{st} = \sum_{i \in N_{st}} K_{it}$ and $X_{st} = \sum_{i \in N_{st}} X_{it}$. L_{it} is the amount of labor used by firm i at time t, K_{it} the amount of capital and X_{it} the quantity of outsourcing intermediate inputs. Firms use Cobb-Douglas technology for producing a differentiated final good:

$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{\beta} X_{it}^{\gamma} \tag{3}$$

[2] As in Osotimehin (2016), I assume that each good has the same weight in the aggregation and hence abstract from firm-specific demand shocks.

Firm i combines intermediate composite good X_{it} with labor L_{it} and capital K_{it} in a Cobb-Douglas fashion with efficiency A_{it}. The Cobb-Douglas weights, α, β and γ, measured importance of each input for production. Firms face constant returns to scale such as $\alpha + \beta + \gamma = 1$ [3]. Factor elasticities are assumed to be identical within a sector.

Capital is internationally mobile with a sector price R_t and input share α. Labor is an internationally immobile primary factor with a sector prices w_t and input shares β. The third factor of production is a composite intermediate good with firm-level price index P_{Xit} and input share γ. Intermediate goods could be either produced domestically or imported. A composite intermediate good is a CES composite of a domestic variety, Z_{it}, and a foreign one M_{it}[4].

$$\begin{aligned} X_{it} &= [{Z_{it}}^{\rho} + M_{it}^{\rho}]^{\frac{1}{\rho}} \\ M_{it} &= (\sum_{k}^{\Omega_{it}} m_{ikt}^{\rho})^{\frac{1}{\rho}} \end{aligned} \tag{4}$$

Where Ω_{it} is the set of foreign input varieties imported by firm i, m_{ikt} is the quantity of imported variety k and $1/1-\rho$ is substitution elasticity between foreign and domestic input varieties or the elasticity of substitution within foreign varieties ($\rho > 1$).

Producers are price-takers in intermediate input market.The price of domestic and foreign inputs are respectively denoted P_{Zt} and P_{Mit}. Note that P_{Zt} is identical for all firms because there is a unique domestic variety. P_{Mit} includes all variable trade costs. By solving the cost-minimization problem associated with equation (4), the effective price of composite good is:

$$\begin{aligned} P_{Xit} &= (P_{Zt}^{\frac{\rho}{\rho-1}} + P_{M_{it}}^{\frac{\rho}{\rho-1}})^{\frac{\rho-1}{\rho}} \\ P_{M_{it}} &= (\sum_{k}^{\Omega_{it}} P_{mt}^{\frac{\rho}{\rho-1}}) = P_{mt}|\Omega_{it}|^{\frac{\rho}{\rho-1}} \end{aligned} \tag{5}$$

Imported input price index differs across firms depending on the number of imported goods Ω_{it} as in Gopinath and Neiman (2014)[5]. Moreover higher number of imported inputs

[3]Constant returns to scale is needed in empirical parts to estimate factor elasticities in production function. This hypothesis has no impact on the model conclusions.

[4]I suppose no relative efficiency (i.e. quality advantage) of foreign inputs in firm production process contrary to Bas and Berthou (2013) ; Halpern, Koren and Szeidl (AER, 2015) ; Blaum, Lelarge and Peters 2016 where they measure the impact of traded inputs on firm-level productivity.

[5]I suppose all firms are importers. This hypothesis is supported by data in the empirical part. After combining customs database and Fiben firms' balance sheet database, more than 65% of incumbent firms in the sample import intermediate inputs each year and they represent more than 90% of total value added

is lower marginal cost, all else equal.

Firm i chooses the set of imported varieties Ω_{it} to maximize profits net of the fixed cost:

$$\Omega_{it} = argmax \pi_{it} - wF(|\Omega_{it}|) \tag{6}$$

With:

$$\pi_{it} = P_{it}Y_{it} - R_t(1+\tau_{Kit})K_{it} - w_t(1+\tau_{Lit})L_{it} - P_{Xit}(1+\tau_{Xit})X_{it} \tag{7}$$

Firms have to pay a fixed cost for importing foreign varieties denominated in units of labour, $wF(|\Omega_{it}|)$. A variation of marginal cost of intermediate inputs produced abroad directly enter in equation (6). If marginal costs of foreign inputs decline over time, firms import a broader set of varieties from abroad.

Then firms decide the optimal amount of capital, labour and the quantity of each type of intermediate inputs by maximizing their annual profit in equation (7). They face frictions on each input market and these friction are captured by wedges on capital $(1+\tau_{Ki})$, labour $(1+\tau_{Li})$ and intermediate inputs $(1+\tau_{Xi})$.

The profit maximization yields standard conditions where firm's output price is a fixed markup over marginal cost [6] :

$$P_{it} = \frac{\sigma}{\sigma-1}\left(\frac{R_t(1+\tau_{Kit})}{\alpha}\right)^{\alpha}\left(\frac{w_t(1+\tau_{Lit})}{\beta}\right)^{\beta}\left(\frac{P_{Xit}(1+\tau_{Xit})}{\gamma}\right)^{\gamma}\frac{1}{A_{it}} \tag{8}$$

Firm marginal revenue products of capital and labor can be written :

$$\begin{aligned} MRPK_{it} &= \alpha\frac{P_{it}Y_{it}}{P_{st}K_{it}} = R_t(1+\tau_{Ki}) \\ MRPL_{it} &= \beta\frac{P_{it}Y_{it}}{P_{st}(L_{it}-f_{it})} = w_t(1+\tau_{Li}) \end{aligned} \tag{9}$$

Where P_{st} is the sector price index of final good and f_{it} is amount of labor for paying the fixed cost. If there is no friction in capital and labor markets, firm marginal cost of input is equal to sector price, *i.e.* marginal revenue products are equalized across firms and resources are efficiently allocated. If firms face distortions, marginal revenue products are no longer equalized and inputs are not efficiently allocated across firms. Here, a distortion is defined as the wedge in the first-order condition of the first-best allocation of resources.

between 1999 and 2012.

[6]Due to CES preferences and monopolistic competition, the constant markup of price over marginal cost ensures that higher firm productivity is passed on fully to consumers in the form of a lower prices. Since demand is elastic, this lower price implies higher revenue for more productive firms (see Melitz and Redding, 2015).

Moreover firm marginal revenue product of intermediate composite good is:

$$MRPX_{it} = \gamma \frac{P_i Y_i}{X_{it}} = P_{Xit}(1 + \tau_{Xi}) \tag{10}$$

However I do not observe quantity of intermediate inputs used in data, X_{it}, but total expenditure: $V_{it} = P_{Xit} X_{it}$. As in Blaum, LeLarge, and Peters (2015), the unobserved price index P_{Xit} is related to the observed expenditure share of domestic inputs sd_{it} such as:

$$sd_{it} = (\frac{P_{Zt}}{P_{Xit}})^{\frac{\rho}{\rho-1}} (11)$$

Where P_{Zt} is the domestic price index of intermediate inputs.

The measured quantity of intermediate inputs used by firm is:

$$X_{it}^{obs} = V_{it} P_{Zt} sd_{it}^{\frac{\rho-1}{\rho}} \tag{12}$$

The measured marginal revenue product of inputs is then:

$$MRPX_{it}^{obs} = \gamma \frac{P_{it} Y_{it}}{P_t X_{it}^{obs}} = (1 + \tau_{Xit}) \tag{13}$$

As for capital and labour, wedges on intermediate inputs capture distortions faced by firms. The extent of sector misallocation still depends on the distance between firm marginal product of inputs. However, intermediate inputs wedges also depend on the number of imported varieties coming from firm profit maximization (equation 6). After the Chinese trade shock, marginal costs of Chinese intermediate inputs decrease and an increasing number of firms is able to import new varieties. The quantity of inputs X_{it} increases and $MRPX_{it}$ decreases for firms able to pay the fixed cost for importing, all else equal. As only the most productive firms are able to pay the fixed cost for importing foreign varieties, only firms in the mid-to-top productivity distribution benefit from trade liberalization. This generates resource reallocation towards the most productive firms and correct the sub-optimal allocation of resources created by the presence of market frictions.

