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Abstract

In the process of economic development, the share of manufacturing in total employment first increases and then declines after incomes per capita have passed a given threshold. Advanced economies are all beyond that threshold and thus experience a secular decline in the share of manufacturing. Baumol explained such a process of deindustrialization as resulting from faster productivity growth in manufacturing relative to services. More recently, trade with emerging economies, especially with China, is often identified as the main determinant of deindustrialization in advanced economies. Disentangling the trade channel from the traditional productivity channel is a complicated task. In this paper, we develop a simple model of structural change in an open economy to derive empirical implications, which we analyze for a sample of OECD countries. The model is based on trade between advanced and emerging economies. In a closed economy framework, faster productivity in manufacturing induces a fall in the share of manufacturing in total employment but not in total value added. By contrast, in open economies, what matters is not only the relative growth of productivity in manufacturing versus domestic services, but also relative productivity growth of domestic versus foreign manufacturing. When productivity growth of domestic manufacturing is faster than that of services but slower than that of foreign manufacturing, the share of manufacturing in advanced economies may fall, both in terms of value added and of employment. We call this phenomenon "twin deindustrialization." We exploit the comparison between estimates for the employment and value added shares to identify the relevance of the trade channel relative to the pure productivity channel. We find significant and quantitatively relevant effects of trade on structural change in advanced economies. Furthermore, we show that the strength of the trade effect depends on the nature of technological progress occurring in emerging economies.

JEL Classification: E21, E22, F31, F41, O40

Keywords: structural change, deindustrialization, open economies

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Structural Change and the China Syndrome: Baumol vs Trade Effects

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Abstract

In the process of economic development, the share of manufacturing in total employment first increases and then declines after incomes per capita have passed a given threshold. Advanced economies are all beyond that threshold and thus experience a secular decline in the share of manufacturing. Baumol explained such a process of deindustrialization as resulting from faster productivity growth in manufacturing relative to services. More recently, trade with emerging economies, especially with China, is often identified as the main determinant of deindustrialization in advanced economies. Disentangling the trade channel from the traditional productivity channel is a complicated task. In this paper, we develop a simple model of structural change in an open economy to derive empirical implications, which we analyze for a sample of OECD countries. The model is based on trade between advanced and emerging economies. In a closed economy framework, faster productivity in manufacturing induces a fall in the share of manufacturing in total employment but not in total value added. By contrast, in open economies, what matters is not only the relative growth of productivity in manufacturing versus domestic services, but also relative productivity growth of domestic versus foreign manufacturing. When productivity growth of domestic manufacturing is faster than that of services but slower than that of foreign manufacturing, the share of manufacturing in advanced economies may fall, both in terms of value added and of employment. We call this phenomenon "twin deindustrialization." We exploit the comparison between estimates for the employment and value added shares to identify the relevance of the trade channel relative to the pure productivity channel. We find significant and quantitatively relevant effects of trade on structural change in advanced economies. Furthermore, we show that the strength of the trade effect depends on the nature of technological progress occurring in emerging economies.

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1 Introduction

The decline of the share of manufacturing in total GDP and in total employment has become a key concern for policymakers in advanced economies. In the public debate, one of the main causes for such deindustrialization is identified in the surge of imports from emerging economies, China in primis. The relevance of the import channel is contrasted with the effect due to fast productivity growth in manufacturing relative to services. The issue, especially in connection with the US experience, has attracted a rapidly growing attention in academic analyses as well.

Autor et al. (2013) study the impact of exposure to Chinese imports on local labor markets in the US. Similarly, Acemoglu et al. (2016) and Pierce and Schott (2012) analyze the effects of import penetration from China on US manufacturing employment, while Bloom et al. (2016) analyze the impact of pressure from Chinese imports on innovation by US firms. According to this literature, the growing exposure to Chinese imports exerted significant effects on employment and innovation in US firms.

In this paper, we use the exposure to Chinese imports as a way to identify a more general effect of international trade on structural change, defined as the process of relative dynamics across different macro-sectors of the economy. As our focus is on advanced economies, we concentrate on the relative dynamics of manufacturing versus services. The main objective of the paper is to identify and quantify the relative importance of the trade channel in explaining the reduction of the share in employment (and in value added) of manufacturing sectors in OECD countries during the period 1990-2007, prior to the global financial crisis.[1]

Traditionally, the literature on structural change has been overwhelmingly based on closed-economy models.[2] There are a few notable exceptions that emphasize the relevance of exposure to trade on structural change, such as Matsuyama (2009) and Uy et al. (2013) . In the traditional closed economy model, deindustrialization generally arises because of a faster growth in productivity in manufacturing relative to services (the well known Baumol effect[3]) and because of non-homothetic preferences , which imply that demand shifts towards services as incomes increase.[4] As shown by Matsuyama (2009), in an interdependent world with free trade, deindustrialization might be stronger for high income countries, as not only labor shifts from home manufacturing to services (which we define as the Baumol effect), but also labor shifts from home manufacturing to manufacturing industries in emerging countries, which are catching up in productivity with richer countries (we define this as the trade effect). Both effects operate through a price channel. While the Baumol effect acts through the relative price of manufacturing goods versus the little substitutable services, the trade effect acts through the relative prices of man-

[1]The choice of excluding the period covering the global financial crisis is partly due to considerations of data availability. However, it is likely that specific financial factors operated during the financial crisis, and these may complicate the identification of the structural factors that are the focus of the paper.

[2]See the survey by Herrendorf et al. (2014).

[3]This was first proposed byBaumol (1967) and it is also known as the cost disease (see Imbs (2014)).

[4]See (Kongsamut et al., 2001) , Gollin et al. (2002) and Foellmi and Zweimüller (2008).

ufacturing in advanced countries versus the highly substitutable goods produced in emerging countries. In the literature on structural change, two main forces have been stressed: the income effect and the relative price mechanism. Income effects are derived by assuming non-homothetic preferences, which give rise to an increase in the share of total demand directed towards services. The relative price mechanism is induced by differential growth rates in productivity in manufacturing versus service sectors. This unbalanced productivity growth is associated with the shift of resources from manufacturing to services, as emphasized in Ngai and Pissarides (2007). As the focus of our paper is on international trade, we follow Ngai and Pissarides (2007) and assume homothetic preferences and unbalanced productivity growth in manufacturing relative to service sectors. Interestingly, Herrendorf et al. (2013) show that if one focuses on value added (instead of final expenditure), such assumption is consistent with the main stylized facts on structural change.

Assuming homothetic preferences and low substitutability between manufacturing goods and services, the Baumol effect induces deindustrialization as measured by employment shares but not by value added shares. By contrast, the trade effect induces deindustrialization in both employment and value added. This is a crucial empirical implication that we exploit in the paper.

The relevance of the trade effect for the deindustrialization process in advanced economies, in particular the impact of the exposure to low income countries, was dismissed in the older trade literature. One main reason was that the share of low income countries in the imports of high-income countries was small until the beginning of the 1990s Krugman (2000). In 1991, low-income countries accounted for just 9 percent of US manufacturing imports. However, the situation markedly changed during the 1990s and even more during the 2000s. In 2000 the share of low-income countries in total US imports had increased to 15 percent, to then climb to 28 percent in 2007. Among low income countries, China alone accounted for nearly 90 percent of this growth. [5]

A similar pattern can be observed for other high income countries, which also experienced an increased exposure of their domestic industries to the fast growing Chinese manufacturing. [6]

Although the exposure of industries in advanced economies to imports from China continuously increased in the last three decades, there was a clear acceleration in the 2000s, following the entry of China in the WTO. Furthermore, following he entry in the WTO, Chinese exports experienced a significant change in their structure, with a jump in the share of ICT exports in total exports. Therefore, competition from Chinese exports is not limited to traditional sectors, but it involves as well more technologically advanced sectors.

The main novel contribution of the paper is that we use the above two stylized

[5] Autor et al. (2013).

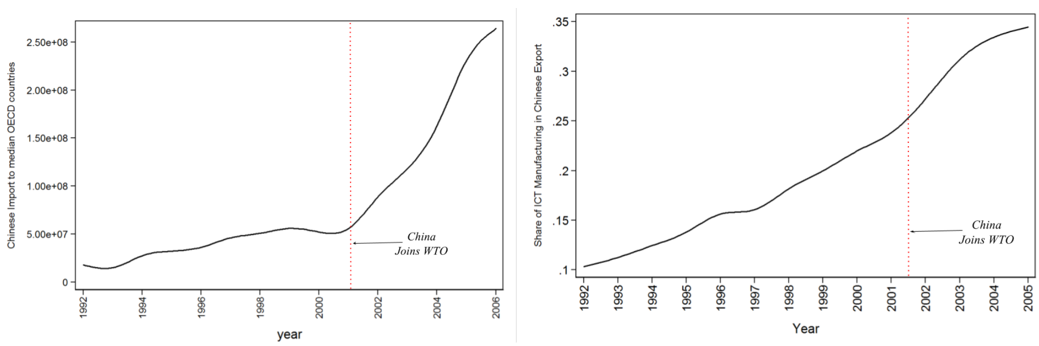
[6] China experienced a spectacular productivity growth through sweeping economic reforms initiated in the 1980s and extended in the 1990s Hsieh and Ossa (2016). These resulted in rural to urban migration flows in excess of 150 million workers Li et al. (2012), and massive capital accumulation Brandt et al. (2012).

facts as instruments for the identification of the trade effect on structural change in OECD countries. Indeed, we implement a difference-in-difference approach, analyzing post-versus-pre WTO entry periods and the exposure to Chinese imports in ICT vs non-ICT sectors. Our results indicate that indeed exposure to competition from Chinese exports significantly affected employment in OECD countries. Furthermore, such effect is stronger for ICT industries. Comparing results for employment and value added shares, we find that the trade channel was significant, as the more exposed industries experienced a fall in their share in both employment and value added.

The rest of the paper is structured as follows. Section 2 illustrates the main stylized facts associated to the growing exposure to Chinese imports of industries in OECD countries and the potentially related process of structural change taking place in those countries. In section 3, we present a simple model that serves to highlight the main channels affecting structural change, namely the socalled Baumol effect, occurring as well in a closed economy, and the trade effect. In section 4, we illustrate the characteristics of the dataset and the construction of our index for import exposure. Furthermore, we describe our empirical methodology and the strategy adopted for identifying the trade effect. Section 5 presents our main empirical results. Section 6 contains some concluding remarks.

2 Exposure to Imports from China and Structural Change in OECD Countries: Stylized Facts

Figure 1(a) illustrates the acceleration of the exposure to Chinese imports after China joined the WTO in 2001. Chinese imports in the median OECD country increased almost five times from 2001 to 2007. Moreover, a fact scarcely noticed, the structure of Chinese exports significantly changed over time, with the gradual specialization of China in ICT manufacturing exports.