2.2. Sectoral production functions and aggregate TFP

The objective of the section is to aggregate firm-level productivity and define a measure of resource allocative efficiency at sector level. For aggregating firm production functions, I follow the methodology proposed by Osotimehin (2016). I first aggregate production functions at sectoral level (CES aggregate defined in equation (2)) and then aggregate sectoral production functions at country (Cobb-Douglas aggregate defined in equation (1)) level[7]. In fact, the sectoral production function $Y_{st} = F_{st}(L_{st}, K_{st}, X_{st}, TFP_{st}, \tau_{st})$ in sector s at time t has the same functional form as the individual production functions and sector output is given by a CES aggregate demand defined in equation (2) such as:

$$F_{st}(L_{st}, K_{st}, X_{st}, TFP_{st}, \tau_{st}) = TFP_{st} K_{st}^{\alpha} L_{st}^{\beta} X_{st}^{\beta}$$

With

$$TFP_{st} = n_{st}^{\frac{\theta-1}{\theta}} \left(\sum_{i \in N_{st}} A_{it}^{\theta} \left(\frac{K_{it}}{K_{st}} \right)^{\alpha\theta} \left(\frac{L_{it}}{L_{st}} \right)^{\beta\theta} \left(\frac{X_{it}}{X_{st}} \right)^{\gamma\theta} \right)^{1/\theta} \tag{14}$$

Where K_{it}/K_{st}, L_{it}/L_{st} and X_{it}/X_{st} are functions of the vector of firm-level productivities $TFP_t = \{A_{it}, i \in C_{st}\}$ and wedges $\tau_t = \{\tau_{it}, i \in C_{st}\}$ with C_{st} the number of continuing firms.[8]

However TFP_{st} is quantity-based TFP and it is not measurable because firm-level prices are not available in France. I measure revenue-based TFP, $TFPR_{st}$, deflated with sector-level prices:

$$TFPR_{st} = n_{st}^{\frac{\theta}{\theta-1}} \left(\sum_{i \in N_{st}} A_{it}^{\theta} \left(\frac{K_{it}(1+\tau_{Kit})}{K_{st}} \right)^{\alpha\theta} \left(\frac{L_{it}(1+\tau_{Lit})}{L_{st}} \right)^{\beta\theta} \left(\frac{X_{it}(1+\tau_{Xit})}{X_{st}} \right)^{\gamma\theta} \right)^{1/\theta} \tag{15}$$

Regarding to the decomposition proposed by Osotimehin (2016), sectoral TFP growth among continuing firms can be decomposed into changes in technical efficiency (ΔTE_{st}), changes in allocative efficiency (ΔAE_{st}) and changes in extensive margins ΔEX_{st} such as :

$$\Delta TFPR_{st} = \Delta TE_{st} + \Delta AE_{st} + \Delta EX_{st} \tag{16}$$

Changes in firm-level productivity can be approximated as a combination of weighted

[7]First, I derive the aggregate production function for a given allocation rule, which define how inputs are allocated across firms. I set the allocation rules as a function of firm-level distortions (i.e. the difference from the first order condition of the best allocation of resources). I then aggregate the sectoral production functions and take into account the heterogeneity between sectors.

[8]Allocotive efficiency measures the efficiency of resource allocation across incumbent firms in Osotimehin (2016). As the paper objective is to determine how resource reallocation after a trade shock improves allocative efficiency and aggregate productivity, I do not look at entry and exit firms which would be the extensive margin of aggregate productivity.

[8]Due to data limitation, I do not look at the contribution of firm entry and exit. More details in section 3.1

average of the firm-level productivity changes[9]:

$$\Delta TE_{st} \approx \frac{1}{1-\theta} \sum_{i \in C_s t} \frac{\Delta A_{it}}{A_{it-1}} \left(\frac{P_{it-1}Y_{it-1}}{P_{st-1}Y_{st-1}} - \alpha\theta \frac{K_{it-1}}{K_{st-1}} - \beta\theta \frac{L_{it-1}}{L_{st-1}} - \gamma\theta \frac{X_{it-1}}{X_{st-1}} \right) \tag{17}$$

Where C_{st} is the set of continuing firms in sector s at time t. Technical efficiency component includes both the effects of changes in firm-level productivity with firms' input shares constant and the effect of the implied changes in input shares for a given level of allocative efficiency[10].

The changes in allocative efficiency is a combination of weighted averages of the firm-level changes in wedges :

$$\begin{aligned} \Delta AE_{st} \approx & -\frac{\alpha}{(1-\theta)} \sum_{i \in C_s t} \frac{\Delta \tau_{Kit}}{\tau_{Kit-1}} \left(\frac{p_{it}Y_{it}}{P_{st}Y_{st}} - (1-(1-\alpha)\theta) \frac{K_{it}}{K_{st}} - \beta\theta \frac{L_{it}}{L_{st}} - \gamma\theta \frac{X_{it}}{X_{st}} \right) \\ & - \frac{\beta}{(1-\theta)} \sum_{i \in C_s t} \frac{\Delta \tau_{Lit}}{\tau_{Lit-1}} \left(\frac{p_{it}Y_{it}}{P_{st}Y_{st}} - \alpha\theta \frac{K_{it}}{K_{st}} - (1-(1-\beta)\theta \frac{L_{it}}{L_{st}} - \gamma\theta \frac{X_{it}}{X_{st}} \right) \\ & - \frac{\gamma}{(1-\theta)} \sum_{i \in C_s t} \frac{\Delta \tau_{Xit}}{\tau_{Xit-1}} \left(\frac{p_{it}Y_{it}}{P_{st}Y_{st}} - \alpha\theta \frac{K_{it}}{K_{st}} - \beta\theta \frac{L_{it}}{L_{st}} - (1-(1-\gamma)\theta) \frac{X_{it}}{X_{st}} \right) \end{aligned} \tag{18}$$

The allocative efficiency measures the effect of changes in input allocation across firms on aggregate productivity. In the general case, allocative efficiency change equals zero if the level of distortions is unchanged or if the change in the distortions is identical across all firms (i.e. firms' marginal productivity remains relatively unchanged).

After the Chinese trade shock, the marginal cost of Chinese imports decreases. Firms in the mid-to-top productivity distribution import cheaper Chinese varieties, reduce their production cost and improve their sales. As the size of the most productive firms increases relative to the least productive ones, resource reallocation generates higher allocative efficiency and aggregate productivity gains.

Finally changes in the extensive margins measure the variation of the number of continuing firms :

$$\Delta EX_{st} = \frac{\theta - 1}{\theta} \frac{\Delta n_{st}}{n_{st-1}} \tag{19}$$

Contrary to Osotimehin (2016) that use an exhaustive firm-level data from INSEE, I do not observe firm entries and exits in the data and I can not quantify their exact contribution in the TFP growth.

[9]More details in appendix 5.2.

[10]Technical efficiency is also likely to reflect other shocks than technology upgrading such as demand shocks or factor utilization. When goods are heterogeneous the firm's productivity is also a function of firm-specific demand shocks (see Osotimehin, 2016). Furthermore, technical efficiency is also affected by the composition of intermediate inputs used. Firms with access to high productive inputs have higher technical efficiency (see Halpern, Koren, Szeidl, et al. (2015)).

3. Empirical framework

I estimate the decomposition by using firm-level data to measure how decreasing marginal costs of Chinese intermediate inputs contribute to allocative efficiency and aggregate productivity growth in France between 1999 and 2012. In this section, I describe the data used, the estimation of aggregate productivity growth decomposition, the empirical strategy and results.

3.1. Data description

To implement the productivity decomposition, I use French firm-level dataset collected by the Banque de France, called Fiben. This database includes all firms with a turnover of at least 750 000 euros between 1995 and 2012. It gathers accounting and financial data from firm balance sheets, which includes measures of firms' value added, investment expenditures, number of employees and raw material costs.

Table 1: Desciptive Statistics

	#Firms$_{st}$	Rev$_{it}$	L$_{it}$	rK$_{it}$	V$_{it}$	sdit
Mean	1 605	29 574	131	12 523	20 895	0.89
SD	1 479	453 573	733	162 070	393 498	0.17

Notes: $\#Firms_{st}$ is the number of firms per sector and year. Rev_{it} is the annual firm revenue in thousand of euros. L_{it} is the number of employees. rK_{it} is the stock of capital in thousand of euros. V_{it} is the expenditure on raw material in thousand of euros. *sdit* is the share of domestic inputs in total expenditure.

Each firm is assigned by an identification number (siren) which allows us to detect potential entries and exits. However Fiben is not the appropriate database to study the extensive margin due to the presence of turnover threshold. I am exclusively focusing on continuing firms and the extensive margin captures variation of the number of continuing firms and not the contribution of entry and exit. I also consider firms with less than 20 employees as outliers due to this threshold (see Berthou et al., 2017). I assume that industries correspond to the 2-digit industry-level of the NACE revision 2 classification. I exclude agricultural and mining sectors and remove sectors which do not provide market services (*i.e.* education, health, education and non-profit sectors) due to measurement issues on capital and raw materials. I then exclude from the sample firms whose productivity changes are in the bottom and top 2 percentiles (Osotimehin, 2016).