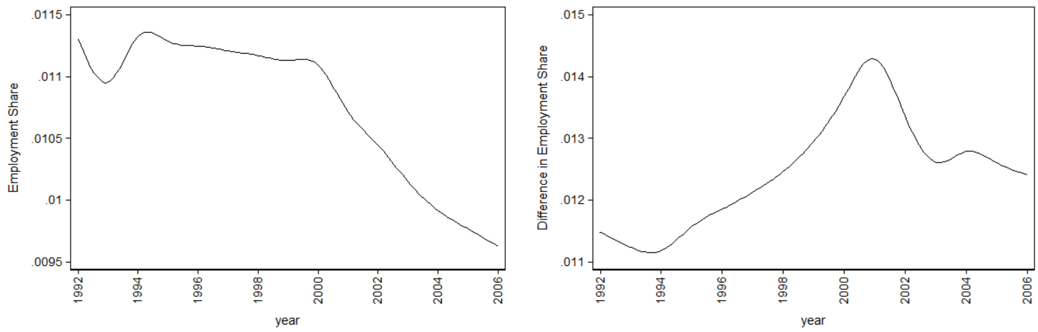


(a) Chinese Import Exposure in OECD

(b) Share of ICT in Chinese export

Figure 1

Figure 1(b) indicates that the share of ICT manufacturing increased from the early 1990s to the 2000s . More important, this trade specialization in ICT manufacturing sharply accelerated after 2001, with the share of ICT in total Chinese exports reaching almost 35%.



(a) Employment Share of Average Manufacturing Sector in OECD (b) Difference in Employment Share , Average ICT vs Average Non ICT

Figure 2

The two stylized facts about the magnitude and the product concentration of the exposure to Chinese imports mirror two stylized facts about the magnitude and characteristics of structural change. Figure 2 (a) indicates that the pace of the decline of the share of manufacturing in total employment is markedly faster during the 2000s compared with the 1990s. Interestingly, such an acceleration in the fall in the employment share of manufacturing is associated with a deeper fall in the share of employment in ICT sectors (here identified in Electrical/Optical industries). Figure 2 (b) indicates the difference between the employment share of ICT and non-ICT sectors in OECD countries during the period 1992- 2007. The relative share of ICT to Non-ICT sectors steadily increased during the 1990s. However, this pattern was reversed after 2001.

This stylized fact is useful to understand the process of deindustrialization in OECD countries during the 2000s, and, in particular, it sheds light on the determinants of the acceleration of such deindustrialization since the beginning of the 2000s. During the 1990s, employment in the ICT sectors contracted much less than the average manufacturing sector in OECD countries and this helped reducing the overall deindustrialization during that decade. By contrast, during the 2000s the sectoral distribution of structural change in OECD countries dramatically changed.

Employment in the ICT sectors dropped at a rate much faster than in the other sectors, significantly contributing to the acceleration in the process of deindustrialization that occurred during the years 2000s.

The overall acceleration of deindustrialization during the 2000s and the differential pattern of sectoral structural change in ICT vs Non-ICT industries in OECD countries suggest the potential role of international trade, through the drastic increase in import exposure to fast growing Chinese manufacturing and through an increasing exposure to Chinese exports in ICT manufacturing sectors.

We investigate this question by dividing sectors according to the increase in their import exposure from the 1990s to the 2000s. We compare the sectoral structural change of those country-industry pairs that have been experiencing the higher increase in their Chinese import exposure with those industries that have experienced a lower increase in their exposure. Moreover, dividing our sample into ICT and Non-ICT sectors, we aim to better identify the potential role of the trade effect on structural change, as the growth in the exposure to Chinese imports during the 2000s took place in ICT sectors. In the next section, we present a highly simplified model of structural change in an open economy, with the goal of identifying in the sharpest way the hypotheses we wish to verify in the empirical analysis.

3 A Simple Model

We consider a small open economy comprising two sectors, manufacturing and services. For simplicity, we assume that manufacturing goods are tradable, whereas services are not tradable. There is a continuum of identical consumers whose mass is normalized to one. Each individual consumer inelastically supplies labor to the firms, and, as the owner of the firms, collects the firms' profits. The consumer consumes services and manufactured goods, which consist of bundles of different varieties of domestic and foreign products. The consumer chooses consumption of the foreign/domestic manufacturing goods and services to maximize utility

$$U = [(1-\gamma)^{\frac{1}{\theta}} c_s^{\frac{\theta-1}{\theta}} + \gamma^{\frac{1}{\theta}} (\gamma'^{\frac{1}{\nu}} c_{m_h}^{\frac{\nu-1}{\nu}} + (1-\gamma')^{\frac{1}{\nu}} c_{m_f}^{\frac{\nu-1}{\nu}})^{\frac{\nu}{\nu-1}\frac{\theta-1}{\theta}}]^{\frac{\theta}{\theta-1}} \quad (1)$$

subject to the budget constraint

$$P_h c_{m_h} + P_f c_{m_f} + P_s c_s = w_h L_h + \pi_h \quad (2)$$

where ν denotes the elasticity of substitution between home and foreign manufacturing products, while θ denotes the elasticity of substitution between tradable and non-tradable goods. The first order conditions for utility maximization by home consumers determine the consumption of home and foreign manufacturing relative to services.

$$\begin{aligned} \frac{C_{mh}}{C_s} &= \gamma' \frac{\gamma}{1-\gamma} (\frac{P_s}{P_h})^{\theta} (\gamma' + (1-\gamma')(\frac{P_h}{P_f})^{\nu-1})^{\frac{\theta-\nu}{\nu-1}} \\ \frac{C_{mf}}{C_s} &= (1-\gamma') \frac{\gamma}{1-\gamma} (\frac{P_s}{P_f})^{\theta} (\gamma'(\frac{P_f}{P_h})^{\nu-1} + (1-\gamma'))^{\frac{\theta-\nu}{\nu-1}} \end{aligned}$$

The first line of F.O.Cs gives the domestic demand for home manufacturing relative to services. Combining the second line of our F.O.Cs with the balanced trade condition, we obtain the foreign demand for home manufacturing relative to services

$$C^*_{mf} = (1-\gamma') \frac{\gamma}{1-\gamma} (\frac{p_f}{p_h})^{1-\nu} (\frac{P_s}{P_h})^{\theta} (\gamma' + (1-\gamma')(\frac{P_h}{P_f})^{\nu-1})^{\frac{\theta-\nu}{\nu-1}} C_s \quad (3)$$

From the above conditions, we can derive the demand for home manufacturing (the sum of domestic and foreign demand) relative to services. Moreover, imposing the equilibrium conditions in the domestic markets for services and manufacturing (with balanced trade), relative consumption equals relative output:

$$\frac{y_m}{y_s} = \frac{C_m}{C_s} = \frac{C_{mh} + C^*_{mf}}{C_s} \overbrace{\frac{\gamma}{1-\gamma}(\frac{P_s}{P_h})^{\theta}}^{Baumol\,effect}\overbrace{[(\gamma' + (1-\gamma')(\frac{P_f}{P_h})^{1-\nu})^{\frac{1}{1-\nu}}]^{1-\theta}}^{Trade\,Effect} \tag{4}$$

Denoting with Φ_y the share of manufacturing in total output, and assuming, for simplicity, that ν is close to 1, (4) can be rewritten as:

$$\Phi_y = \frac{\phi_y}{1-\phi_y} = \frac{y_m}{y_s} = \frac{\gamma}{1-\gamma}(\frac{P_M}{P_S})^{-\theta}(\frac{P_F}{P_M})^{(1-\theta)(1-\gamma\prime)} \tag{5}$$

The sectoral shares crucially depend on two channels, the Baumol effect and the trade effect, which in turn operate through the relative price of home manufacturing vs services and through the relative price of home manufacturing vs foreign manufacturing. Interestingly, the quantitative effect of the trade channel crucially depends on the share of foreign manufacturing in the total manufacturing consumption of domestic consumers, which is given by $1-\gamma\prime$. As noted above, before the 1990s, the share of manufacturing imports from emerging economies in the GDP of advanced economies was almost insignificant. This share surged in the 2000s, especially because of the surge in Chinese exports.

In the next section we add the supply side to the model, which allows us to rewrite the relative price channels in terms of relative productivity growth and relatie wages. In order to derive the relative dynamics of employment and value added in the two sectors and distinguish the domestic sources from the foreign trade sources of structural change, we build an extremely simple model for the supply side.

3.1 The production side

We assume that services and manufacturing (both home and foreign) are produced by continuum of identical firms, whose mass is normalized to one. Production of the representative firm i is a function of labor (l), which is the only variable factor

$$y_i = F(A_i, l_i) = A_i l_i^{\alpha} \tag{6}$$

with $\alpha \leq 1$.

Let us begin with a closed economy framework. Labor can freely move across sectors, which implies that wages are equalized across sectors. Assuming a competitive labor market, workers are paid their marginal product in each sector:

$$\alpha A_i l_i^{\alpha-1} P_i = W_i \tag{7}$$

for $i = (m, s)$. The above conditions imply:

$$\frac{P_s}{P_m} = (\frac{l_m}{s})^{\alpha-1}\frac{A_m}{A_s} \tag{8}$$

Using the relative demand of the two goods, as a function of relative prices, setting the equilibrium condition $c_i = y_i$ and using the production function, we obtain the following condition for the ratio of employment in manufacturing in terms of services:

$$\frac{l_m}{l_s} = (\frac{A_m}{A_s})^{-\frac{1-\theta}{\alpha(1-\theta)+\theta}} \tag{9}$$

.

Log-differenting the above equation, with $\hat{x}$ denoting the percentage change of x, we can derive the dynamics of the relative employment in the two sectors:

$$\hat{l}_m - \hat{l}_s = -\frac{1-\theta}{\alpha(1-\theta)+\theta}(\hat{A}_m - \hat{A}_s) \tag{10}$$

Similarly, for the share in value added, we obtain:

$$\frac{y_m}{y_s} = (\frac{A_m}{A_s})^{\frac{\theta}{\alpha(1-\theta)+\theta}} \tag{11}$$

which implies that the change in the relative value added in the two sectors is

$$\hat{y}_m - \hat{y}_s = \frac{\theta}{\alpha(1-\theta)+\theta}(\hat{A}_m - \hat{A}_s) \tag{12}$$

Equations 10 and 12 indicate that in a closed economy framework there are two key parameters that determine the magnitude of the productivity-gap-driven structural change.[7] First, the output elasticity of labor, α : with high elasticity, there will be a stronger cross-sectoral reallocation for both value added and labor.

The second parameter is given by the substitutability in demand between manufacturing and services θ : when the elasticity of substitution is low, demand survives even in sectors with rising relative prices (i.e. services with low productivity growth). This induces a larger reallocation of labor towards low productivity sectors. Under our maintained assumption of θ close to zero, equation 12 implies that the manufacturing share in value added remains constant, in spite of the differential productivity growth in the two sectors. In summary, differential productivity growth across sectors causes structural change with respet to employment shares but not with respect to value added.