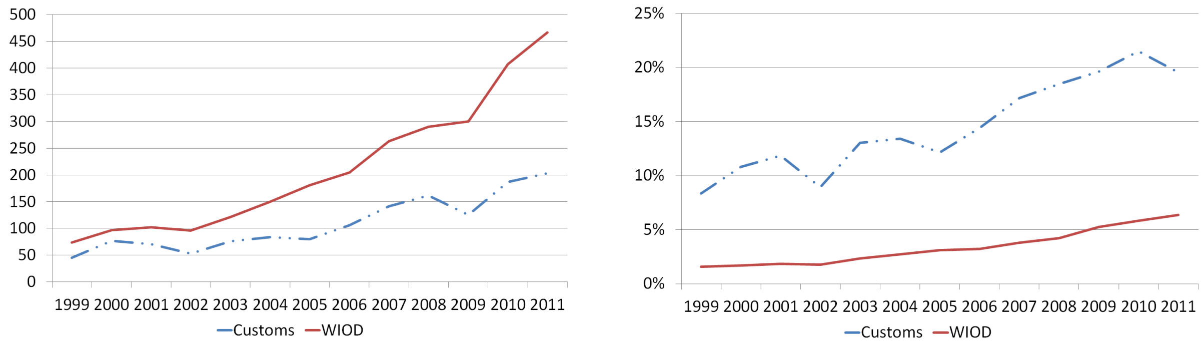
Table 1 gives some descriptive statistics about the firm-level data. The sample contains about 1 605 active firms per sector and year between 1999 and 2012. There are 22 manufacturing sectors. Firm revenue Rev_{it} is the turnover (gross output and commercial margins) deflated by the corresponding production deflators from Stan-OECD. I measure labor cost as wage bill, but the number of employees (L_{it}) is also available in the data. Following the CompNet methodology (Lopez-Garcia et al., 2014), I compute the capital stock rK_{it} as the book value of tangible fixed assets, deflated by the industry price deflators from Stan-OECD database. Intermediate input expenditure is raw material costs deflated by the corresponding domestic producer price indices from Stan-OECD. On average, firm turnover is around 29 million of euros. The average firm uses 131 employees, 12 million of euros of capital, 20 million of euros of intermediate inputs. I combine Fiben with the customs database at firm level. I use the BEC classification for determining which imported goods are intermediate inputs. On average, 89% of intermediate inputs are domestically bought.

Finally I also use World Input Output Database (WIOD) to measure all intermediate inputs by sector that are imported in France between 1999 and 2012. WIOD is available in NACE 2-digit classification and imported goods are already defined. In figure 2a, the values of imported inputs from China in costums database combined with Fiben database is lower than the values in WIOD. As I do not have the universe of firms in Fiben database and I identify intermediate inputs by using the concordance table between BEC and NACE classifications, I lost some values that are well-measured in WIOD. In the two databases, Chinese imported inputs grow on average by 15% per year. In figure 2b, intermediate inputs imported from China represent on average 4% of total imports of intermediate goods. In customs and Fiben databases, firms importing from China seem to be over-represented as they represent 15% of total imports of intermediate inputs. The most productive firms seem to import more from China than the least productive ones that are not in the Fiben database. This would bias upward our results on the impact on Chinese shock on aggregate productivity growth because of the absence of small firms in the data. In the estimations, I use WIOD data for computing the growth rate of Chinese imported inputs in France.

3.2. Estimation method of aggregate TFP

In this section, I describe method used to estimate firm-level distortions, factor elasticities, firm- and sector-level productivities, and aggregate productivity growth decompositition.

Fig. 2. Evolution of imported inputs from China in French customs and WIOD databases



(a) Values of French imports from China (in million of Euros)

(b) Share of Chinese goods in total imports of intermediate inputs

3.2.1. Definition of measured wedges and productivities at firm level

Distortions facing by firms are described in equations (9) et (13). They are wedges between firm marginal productivities and frictionless value. As shown by Osotimehin (2016), the impact of the distortions on aggregate productivity only depends on the relative marginal productivity of firms. This property simplifies the estimation of firm-level distortions that can be computed from firm-marginal productivities in nominal terms :

$$\begin{aligned}(1+\tau_{K_i}) &= \alpha\frac{MVPK_{it}}{R_{st}P_{st}}\\(1+\tau_{w_i}) &= \beta\frac{MVPL_{it}}{w_{st}P_{st}}\\(1+\tau_{Xit}) &= \gamma\frac{MVPX_{it}^{obs}}{P_{st}}\end{aligned} \tag{20}$$

Substitute in equation (18), allocative efficiency is then:

$$\begin{aligned}\Delta AE_{st} \approx &-\frac{\alpha}{(1-\theta)}\sum_{i\in C_st}\frac{\Delta\tau_{Kit}}{\tau_{Kit-1}}\left(\frac{p_{it}Y_{it}}{P_{st}Y_{st}}-(1-(1-\alpha)\theta)\frac{K_{it}}{K_{st}}-\beta\theta\frac{L_{it}}{L_{st}}-\gamma\theta\frac{X_{it}^{obs}}{X_{st}^{obs}}\right)\\&-\frac{\beta}{(1-\theta)}\sum_{i\in C_st}\frac{\Delta\tau_{Lit}}{\tau_{Lit-1}}\left(\frac{p_{it}Y_{it}}{P_{st}Y_{st}}-\alpha\theta\frac{K_{it}}{K_{st}}-(1-(1-\beta))\theta\frac{L_{it}}{L_{st}}-\gamma\theta\frac{X_{it}^{obs}}{X_{st}^{obs}}\right)\\&-\frac{\gamma}{(1-\theta)}\sum_{i\in C_st}\frac{\Delta\tau_{Xit}}{\tau_{Xit-1}}\left(\frac{p_{it}Y_{it}}{P_{st}Y_{st}}-\alpha\theta\frac{K_{it}}{K_{st}}-\beta\theta\frac{L_{it}}{L_{st}}-(1-(1-\gamma)\theta)\frac{X_{it}^{obs}}{X_{st}^{obs}}\right)\end{aligned} \tag{21}$$

Technical efficiency in equation (17) is computed as a Laspeyres index and allocative efficiency in equation (21) as a Paasche index for simplicity. To tackle this arbitrary choice,

Table 2: Cobb-Douglas coefficients in the revenue-based production function

Formula	Estimated values (sd)*	Halpern et al.**
$\beta_s = \frac{1}{T}\sum_t \frac{w_{st}L_{st}}{P_{st}Y_{st}}$	0.230 (0.06)	0.198
$\gamma_s = \frac{1}{T}\sum_t \frac{M_{Xst}}{P_{st}Y_{st}}$	0.690 (0.07)	0.752
$\alpha_s = 1 - \beta_s - \gamma_s$	0.081 (0.03)	0.041

* Simple average of sector-level values

** Refers to Halpern, Koren, Szeidl, et al. (2015): estimated coefficients for the entire manufacturing sector following Olley-Pakes approach.

I compute allocative efficiency and technical efficiency as Fischer indexes. Fischer index is a geometric mean of Laspeyres and Paasche indexes . The exact decomposition of aggregate productivity growth is given in appendix 5.2.

The estimation of production function is challenging in presence of resource misallocation. I can not implement the Olley and Pakes (1996) semi-parametric method, as in Halpern et al (2015). In this framework, firm decision depends on its productivity but also on factor distortions. Olley and Pakes approach can only deal with a unique unobservable state variable and it is not appropriate here because firm-level distortions are also unobserved.

Following Osotimehin (2016), I assume that input price heterogeneity is the only source of average distortions ($\frac{1}{T}\sum_t \frac{1}{1+\tau_t} = 1$ and $\frac{1}{T}\sum_t \frac{1}{\mathrm{e}^{e_{it}G_i}} = 1$). Then I can use labor income and raw material cost shares to estimate labor and input elasticities :

$$\begin{aligned}\beta_s &= \frac{1}{T}\sum_t \frac{w_{st}L_{st}}{P_{st}Y_{st}} \\ \gamma_s &= \frac{1}{T}\sum_t \frac{P_{Xst}X_{st}}{P_{st}Y_{st}}\end{aligned} \tag{22}$$

Assuming constant return to scale, I get $\alpha_s = 1-\beta_s-\gamma_s$. Table 2 summarizes production function parameters which are sectors-specific. Estimated values from factor share approach are closed to estimates in Halpern, Koren, Szeidl, et al. (2015).

Sectoral productivity is given by the standard Solow residual:

$$TFPR_{st} = \frac{Y_{st}}{K_{st}^{\alpha_s} L_{st}^{\beta_s} X_{st}^{\gamma_s}} \tag{23}$$

To estimate TFPR at firm-level, I have to deal with unobservable firm prices. I use the

[10] See more details in appendix.

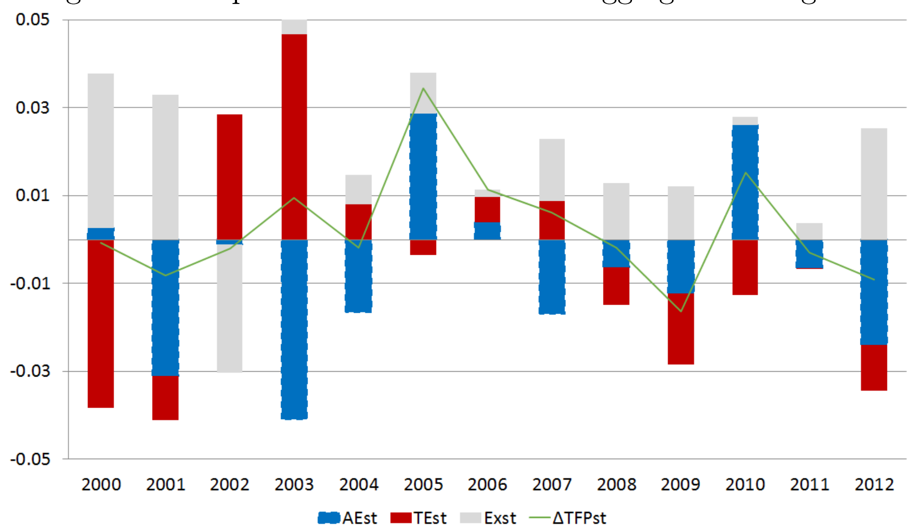
common assumption about the demand function, $P_{it}/P_{st} = (n_{st}Y_{it}/Y_{st})^{\theta-1}$ and estimated firm productivity is[11] :

$$TFPR_{it} = \frac{(P_{it}Y_{it})^{1/\theta}}{K_{it}^{\alpha_s}L_{it}^{\beta_s}X_{it}^{obs\gamma_s}}\left(\frac{Y_{st}}{n_{st}}\right)^{\frac{(\theta-1)}{\theta}} \tag{24}$$

Where P_{st} is measured by sectoral deflator and Y_{st} is sector nominal revenue. I set a within-sector elasticity of substitution of 3 ($\theta = 0.66$), in line with Broda and Weinstein (2006).

Then I compute aggregate productivity at sector level and aggregate it at the country level. French manufacturing industries experiment a revenue-based TFP growth around 0.8% per year between 1999 and 2012. Figure 3 shows the decomposition of aggregate TFP growth over that period. Even if technical efficiency remains the main driver of aggregate productivity growth, allocative efficiency is also an important driver. Moreover allocative efficiency improves considerably between 2001 and 2002, and becomes positive in 2005 and 2006.

Fig. 3. Decomposition of revenue-based aggregate TFP growth



Notes: $dAEst$ is the allocative effiency, $dTEst$ is the technical efficiency and $dTFPst$ is revenue-based aggregate TFP growth. The sum of allocative efficiency and tecnical efficiency is exactly equal to aggregate TFP growth. The three variables are weighted average of sector-level measures. They are weighted by the sector share in total gross output.

[11] A standard limitation of this firm productivity measure is that it does not capture only technical productivity, but also firm-specific demand shocks or shifting in factor utilization for instance.

3.3. Heterogenous impact of Chinese trade shock along firm size distribution: evidence from firm-level wedges

The objective of the section is to understand the role played by the Chinese intermediate goods on aggregate TFP dynamics. China's entry at WTO is like a foreign productivity shock that has decreased the marginal cost of intermediate inputs. In the theoretical part, I show that lower marginal cost of foreign varieties decreases firm-level wedges on intermediate goods. As the impact of trade shock is heterogeneous across firms, I provide quantitative evidence on the impact of Chinese imports on firm-level wedges and their dispersion at sector level.

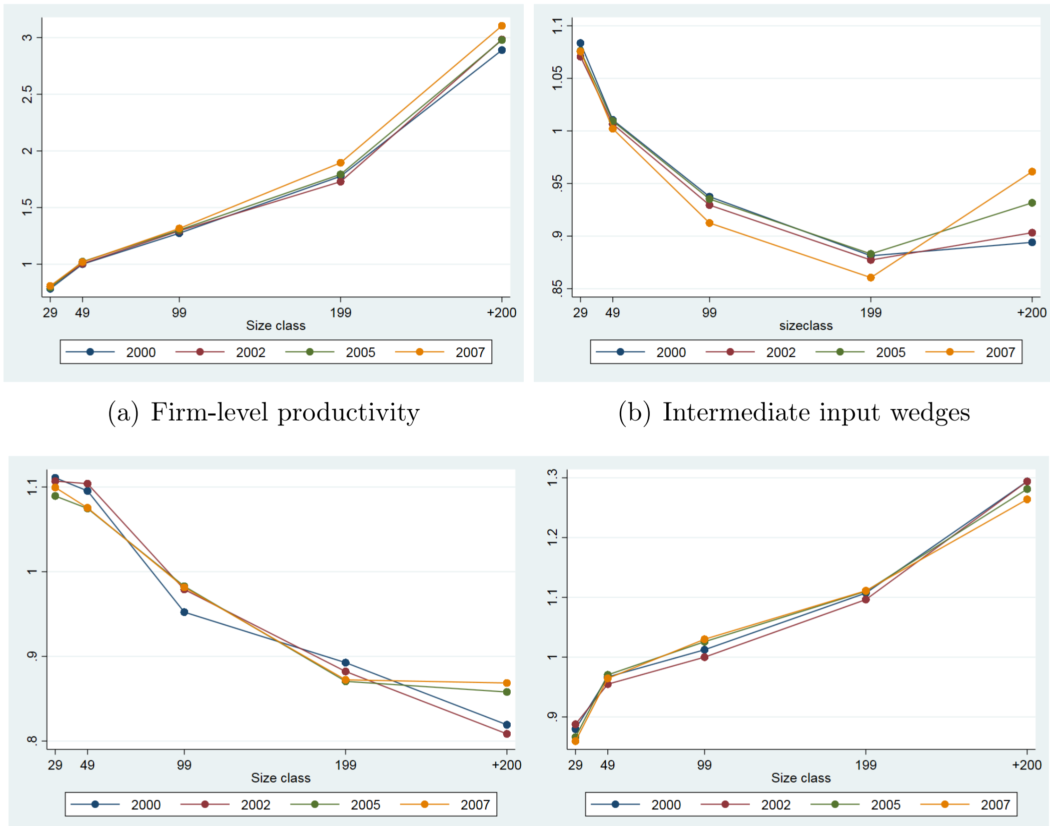
3.3.1. Evidence from firm-level wedges

Regarding the theoretical part, we expect that wedges on intermediate inputs go down after the Chinese trade shock for firms in the mid-to-top size distribution. The decreasing cost of trade inputs from China directly reduces firm marginal product for firms that start to import from China because they are now able to import cheaper varieties. Figures 5(a), 5(b), 5(d) and 5(c) display the distribution of firm-level productivity and wedges by firm size. First, firm-level productivity is perfectly correlated with firm size as expected (figure 5(a)).

Figure 5(b) reveals that wedges on intermediate inputs are decreasing in firm size, consistently with the fact that larger and more productive firms are more likely to faced less frictions for importing foreign varieties. However firm-level wedges relative to the sector median are decreasing for each size class between 2000 and 2007, excepted for the class with firms having more than 200 employees which slightly raised over the period. This is consistent with the fact that firms in the middle of the size distribution are more likely to benefit from trade liberalization. The decreasing marginal cost of traded inputs from China benefits to firms which are closed to the threshold for importing new varieties and they seem to employ on average less than 200 employees. From the point of view of the social planner, allocation is optimal when wedges equal one. The wedges of the most productive firms tend to converge towards one between 2000 and 2007, and it would contribute positively to the aggregate productivity regarding rules designed by the social planner. Firms with more than 200 employees have already paid the fixed cost for importing the optimal number of foreign varieties and do not benefit from trade liberalization. They lost their advantage on foreign markets relative to other firms and firms having between 50 and 200 employees catch up to them by getting access to new inputs. Dispersion of $MRPX_{it}$ is decreasing after trade liberalization.

In figure 5(c), capital distortions are negatively related to firm size. More productive

Fig. 4. Firm-level productivity and input wedges in 2000, 2002, 2004, 2005, 2007, by firm size



(a) Firm-level productivity

(b) Intermediate input wedges

(c) Capital wedges

(d) Labor wedges

Note: The figure gives the median of the relative firm-level productivity, and intermediate input, capital and labor wedges in 2000, 2002, 2004, 2005, 2007 by firm size. The size classes refer to the number of employees and they are: 20-29,30-49, 50-99, 100-199 and +200. Each size class is represented by a midpoint. The productivity and wedges are relative to 2-digit industry medians.

firms are more likely to face lower financial frictions. Between 2000 and 2007, wedges for firms having between 100 and 200 employees are decreasing, but increasing for firms having more than 200 employees. The impact on allocative efficiency is ambiguous.

At the opposite labor wedges are increasing in firm size and remain relatively stable over time. For instance, labor distortions capture adjustment costs and tighter regulations for firms with more than 50 employees that are unchanged over the period.

3.3.2. *Dispersion of firm-level wedges as measure of sector-level misallocation*

In the seminal paper by Hsieh and Klenow (2009), the dispersion of marginal revenue product of inputs is a measure of misallocation. As Chinese trade shock only decreases wedges for firms in the mid-to-top productivity distribution, what is the effect on the dispersion of wedges at sector level? To measure in which extent the trade shock reduces dispersion of input wedges and misallocation, I regress sector-level dispersion of wedges on the share of Chinese imports in total imports of input:

$$WedgeSD_{kt} = \alpha + \beta ShareCN_{kt} + \phi_k + \phi_t +_{ikt} \tag{25}$$

Where $WedgeSD_{kt}$ is the standard deviation of $MRPK$, $MRPL$ and $MRPX$ by sector K and year t.

Results are in table 3. The increasing share of Chinese inputs in total imported inputs decreases the dispersion of wedges on intermediate inputs and in lower extent the ones on labour. As described previously, the Chinese trade shock reduces relative wedges on inputs for firms in the mid-to-top productivity distribution, but increases wedges for the most productive firms that already import the optimal number of varieties before the trade liberalization. Allowing more firms to import intermediate inputs reduces dispersion of firm wedges and within-sector misallocation.