[7] For a similar discussion of these two parameters see Imbs (2014),Ngai and Pissarides (2007) and Acemoglu and Guerrieri (2008)

Let us now consider the open economy case. We assume competitive goods and labor markets, and perfect labor mobility across sectors within the country, but no mobility of labor across countries. To simplify the algebra and derive the simple expressions for the dynamics of the value added and employment shares in the main text, we assume a linear production function:

$$y_i = A_i l_i \tag{13}$$

In an open economy, the following condition on relative prices holds:

$$(\frac{p_m}{p_s})^\theta = \frac{c_s}{c_m}\frac{\gamma}{(1-\gamma)}(\gamma' + (1-\gamma')\frac{p_h}{p_f}^{1-\nu})^{\frac{1-\theta}{1-\nu}} \tag{14}$$

Log-differentiating the above expression, and imposing the equlibrium conditions $c_i = y_i$, for $i = (m, s)$, yields:

$$\hat{y}_m - \hat{y}_s = -\theta(\hat{p}_m - \hat{p}_s) + (1-\theta)(1-\gamma')(\hat{p}_h - \hat{p}_f) \tag{15}$$

Under perfect competition, prices equal marginal costs:

$$p_i = \frac{w_i}{A_i} \tag{16}$$

Assuming perfect mobility across sectors, the dynamics of sectoral relative prices between manufacturing and services only depends on the dynamics of relative productivity

$$\hat{p}_s - \hat{p}_m = \hat{A}_m - \hat{A}_s \tag{17}$$

By contrast, lack of labor mobility across countries implies that the relative price of domestic manufacturing versus foreign manufacturing follows the dynamics:

$$\hat{p}_m - \hat{p}_{m^*} = (\hat{A}_m - \hat{A}_{m^*}) - (\hat{w}_{m^*} - \hat{w}_{m^*}) \tag{18}$$

Substituting the above two expressions in equation 15, we obtain the dynamics for value added. The dynamics of value added shares is a function of the relative growth of productivity in home manufacturing vs services (Baumol effect) and of the relative growth of productivity of home manufacturing vs foreign manufacturing (trade effect).

As we are focusing on trade of advanced with emerging economies (North-South trade), the maintained assumption is that the productivity growth in manufacturing is higher in emerging countries, which are catching up to the levels of productivity of advanced economies. The dynamics of the share of manufacturing in total value added is thus:

$$\hat{\Phi}_y = \overbrace{\theta(\hat{A}_m - \hat{A}_s)}^{Baumol\,effect} - \overbrace{(1-\theta)(1-\gamma\prime)[(\hat{A}_F - \hat{A}_m) - (\hat{w}_F - \hat{w}_m)]}^{Trade\,Effect} \tag{19}$$

The closed economy channel (Baumol effect) implies that a faster growth in productivity in manufacturing relative to services would increase the manufacturing share. However, given the low substitutability in consumption of manufacturing and services, θ is likely to be close to zero and thus, absent the trade effect, the share of manufacturing in total value added remains constant, at the value $\frac{\gamma}{1-\gamma}$. Therefore, with low substitutability in consumption between manufacturing and services, deindustrialization as measured in terms of value added shares occurs entirely through the trade channel.

To move from the dynamics of the value added shares to the employment shares , we simply use the following relationship from the production function:

$$\hat{l}_i = \hat{y}_i - \hat{A}_i \tag{20}$$

Analyzing employment shares,the dynamics of the employment share of manufacturing in total employment is given by the following equation:

$$\hat{\Phi}_l = -\overbrace{(1-\theta)(\hat{A}_m - \hat{A}_s)}^{Baumol\,effect} - \overbrace{(1-\theta)(1-\gamma\prime)[(\hat{A}_F - \hat{A}_m) - (\hat{w}_F - \hat{w}_m)]}^{Trade\,Effect} \tag{21}$$

Again, assuming low substitutability between services and manufacturing products, θ is close to zero. Therefore, faster productivity growth in manufacturing relative to services, will induce, through the Baumol effect, a proportional fall in the share of manufacturing in total employment. The trade effect depends not only on the dynamics of productivity differentials between manufacturing at home and abroad, but also on the dynamics of real wages in manufacturing at home and abroad.

In summary, the trade channel helps to rationalize the deindustrialization in advanced economies, measured both in terms of employment ad value added shares. By contrast, the closed economy channel (Baumol effect) predicts deindustrialization in terms of employment shares but not in terms of value added shares. Therefore, in spite of its simplicity, the model provides a sharp implication that can be empirically verified: different behavior of employment and value added shares will provide the basis for our assessment of the relevance of the trade channel, versus the traditional productivity channel.

As noted above, following China's entry in the WTO two main stylized facts stand out. First, as already emphasized in the literature,there is a marked increase in the exposure of manufacturing production in advanced economies to imports from China. Second, and less noted, Chinese exports become increasingly concentrated in ICT sectors. This second stylized fact likely reflects a changing nature of productivity growth in China. We thus extend the model to account for the changing nature of Chinese trade and the accompanying change in the determinants of productivity growth.

4 The changing nature of Chinese trade and technological change

In the last twenty years China experienced a rapid process of technological change and adoption of innovation, shifting from a process of efficiency improvements in traditional industries to faster change in technological change, which was associated to a changing patter of trade specialization. One feature of technological change is that new technologies rapidly displace old ones, determining a faster depreciation of the existing capital stock.