Table 3: Sector-level dispersion of wedges and share of imported inputs from China

	(1)	(2)	(3)
VARIABLES	MRPX SD_{kt}	MRPK SD_{kt}	MRPL SD_{kt}
Share CN_{kt}	-0.832**	0.160	-0.349*
	(0.414)	(0.303)	(0.206)
Observations	247	247	247
R-squared	0.822	0.827	0.952

MRPX SD_{kt}, MRPK SD_{kt} and MRPL SD_{kt} are the standard deviation of logs of $MRPX_{ikt}$, $MRPK_{ikt}$ and $MRPL_{ikt}$.The outcome variable is dispersion of firm-level wedges computed by 2-digit sector. All columns include industry and year fixed effects. The constant term is not reported. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, *p<0.1

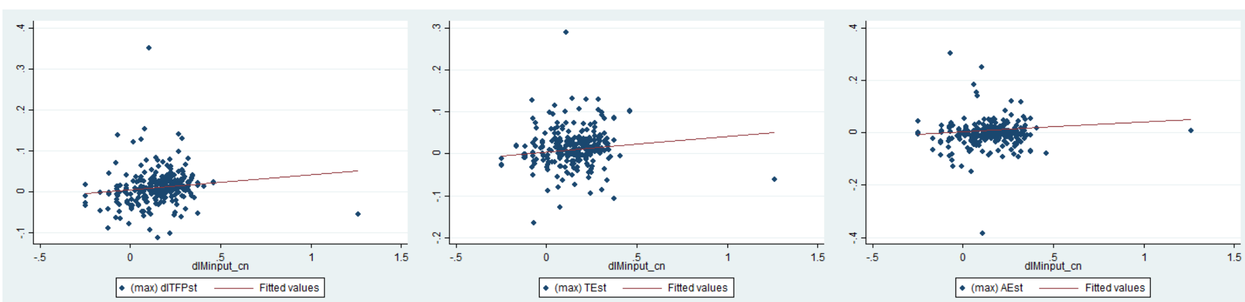
3.4. TFP growth and Chinese trade shock

The share of Chinese intermediate inputs in total imported inputs diminishes input wedge dispersion across firms and within-sector misallocation. In this section, I quantify the impact of Chinese trade shock on aggregate productivity growth and allocative efficiency in France. As I can only decompose the growth rate of TPF to identify allocative efficiency, variables used in this sector are in delta logs.

3.4.1. OLS baseline specification and results

In the data, the growth of Chinese imported intermediate goods is positively correlated with aggregate productivity growth in France (figure 5a) and its two sub-components, technical efficiency (figure 5b) and allocative efficiency (figure 5c).

Fig. 5. Correlation between annual growth rates of Chinese imports and aggregate productivity in France between 2000 and 2012



(a) Correlation between imported inputs and aggregate productivity (b) Correlation between imported inputs and technical efficiency (c) Correlation between imported inputs and allocative efficiency

Notes: Weighted average of sector-level measures. Each point represents a sector-year-level value. There are 22 manufacturing industries available between 2000 and 2012. Aggregate productivity growth is the sum of technical efficiency growth and allocative efficiency growth.
Source: Customs and Fiben databases

To further explore the link between Chinese trade flows and aggregate productivity growth, the baseline OLS specification takes the following form:

$$\Delta TFPR_{kt} = \alpha + \beta_1 \Delta CNinputs_{kt} + \beta_2 ShareCN_{kt-1} + \beta_3 TFPR_{kt-1} + \phi_s + \phi_t +_{kt} \quad (26)$$

Here $\Delta TFPR_{kt}$ is the change of log aggregate productivity growth or its sub-components: logs of technical efficiency ΔTE_{kt}, allocative efficiency ΔAE_{kt} and extensive margin $\Delta EXkt$, in industry k at the 2-digit Nace rev.2 level between years t and $t-1$. I use annual growth rates due to the decomposition constraint. Since the decomposition connects the four depend variables, the coefficients estimates for ΔTE_{kt}, ΔAE_{kt} and $\Delta EXkt$ sum up to the coefficient estimate for $\Delta TFPR_{kt}$. Distinguishing between these different margins allows me to quantify the impact of the trade shock on aggregate productivity, technical efficiency and allocative efficiency.

The main coefficient of interest is β_1 capturing the percentage change in sector TFP growth associated with the growth of Chinese imported intermediate inputs. The variable $\Delta CNinputs_{kt}$ is the annual change of log Chinese imported intermediate inputs in sector k between year t and $t-1$. Given the endogeniety issue (described in details in the next section), estimate of β_1 simply gives indicative correlation.

I control for the initial share of Chinese goods in total French imports of intermediate inputs, $ShareCN_{kt-1}$. If the initial share of Chinese goods in total French imports of inputs is high, higher TFP gains and a positive β_2 are expected. I also control for the initial level of $TFPR_{kt-1}$. β_3 is expected to be negative due to catch up effect: less productive gains are expected in sectors that are initial very productive.

Then I include industry and year fixed effects to absorb unobserved heterogeneity across sectors in the determinants of productivity and unobserved year-specific macro shocks.

Results from equation 26 for the period 1999-2012 are in the table 4. The dependant variable is sector aggregate TFP growth in column 1, technical efficiency in column 2, allocative efficiency in column 3 and extensive margin in column 4.

The signs on aggregate productivity and allocative efficiency are positive, even if it is not statistically significant. The non significativity of coefficients can be explained by the high correlation between sector productivity and trade. Endogeneity issues are deeply described in the next section.

3.4.2. Endogeniety of industry trade flows and productivity

The above OLS estimations characterize the correlation between the growth of Chinese imported inputs and aggregate productivity. This correlation may not identify the causal effect of trade on productivity because of endogeneity issues link to simultaneity and reverse causality biases (Berthou et al., 2017).

First, trade and sector performance can be jointly determined by some omitted variables. Such omitted variables would have to vary systematically over time within sectors given the industry fixed effects in the baseline OLS specification. For instance, they could be variations of macroeconomic conditions, speed variation of physical and human capital accumulations, etc. However the year fixed effect would capture most of macroeconomic variations in the short run.

Secondly, reverse causality brings up a more important concern as aggregate productivity

Table 4: OLS baseline

VARIABLES	(1) $\Delta TFPR_{kt}$	(2) ΔTE_{kt}	(3) ΔAE_{kt}	(4) $\Delta EXkt$
Δ CN inputs$_{kt}$	0.003	-0.027	0.024	0.006
	(0.032)	(0.030)	(0.037)	(0.017)
Share CN$_{kt-1}$	0.225	0.073	0.454	-0.302
	(0.203)	(0.369)	(0.426)	(0.190)
TFPR$_{kt-1}$	-0.199	0.033	-0.289*	0.057
	(0.152)	(0.097)	(0.158)	(0.100)
Observations	228	228	228	228
R-squared	0.359	0.143	0.163	0.301

All variables are in logs. The constant term is not reported. The outcome variable is delta logs of aggregate TFP, technical efficiency, allocative efficiency or extensive margin as indicated in the column heading. Robust standard errors are in parentheses. All columns include year and industry fixed effects. *** p<0.01, ** p<0.05, *p<0.1

can endogenously determine the amount of imported intermediate inputs. Observed import flows capture both endogenous demand conditions in the domestic country and exogenous supply conditions in the foreign country. Regarding the standard trade theory, if a sector becomes more productive, it increases its demand for intermediate inputs to respond to the rising final demand. Thus β_1 would biased upwards. However, a large share of intermediate inputs are traded within sector in French input-output tables. A low productive sector is less competitive from the perspective of foreign country and leads to more entry of foreign input suppliers. In that case,β_1 would be biased downward.

3.4.3. Baseline IV specification

To tackle these endogeneity issues and determine the causal effect of Chinese trade shock on French productivity, I develop a two-step least squares (2SLS) estimation strategy.

The ideal instrument for the growth and initial share of Chinese traded inputs would have a high predictive power in explaining the variation in trade flows and would affect the French sector productivity only through the trade channel. I would like to separate exogenous growth of Chinese input supply of product k from endogenous French import demand for product k.

I construct a Bartik-type instrument to capture the exogenous productivity shock in China. It combines information on country's initial trade structure with the global growth of foreign trade flows. First, I use the fraction of Chinese imports in industry k in 1999 to capture the initial structure of French trade in 1999, $\frac{M^{FR}_{CN,k99}}{M^{FR}_{k99}}$. I suppose that initial structure of trade in 1999 is not influenced by the China's productivity shock in 2000s. Secondly, I measure Chinese supply capacity in levels and delta logs. I use the total Chinese export value-added of intermediate inputs from WIOD database, $XVA_{CN,k,t}$. These instruments are in the spirit of Bloom, Draca, and Van Reenen (2014) and Berthou et al. (2017):

$$\Delta CNsupply_{kt} = \frac{M^{FR}_{CN,kt=0}}{M^{FR}_{kt=0}} \Delta XVA_{CN,k,t} \tag{27}$$

For the share of imported inputs from China, I compute the Chinese supply capacity in levels and then the world supply capacity :

$$ShareCNsupply_{kt} = \frac{\frac{M^{FR}_{CN,kt=0}}{M^{FR}_{kt=0}} XVA_{CN,k,t}}{\sum_c \frac{M^{FR}_{c,kt=0}}{M^{FR}_{kt=0}} XVA_{c,k,t}} \tag{28}$$

Where c is the origin countries of French imports of intermediate inputs and $XVA_{c,k,t}$ the exported value-added of French trading partners from WIOD database.

3.4.4. Baseline IV results

The 2SLQ first stage is in table 5. The dependant variable is the delta logs of Chinese imported inputs in column 1 and the share of Chinese imports in column 2. The two instrumental variables, the delta logs of Chinese supply and the share of Chinese supply in the world supply, have the expected signs in the two specifications. Increasing Chinese supply capacity rises imported inputs from China (column 1) and increasing the Chinese supply relatively to the world supply rises the share of Chinese imports in total imported inputs in France.

The second stage is in table 6 and represents the causal effect of Chinese trade shock on intermediate input market on French aggregate productivity growth between 2000 and 2012. First, changes in Chinese imported inputs significantly boost the aggregate productivity growth. In column 1, one percentage rise in Chinese import growth leads to 0.218% higher productivity growth. As Chinese imported inputs annually grow by 0.5 percentage point on average and annual sector TFP raises by 0.2 percentage point on average, Chinese trade shock explains a half of sector TFP gains between 2000 and 2007 in French manufacturing industry. Regarding columns 3, allocative efficiency is the main driver of aggregate productivity gains following the Chinese trade shock. As expected in the theoretical part, growing inputs from China significantly raises aggregate TFP growth via input reallocation across firms.

Table 5: IV baseline - First stage

VARIABLES	(1) Δ CN inputs$_{kt}$	(2) Share CN$_{kt}$
$\Delta CNinputsupply_{kt}$	0.278***	-0.022***
	(0.081)	(0.007)
Share CNsupply$_{kt-1}$	-0.039	
	(0.033)	
TFPR$_{kt-1}$	-0.403	
	(0.314)	
Share CNsupply$_{kt}$		0.021***
		(0.001)
TFPR$_{kt}$		0.072***
		(0.020)
Observations	228	247
R-squared	0.370	0.929

All variables are in logs. The constant term is not reported. The outcome variable is delta logs of Chinese imported inputs or the share of Chinese goods in total imports as indicated in the column heading. All columns include industry and year fixed effects. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Moreover the larger share of imports from China is the higher allocative efficiency grows. However the positive and significant impact of trade shock on allocative efficiency is partly cancelled by the extensive margin. Even if I can not properly measure entry and exit, the variation of the number of survivors significantly lowers sector productivity growth.

Results are robust after dropping the initial levels of TFP in the specification. The productivity levels can be correlated with the initial share of Chinese goods in total imports of intermediate goods. (see tables 11 and 12 in appendix).

Finally, I introduce the initial levels of R&D expenditure in the sector instead of the initial TFP. In table 13 in appendix, I use the stock of R&D expenditure as proxy for the initial level of productivity of sectors. The initial stock of R&D has a negative impact of the TFP growth due to the catching up effect, and coefficients on the growth of Chinese trade flows and initial share of Chinese goods are almost unchanged.

3.5. Trade margins and TFP gains

In the previous section, I find that aggregate productivity gains following the Chinese trade shocks are due to higher allocative efficiency of inputs across firms. In the theory, within-

Table 6: IV baseline - Second stage

VARIABLES	(1) $\Delta TFPR_{kt}$	(2) ΔTE_{kt}	(3) ΔAE_{kt}	(4) $\Delta EXkt$
Δ CN inputs$_{kt}$	0.218*	0.011	0.334**	-0.127*
	(0.117)	(0.144)	(0.166)	(0.073)
Share CN$_{kt-1}$	0.186	-0.859	1.664**	-0.618
	(0.477)	(0.619)	(0.830)	(0.411)
TFPR$_{kt-1}$	-0.116	0.105	-0.248	0.026
	(0.163)	(0.112)	(0.191)	(0.104)
Observations	228	228	228	228

All variables are in logs. The constant term is not reported. The outcome variable is delta logs of aggregate TFP, technical efficiency, allocative efficiency or extensive margins as indicated in the column heading. All columns include industry and year fixed effects. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

sector reallocation of resources is driven by the fall of marginal product of intermediate inputs. Gains from the variation of marginal costs becomes higher than the fixed cost for importing. The cost minimization gets incentive to firms to increase the numbers of imported varieties. More firms are able to import new input varieties at a lower price.

In this section, I look for trade margins that explain the positive impact Chinese import growth in values on aggregate productivity growth. The raise of total imports from China can be explained by the variation of average unit cost, the number of products or the number of importing firms.

3.5.1. Variations of average unit costs and TFP gains

In theory, variations of marginal cost of intermediate inputs can impact TFP growth and allocative efficiency only via the increase of the quantity imported by firms and no direct impact on TFP growth. To verify this hypothesis, I use the unit cost of imported inputs available in the customs data as a proxy for the marginal cost of imported goods. I follow the same OLS specification as in previous section:

$$\Delta TFPR_{kt} = \alpha + \beta_1 \Delta CNunitcost_{kt} + \beta_2 RatioUnitCost_{kt-1} + \beta_3 TFPR_{kt-1} + \phi_s + \phi_t +_{kt} \quad (29)$$

Where $\Delta CNunitcost_{kt}$ is the delta logs of average unit cost of imported inputs from China in sector k between t and $t-1$, $RatioUnitCost_{kt-1}$ is the ratio of Chinese average unit cost over the world average unit cost of imported inputs in France in sector k at time $t-1$.

In table 7, the decreasing average unit cost of intermediate inputs imported from China or the initial difference between Chinese and world average unit costs have no direct impact on aggregate TFP growth. However, the decreasing unit cost has a small, but significant, impact on technical efficiency. The negative sign on that coefficient means that the decreasing price of Chinese goods lower firm-level TFP growth. Prices of goods can reveal their quality and embodied technology. The decreasing unit cost can mean that firms import lower quality products. In Halpern, Koren, Szeidl, et al. (2015), the quality of imported goods directly enters in the measured TFP of firms and I could extent the model to take into account this negative counter part of decreasing marginal cost on firm and aggregate TFP growth.

Table 7: OLS - Average unit cost of imported inputs from China

VARIABLES	(1) $\Delta TFPR_{kt}$	(2) ΔTE_{kt}	(3) ΔAE_{kt}	(4) $\Delta EXkt$
$\Delta CNunitcost_{kt}$	-0.002	-0.006**	-0.001	0.005
	(0.001)	(0.003)	(0.004)	(0.003)
$RatioUnitCost_{kt-1}$	-0.001	-0.001	-0.002	0.002
	(0.001)	(0.002)	(0.003)	(0.002)
TFPR$_{kt-1}$	-0.188	-0.048	-0.279*	0.043
	(0.142)	(0.091)	(0.150)	(0.093)
Observations	228	228	228	228
R-squared	0.362	0.163	0.159	0.317

All variables are in logs. The constant term is not reported. The outcome variable is delta logs of aggregate TFP, technical efficiency, allocative efficiency or extensive margins as indicated in the column heading. All columns include industry and year fixed effects. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

3.5.2. Number of imported products and TFP gains

In theory, the fall of marginal cost raises the number of imported varieties used by firms. To measure if the increasing number of imported products from China, I use the number of HS-6 products imported from China in the customs data and measure their impact on productivity in the OLS specification:

$$\Delta TFPR_{kt} = \alpha + \beta_1 \Delta CNProductskt + \beta_2 ShareProdCN_{kt-1} + \beta_3 TFPR_{kt-1} + \phi_s + \phi_t +_{kt} \quad (30)$$

Where $\Delta CNProductskt$ is the delta logs of the number of products imported from China and $ShareProdCN_{kt-1}$ is the initial share of Chinese products in total number of imported intermediate goods.

In table 8, the increasing number of products imported from China has no direct impact on aggregate productivity growth (column 1). However the initial import penetration of Chinese goods significantly rises the allocative efficiency growth (column 3), but this positive impact is partly cancelled by the deterioration of technical efficiency (column 2).

Table 8: OLS - Average number of products imported from China

	(1)	(2)	(3)	(4)
VARIABLES	$\Delta TFPR_{kt}$	ΔTE_{kt}	ΔAE_{kt}	$\Delta EXkt$
$\Delta CNProductskt$	0.004	-0.031*	0.002	0.034
	(0.010)	(0.018)	(0.032)	(0.033)
Share Prod CN_{kt-1}	0.233	-0.450	1.297**	-0.613
	(0.277)	(0.521)	(0.598)	(0.393)
$TFPR_{kt-1}$	-0.198	0.077	-0.327**	0.053
	(0.149)	(0.095)	(0.148)	(0.087)
Observations	228	228	228	228
R-squared	0.358	0.156	0.186	0.374

All variables are in logs. The constant term is not reported. The outcome variable is delta logs of aggregate TFP, technical efficiency, allocative efficiency or extensive margins as indicated in the column heading. All columns include industry and year fixed effects. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

To disentangle these results, I go back to the theory. The wedges on intermediate inputs decrease if firms increase the total quantity of intermediate inputs used. However the quantity increases if firms decide to buy new varieties and keep the old ones. Here the non significant impact of the increasing number of products imported from China would mean that importers do not increase the total number of varieties used, but they only substitute former varieties by new Chinese ones.