This channel potentially modifies the process affecting structural change in advanced economies that trade with an emerging economy like China. Specifically, if faster productivity growth in China derives from a faster process of technological change, the trade effect, inducing in the advanced trading partner a decline in the share of manufacturing in both employment and value added, becomes stronger.

Figure 3 displays the difference in levels between the depreciation rate in China with respect to the average OECD countries. After the year 2000, there is a sharp increase in China unmatched by the behavior of depreciation in OECD countries. The jump in the rate of depreciation seems to confirm our conjecture on a shift in the pattern of technological change in the Chinese economy.

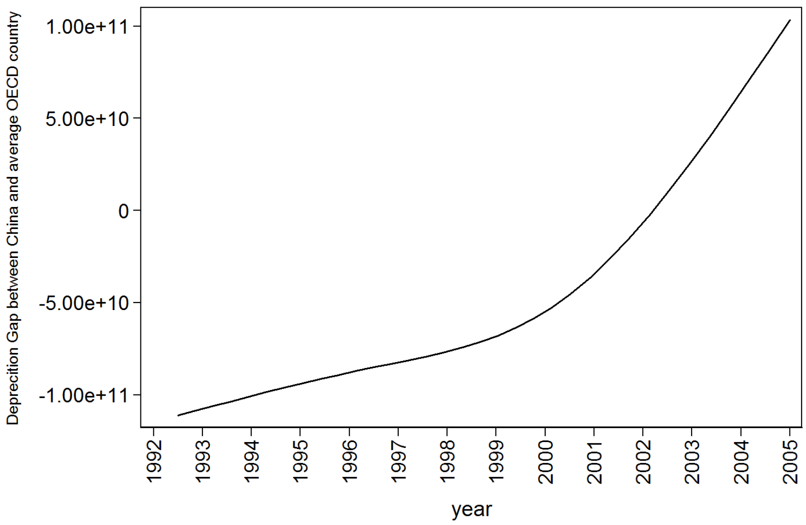


Figure 3: Depreciation gap in level $\delta_{CHINA} - \delta_{Average\,OECD}$

This new channel can be derived from a simple extension of our previous model.

4.1 Technological change and depreciation of capital

We assume that manufacturing (both home and foreign) is given by bundles of different varieties of goods, which are produced by a continuum of identical monopolistically competitive firms, whose mass is normalized to one. Each firm in sector i is the unique producer of a differentiated product variety, which is imperfectly substitutable to the other varieties within the sector i, with σ denoting the elasticity of substitution.

$$Y_i = (\int_{\Omega_i} y_i^{\frac{\sigma-1}{\sigma}}(\omega)d\omega)^{\frac{\sigma}{\sigma-1}} \tag{22}$$

with $\epsilon\{h, f\}$

We introduce the role of technological change and the depreciation of capital associated to old technologies in the simplest way, by assuming that every firm has to use one unit of fixed capital to have a positive production. This i unit of capital depreciate at the rate δ_i . Firm's demand for labor to produce q_i units of the individual variety in sector i, as well as replacing δ_i units of depreciated capital, is given by

$$l_i = \delta_i + \frac{y_i}{A_i} \tag{23}$$

whereA_i indicates productivity in sector i. The zero profit condition implies that

$$y_i = A_i\delta_i(\sigma - 1) \tag{24}$$

Combining the last two equations we find

$$y_i = A_i \frac{\sigma - 1}{\sigma} l_i \tag{25}$$

We next derive optimal prices from the optimization problem for a monopolistically competitive firm:

$$max_{p_{ij}} \pi_{ij} = p_{ij} x_{ij} - C(x_{ij}), \tag{26}$$

Thus, the price that set by firms is given by

$$p = \frac{\sigma}{\sigma - 1} \frac{w}{A} \tag{27}$$

which implies that the firm sets prices as a constant markup over its marginal costs, which is equal to $\mu = \frac{\sigma}{\sigma - 1}$.

Finally, denoting γ' for the foreign country with a star (γ'^*), assuming that ν is close to 1 and that trade is balanced, we can derive the relative demand for home and foreign manufacturing goods, which in equilibrium will be equal to the relative supply.

$$\frac{y_m}{y_f} = (\frac{p_f}{p_h}) \frac{1 - \gamma'^*}{1 - \gamma'} \tag{28}$$

Using 28, 27 and 24, we can substitute for prices and value added to obtain the relative wage dynamics. Log-differentiating, we obtain:

$$(\hat{w}_m - \hat{w}_f) = \frac{(\nu - 1)}{\nu} (\hat{A}_m - \hat{A}_f) - \frac{1}{\nu} (\hat{\delta}_m - \hat{\delta}_f)] \tag{29}$$

This gives us the dynamics in the relative wage gap as a function of the relative dynamics in productivity and depreciation rates:

$$(\hat{A}_m - \hat{A}_f) - (\hat{w}_m - \hat{w}_f) = \frac{1}{\nu} [(\hat{A}_m - \hat{A}_f) + (\hat{\delta}_m - \hat{\delta}_f)] \tag{30}$$

Assuming ν is close to 1, the relative dynamics of the wage gap between wages of domestic versus foreign manufacturing is just a function of relative changes in depreciation rates:

$$(\hat{w}_m - \hat{w}_f) = -(\hat{\delta}_m - \hat{\delta}_f)] \tag{31}$$

Therefore, the dynamics of manufacturing shares in employment and value added in open economies become:

$$\hat{\Phi}_l = -\overbrace{(1-\theta)(\hat{A}_m - \hat{A}_s)}^{Baumol\,effect} - \overbrace{(1-\theta)(1-\gamma\prime)[(\hat{A}_f - \hat{A}_m) + (\hat{\delta}_f - \hat{\delta}_m)]}^{Trade\,Effect} \tag{32}$$

for employment shares and

$$\hat{\Phi}_y = \overbrace{\theta(\hat{A}_m - \hat{A}_s)}^{Baumol\,effect} - \overbrace{(1-\theta)(1-\gamma\prime)[(\hat{A}_f - \hat{A}_m) + (\hat{\delta}_f - \hat{\delta}_m)]}^{Trade\,Effect} \tag{33}$$

for value added shares.