3.5.3. Number of importers and TFP gains

In the previous section, the number of imported products does not drive the productivity gains following the increasing value of Chinese intermediate inputs. Here, I look at the number of firms importing from China to capture the other extensive margin of trade. I use the OLS specification:

$$\Delta TFPR_{kt} = \alpha + \beta_1 \Delta CNImporterskt + \beta_2 ShareImportersCN_{kt-1} + \beta_3 TFPR_{kt-1} + \phi_s + \phi_t +_{kt} \quad (31)$$

Where $\Delta CNImporterskt$ is the delta logs of the number of firms importing inputs from China and $ShareImportersCN_{kt-1}$ is the initial share of firms importing from China in total number of importers.

In table 9, the increasing number of firms importing intermediate inputs from China has a positive and significant impact on aggregate TFP growth (column 1). TFP gains are exclusively driven by higher allocative efficiency of resources across firms (column 3).

To sum up, TFP gains from trade are driven by reallocation of resources across firms and the decreasing marginal cost of inputs allow more firms to import cheaper foreign varieties. As more productive firms have access to a larger bundle of inputs, the firm-level wedges decreased for firms that are closed to threshold for importing before the shock. This decreases the dispersion of firm-level wedges and fosters aggregate productivity by improving allocative efficiency. This result confirms mechanisms described in the theory.

Table 9: OLS - Number of firms importing intermediate goods from China

	(1)	(2)	(3)	(4)
VARIABLES	$\Delta TFPR_{kt}$	ΔTE_{kt}	ΔAE_{kt}	$\Delta EXkt$
Δ CN Importers$_{kt}$	0.048**	-0.029	0.175***	-0.098
	(0.023)	(0.050)	(0.061)	(0.073)
Share Importers CN$_{kt-1}$	0.011	-0.008	0.068	-0.049
	(0.012)	(0.037)	(0.042)	(0.050)
TFPR$_{kt-1}$	-0.189	0.049	-0.283**	0.044
	(0.139)	(0.095)	(0.129)	(0.084)
Observations	228	228	228	228
R-squared	0.375	0.142	0.243	0.381

All variables are in logs. The constant term is not reported. The outcome variable is delta logs of aggregate TFP, technical efficiency, allocative efficiency or extensive margins as indicated in the column heading. All columns include industry and year fixed effects. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

4. Conclusion

This paper examines the impact of firm outsourcing strategy abroad on French aggregate productivity growth. More precisely, I study the effect of falling prices of Chinese intermediate inputs on French firms and aggregate TFP.

Theoretically, I show that decreasing marginal cost of foreign intermediate inputs has a direct impact on domestic aggregate productivity through input-output linkages. Falling prices of foreign intermediate goods allow more firms in the mid-to-top productivity distribution to outsource and to grow by reducing their production cost. This corrects resource misallocation due to market frictions that prevent these firms to outsource and positively contributes to aggregate productivity growth.

I then provide compiling quantitative evidence of the importance of allocative efficiency to aggregate productivity growth. First, I observe that misallocation, measured as dispersion of wedges on the marginal product of intermediate input, declines by 15% between 1999 and 2012. Secondly, I quantify both the aggregate productivity gains due to the Chinese shock and the contribution of technical efficiency and allocative efficiency separately. I show that one percentage point increases in the growth of Chinese intermediate inputs leads to a 0.2 percentage point higher TFP growth.The gains are fully explained by higher allocative efficiency.

The measure of firm-level distortions and the TFP decomposition allow me to measure efficiency gains after the Chinese trade shock but they are based on the CES demand assumption. One main caveat is that it does not allow to rule out alternative explications such as growing competition and demand shifting. To address these concerns, I could relax the CES assumption on the demand side which would allow firm markups to adjust after trade shock. This would be developed in future research.

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5. Appendix

5.1. *Market frictions on imported intermediate inputs*

Table 10: Barriers cited by French companies as important or very important for planned but not performed outsourcing abroad

	Total (%)	Share cited as very important (%)
Uncertainty about the quality of goods and services provided abroad	57	13
Need proximity to current customers	55	23
Concern from employees or unions in France	48	15
Legal or administrative barriers	48	15
Insufficient management and know-how	40	7
Tariffs and non-tariff barriers	39	8
Tax Issues	37	11
Difficulties in identifying suitable foreign suppliers	34	6
Language or cultural barriers	31	5
Risk of patent infringement or infringement of intellectual property	27	5
Access to finance and other financial constraints	25	3
Political or economic instability of the country or area	22	4

Notes: Survey condected by INSEE in the period 2009 to 2011 over 866 plants.

5.2. Exact decomposition of sectoral TFP

Regarding to the method proposed by Osotimehin (2016), the decomposition of productivity growth is given by :

$$\frac{TFPR_{st}}{TFPR_{st}} = I_{IN}I_{EX} \tag{32}$$

Where I_{IN} is the intensive margin and I_{EX} is the extensive margin.

By using equations (**??**), (**??**) and (**??**), I rewrite RVA, capital, labor and inputs used as function of firm-level productivity and distortions :

$$\begin{aligned}
g^Y(A_i,\tau_i) &= \Omega_{it}^{\frac{\theta}{1-\theta}}(1+\tau_{it^K})^{-\frac{\alpha\theta}{1-\theta}}(1+\tau_{it^L})^{-\frac{\beta\theta}{1-\theta}}(\mathrm{e}^{a_{it}G_i})^{-\frac{\gamma\theta}{1-\theta}} \\
g^K(A_i,\tau_i) &= \Omega_{it}^{\frac{\theta}{1-\theta}}(1+\tau_{it^K})^{-\frac{1-(1-\alpha)\theta}{1-\theta}}(1+\tau_{it^L})^{-\frac{\beta\theta}{1-\theta}}(\mathrm{e}^{a_{it}G_i})^{-\frac{\gamma\theta}{1-\theta}} \\
g^L(A_i,\tau_i) &= \Omega_{it}^{\frac{\theta}{1-\theta}}(1+\tau_{it^K})^{-\frac{\alpha\theta}{1-\theta}}(1+\tau_{it^L})^{-\frac{1-(1-\beta)\theta}{1-\theta}}(\mathrm{e}^{a_{it}G_i})^{-\frac{\gamma\theta}{1-\theta}} \\
g^X(A_i,\tau_i) &= \Omega_{it}^{\frac{\theta}{1-\theta}}(1+\tau_{it^K})^{-\frac{\alpha\theta}{1-\theta}}(1+\tau_{it^L})^{-\frac{\beta\theta}{1-\theta}}(\mathrm{e}^{a_{it}G_i})^{-\frac{1-(1-\gamma)\theta}{1-\theta}}
\end{aligned} \tag{33}$$

And :

$$\begin{aligned}
\Delta TFPR_{st} = \left(\frac{n_{st}}{n_{st-1}}\right)^{\frac{\theta-1}{\theta}} &\left(\frac{\sum_{i\in N_{st}} g^Y(A_{it},\tau_{it})}{\sum_{i\in N_{st}} g^Y(A_{it-1},\tau_{it-1})}\right)^{\frac{1}{\theta}} \left(\frac{\sum_{i\in N_{st}} g^K(A_{it},\tau_{it})}{\sum_{i\in N_{st}} g^K(A_{it-1},\tau_{it-1})}\right)^{-\alpha} \\
&\left(\frac{\sum_{i\in N_{st}} g^L(A_{it},\tau_{it})}{\sum_{i\in N_{st}} g^L(A_{it-1},\tau_{it-1})}\right)^{-\beta} \left(\frac{\sum_{i\in N_{st}} g^X(A_{it},\tau_{it})}{\sum_{i\in N_{st}} g^C(A_{it-1},\tau_{it-1})}\right)^{-\gamma}
\end{aligned} \tag{34}$$

Where

$$\begin{aligned}
I_{IN} = &\left(\frac{\sum_{i\in C_{st}} g^Y(A_{it},\tau_{it})}{\sum_{i\in C_{st}} g^Y(A_{it-1},\tau_{it-1})}\right)^{\frac{1}{\theta}} \left(\frac{\sum_{i\in C_{st}} g^K(A_{it},\tau_{it})}{\sum_{i\in C_{st}} g^K(A_{it-1},\tau_{it-1})}\right)^{-\alpha} \\
&\left(\frac{\sum_{i\in C_{st}} g^L(A_{it},\tau_{it})}{\sum_{i\in C_{st}} g^L(A_{it-1},\tau_{it-1})}\right)^{-\beta} \left(\frac{\sum_{i\in C_{st}} g^X(A_{it},\tau_{it})}{\sum_{i\in C_{st}} g^X(A_{it-1},\tau_{it-1})}\right)^{-\gamma}
\end{aligned} \tag{35}$$

And

$$I_{EX} = \left(\frac{n_{st}}{n_{st-1}}\right)^{\frac{\theta-1}{\theta}} \left(\frac{\sum_{i\in N_{st}} g^Y(A_{it},\tau_{it})}{\sum_{i\in N_{st-1}} g^Y(A_{it-1},\tau_{it-1})} \frac{\sum_{i\in C_{st}} g^Y(A_{it-1},\tau_{it-1})}{\sum_{i\in C_{st}} g^Y(A_{it-1},\tau_{it-1})}\right)^{\frac{1}{\theta}}$$
$$\left(\frac{\sum_{i\in N_{st}} g^K(A_{it},\tau_{it})}{\sum_{i\in N_{st-1}} g^K(A_{it-1},\tau_{it-1})} \frac{\sum_{i\in C_{st}} g^K(A_{it-1},\tau_{it-1})}{\sum_{i\in C_{st}} g^K(A_{it-1},\tau_{it-1})}\right)^{-\alpha}$$
$$\left(\frac{\sum_{i\in N_{st}} g^L(A_{it},\tau_{it})}{\sum_{i\in N_{st-1}} g^L(A_{it-1},\tau_{it-1})} \frac{\sum_{i\in C_{st}} g^L(A_{it-1},\tau_{it-1})}{\sum_{i\in C_{st}} g^L(A_{it-1},\tau_{it-1})}\right)^{-\beta}$$
$$\left(\frac{\sum_{i\in N_{st}} g^X(A_{it},\tau_{it})}{\sum_{i\in N_{st-1}} g^X(A_{it-1},\tau_{it-1})} \frac{\sum_{i\in C_{st}} g^X(A_{it-1},\tau_{it-1})}{\sum_{i\in C_{st}} g^X(A_{it-1},\tau_{it-1})}\right)^{-\gamma} \quad (36)$$

Then, I decompose I_{IN} in two components by using Fischer indexes: the technical efficiency (TE) and the allocative efficiency (AE)

5.3. Validation of the Productivity Dynamics

In figure 6, aggregated revenue-based TFP growth computed from the sub-sample of continuing firm in manufacturing sectors coming from Fiben follows a similar pattern than the aggregated productivity growhth provided by Euklems database in manufacturing industries and OECD database for the whole economy. In 2008, the productivity growth dramatically falls regarding the EU klems data. I do not get the same trend in the sample used because I only consider continuing firms which are the most productive and the most resilient firms. Then, using a three-factor production function allows for comparison between gross output-based and value added-based productivity. Gandhi, Navarro, and Rivers (2016) show that productivity is less heterogeneous across firms in revenue setup because revenue-based productivity has a smaller dispersion. This is due to the fact that value added-based productivity is differences in value added holding capital and labor fixed, while revenue-based productivity is differences in revenue holding three inputs fixed. In figure 7, the two types of productivity follow a similar trend even if revenue-based productivity is less volatile.

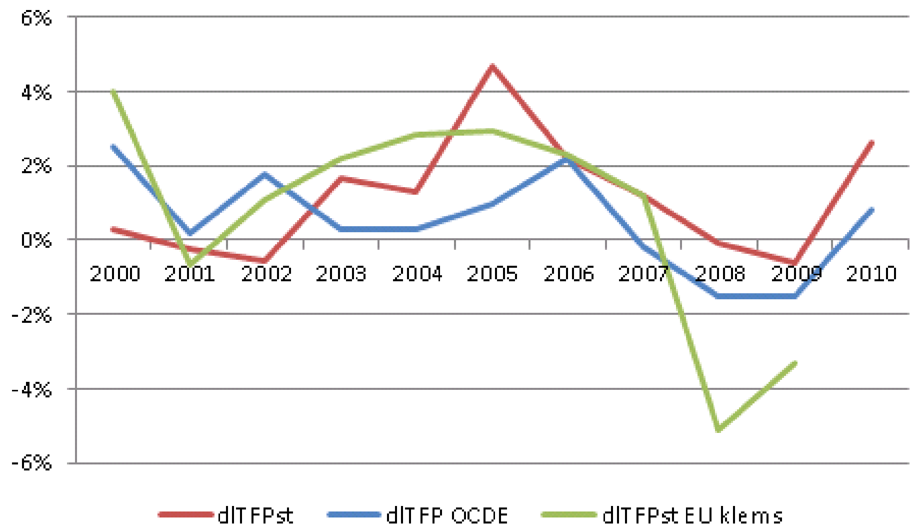
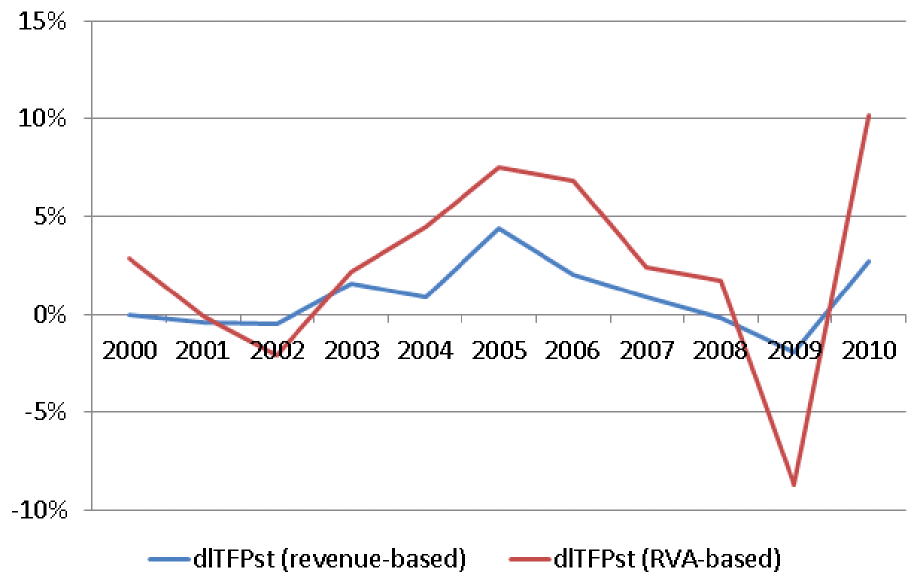


Fig. 6. TFP growth coming from Fiben,OECD and EUklems databases

Notes : dTFPst is a weighted average of sector revenue-based TFP growth based the sub-sample of continuing firm in manufacturing sectors coming from Fiben. dlTFPst EU klems is Weighted average of entire manufacturing sector RVA-based TFP growth coming from EU klems database.dlTFP OECD is RVA-based TFP growth of the entire economy coming from OECD.

Fig. 7. Revenue-based TFP growth and RVA-based TFP growth in French Manufacturing Industries



Notes: Weighted average of sector-level measures.

5.4. *Robustness check*

Results remain stable when we drop the initial levels of TFP that is correlated with the share of Chinese imports in total imports of intermediate inputs.

Table 11: IV baseline without the initial level of TFP - First stages

	(1)	(2)
	a	b
VARIABLES	Δ CN inputs$_{kt}$	Share CN$_{kt-1}$
$\Delta CNinputsupply_{kt}$	0.267***	-0.017**
	(0.083)	(0.007)
Share CNsupply$_{kt-1}$	-0.042	
	(0.033)	
Share CNsupply$_{kt}$		0.022***
		(0.001)
Observations	228	247
R-squared	0.359	0.921

All variables are in logs. The constant term is not reported. The outcome variable is delta logs of Chinese imported inputs or the share of Chinese goods in total imports as indicated in the column heading. All columns include industry and year fixed effects. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 12: IV baseline without the initial level of TFP - Second stages

	(1)	(2)	(3)	(4)
VARIABLES	$\Delta TFPR_{kt}$	ΔTE_{kt}	ΔAE_{kt}	$\Delta EXkt$
Δ CN inputs$_{kt}$	0.204*	0.024	0.304*	-0.124*
	(0.113)	(0.146)	(0.166)	(0.070)
Share CN$_{kt-1}$	0.109	-0.789	1.499**	-0.601
	(0.407)	(0.611)	(0.739)	(0.364)
Observations	228	228	228	228

All variables are in logs. The constant term is not reported. The outcome variable is delta logs of aggregate TFP, technical efficiency, allocative efficiency or extensive margins as indicated in the column heading. All columns include industry and year fixed effects. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 13: IV baseline with initial RD expenditure - Second stages

	(1)	(2)	(3)	(4)
VARIABLES	$\Delta TFPR_{kt}$	ΔTE_{kt}	ΔAE_{kt}	$\Delta EXkt$
Δ CN inputs$_{kt}$	0.213*	0.023	0.317*	-0.127*
	(0.120)	(0.149)	(0.170)	(0.072)
Share CN$_{kt-1}$	0.282	-0.802	1.745**	-0.661*
	(0.513)	(0.637)	(0.787)	(0.381)
R&D expenditure$_{kt-1}$	-0.021	0.002	-0.030	0.007
	(0.025)	(0.016)	(0.027)	(0.007)
Observations	228	228	228	228

All variables are in logs. The constant term is not reported. The outcome variable is delta logs of aggregate TFP, technical efficiency, allocative efficiency or extensive margins as indicated in the column heading. All columns include industry and year fixed effects. Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1