The difference between the change in depreciation rates in foreign versus domestic manufacturing is a proxy of the relevance of innovation in manufacturing and possibly on its impact on trade specialization. This effect seems to capture the increasing competition exerted by China in ICT sectors.

5 Data and Empirical Strategy

In this section, we describe the dataset and our empirical strategy, expecially in connection with the identification of the trade effect.

5.1 Data

Our dataset for employment and real value added at country-industry pairs is collected from the June 2013 release of the OECD Structural Analysis (STAN) database. Employment is measured by the total number of people at work, and value added is expressed in real 2005 prices using sector-specific deflators, in local currency. Data are available from 1992 to 2007, for a sample of 14 OECD countries including the United States, the United Kingdom, Sweden, Norway, the Netherlands,Italy, Hungary, France, Finland, Denmark, Germany, the Czech Republic, Belgium and Austria. The data are rearranged at the two-digit level, with up to 99 categories for all sectors in the economy according to the 3rd revision of International Standard

Industrial Classification (ISIC).

Data for trade exposure are obtained from the UN Comtrade Database on imports from China at the six-digit Harmonized System (HS) product level, for the period 1992- 2007.

To make the industry classification for trade data comparable with industry data on structural change from STAN, we adopt the crosswalk methodology by using the concordance of 1992-2007 HS codes to ISIC from The World Integrated Trade Solution (WITS). This allows us to translate our import data from the six-digit HS classification into the ISIC 4-digits, which then we aggregate to the 2-digits.

5.2 Index of Exposure to Chinese Imports

Several studies have focused on a measure of exposure to Chinese imports as a main channel affecting labor market variables in the US (Autor et al. (2013), Acemoglu et al. (2016), Pierce and Schott (2012)). Moreover, Bloom et al. (2016) investigate the impact of the trade exposure through growth of Chinese import on technical change in OECD countries. The application of such index of exposure to Chinese imports has been extended to other issues, as for instance the effect of trade exposure on the support for the leave campaign across the UK regions in the Brexit referendum (Colantone and Stanig (2016)).

Following this literature, we construct our trade exposure index (TEX) to low income countries for each of our country-industry pairs. TEX measures the extent to which each country-industry pair is affected by the surge in import competition from China after 2000.

We calculate η_{ij} the Napierian logarithm of the ratio of the average Chinese import during the 2000s relative to the 1990s, which, for each industry of our 14 countries, is defined as follows

$$\eta_{ij} = log(\bar{\sigma}_{ij}^{2000s}) - log(\bar{\sigma}_{ij}^{1990s}) \tag{34}$$

where σ_{ij_t} indicates imports from China in period t, in industry j, in country i. Thus, $(\bar{\sigma}_{ij}^{1990s})$ and $(\bar{\sigma}_{ij}^{2000s})$ indicate the average imports during 1990s and 2000s from China for all industry-country pairs.

During the years 2000s, import competition from China surges in most OECD countries. However, the magnitude of such increase in the exposure to Chinese imports varies significantly across industry-country pairs: η_{ij} captures this variation. Interestingly, we could not identify any clear clustering of countries or industries in connection with exposure to Chinese imports. Therefore, the variation of such indicator across country-industry pairs makes this indicator well suited in the regression analysis for structural change.

Finally, we construct the dummy for high exposure to Chinese import as follows

$$\delta_{ij}^{ImEx} = \begin{cases} 1 & if \quad \eta_{ij} >= \eta_{Mdn} \\ 0 & if \quad \eta_{ij} < \eta_{Mdn} \end{cases} \tag{35}$$

where η_{Mdn} indicates the median of the distribution of η on the pooled data of country-industry pairs.

If for industry j in country i $\eta_i j$ is higher than η_{Mdn}, the dummy variable for the Chinese import exposure takes the value of one and it takes the value of zero otherwise.

5.3 Identification

The objective of our regression analysis is to estimate the average yearly growth rates in the sectoral shares in total employment, or total value added. We follow the accounting proposed by Imbs (2014) to measure structural change.

$\hat{S}_{ijt}$ is the growth rate in the share S_{ijt} (in total value added or in aggregate employment) of sector j in country i at time t, and it is given by

$$\hat{S}_{ijt} = \frac{dln(S_{ijt})}{dt} = \frac{S_{ijt+1} - S_{ijt}}{S_{ijt}} \tag{36}$$

The share of employment in sector j country i at time t is equal to the total number of employee in sector j, in country i at time t (excluding self employed) divided by the total number of employee (excluding self employed) in country i at time t:

$$S_{ijt}^{EM} = \frac{N_{ijt}}{\sum\limits_{j} N_{ijt}} \tag{37}$$

As a robustness check, we will also consider the shares in relation with the total number of hours worked rather than the total number of employees.

The share of value added is equal to the value added of sector j at country i time t divided by the total value added of the country at time t:

$$S_{ijt}^{VA} = \frac{Y_{ijt}}{\sum\limits_{j} Y_{ijt}} \tag{38}$$

Our main estimation is given by

$$\hat{S}_{ijt} = \alpha_{ij} + (\beta_1 + \beta_2 \delta_{ij}^{ImEx})\delta_t^{2000} + \epsilon_{ijt} \tag{39}$$

where i defines countries, j indexes the two-digit sectors and t denotes time.

On the right-hand side of the regression, α_{ij} is a fixed effect that is specific to each industry in each country and captures the average growth rate before the year 2000.

Furthermore, to study the potential differences in structural change in two broad groups of sectors, the ICT versus the non-ICT sectors, we divide our sample into E/O (Electrical and Optical industries) and Non-E/O industries using a dummy variable $\delta_{ij}^{E/O}$, which takes the value of one for E/O sectors and zero otherwise. Accordingly, our second estimation is given by

$$\hat{S}_{ijt} = \alpha_{ij} + [\beta_1 + \beta_2 \delta_{ij}^{ImEx} + (\beta_3 + \beta_4 \delta_{ij}^{ImEx})\delta_{ij}^{E/O}]\delta_t^{2000} + \epsilon_{ijt} \tag{40}$$

In summary, our empirical strategy has several elements that help to identify the trade effect on structural change.

First, we split the data in two periods, namely the pre and post-WTO accession of China, assuming that entry of China into the WTO is exogenous to structural change in OECD countries.

Second, as in previous studies, we take the change in the exposure to Chinese imports as the variable measuring the trade effect. However, we add two additional steps to the analysis in order to better disentangle the trade from the productivity channel. One is the distinction between ICT and non-ICT sectors, which allows us to control for the fact that ICT sectors in OECD countries were characterized before the 2000s by a simultaneous fast increase in productivity and an increase in their employment shares.

Furthermore, a large component of the surge in Chinese post-WTO entry imports was associated to ICT sectors. Finally, we analyze both employment and value added shares, and by comparing the results of the two different estimates we can draw inference on the relevance of the trade effect.

6 Results

Table 1 reports the estimates of the coefficients in equation 39, estimated on pooled data for all manufacturing country-industry pairs. While country-industry fixed effects capture the average growth rate in shares of the sectors during 1990s, β_1, captures the difference in the average yearly growth rate after and before 2000s for low exposure country. β_2, captures the difference-in-difference between the average yearly growth rate in the shares after and before 2000 for high and low import exposure country-industry pairs.

Column (2) of Table 1 illustrates the general acceleration of deindustrialization among all sectors after 2000s in OECD countries . However, during the 2000s, the high-import-exposure group of country-industry pairs experienced a much faster decline in employment shares than the low-import-exposure group. Indeed, the share of employment contracted on average by 0.4 % per year more during the 2000s compared with the 1990s among the low-exposure group, while the employment share for the high-exposure group fell by 1.3 % a year more in the 2000s than in the 1990s.

This result is consistent with our hypothesis that manufacturing sectors with more exposure to imports from fast growing Chinese manufacturing experienced a stronger fall in employment.

Table 1: Structural Change and Trade Effect

	(1) Growth in the share of Value Added (%) b/se	(2) Growth in the share of Employment (%) b/se	(3) Growth in the share of Hours Worked (%) b/se
Difference in growth rate of the share of sectors among Low exposure sectors After and before 2000			
$\Delta_L = \hat{S}_{2000s} - \hat{S}_{1990s}$			
$\beta_1 : \delta_t^{2000}$=1	-0.000	-0.004***	-0.006**
	(0.00)	(0.00)	(0.00)
Difference-in-Difference for High vs Low exposure After and before 2000			
$\Delta\Delta = \Delta_H - \Delta_L = (\hat{S}^H_{2000s} - \hat{S}^H_{1990s}) - (\hat{S}^L_{2000s} - \hat{S}^L_{1990s})$			
$\beta_2 : \delta_{ij}^{ImEx \geq 50\%}$=1 $\times$ δ_t^{2000}=1	-0.012**	-0.009***	-0.012***
	(0.01)	(0.00)	(0.00)
Industry Country fixed effect	Yes	Yes	Yes
Observations	3353	3366	1748

A comparison of the estimates for the employment shares (column 2) and the value added shares (column 1) provides further confirmation of our prior on the relevance of the trade effect. Indeed, if we consider only the low-exposure sectors, we find no differential behavior in the 2000s relative to the 1990s, as β_1 is not significantly different from zero. Therefore, low-exposure sectors seem to behave in line with the Baumol effect, as they experienced a fall in their share over total employment, although they maintained unchanged their share in total value added.

Column (3) indicates that the employent adjustment is even stronger if one considers hours worked rather than the number of employees. [8]

Table 2 reports the coefficient of the estimation of equation 40, which allows for a different effect across E/O (Electrical and Optical industries) and Non E/O industries. $\delta_{ij}^{E/O}$ and $\delta_{ij}^{ImEx_{EO}}$ are two dummies that divide our sample into four groups.

The first group is given by Non E/O sectors with low exposure to Chinese imports. β_1 indicates that the employment share and the share in hours worked respectively contracted per year by .7% and 1.2% faster during 2000s compared with 1990s, while there is no significant change in the share of value added. The second group includes E/O industries with low exposure and the third group includes

[8]It is worth noting that due to more aggregated data for reporting the hours worked the sample size is considerably reduced.

Non E/O industries with high exposure. The value of the coefficients β_2 and β_3 point out that the behavior of theses two groups do not display any statistically significant difference with respect to the first group.

By contrast, β_4 indicates that for high exposure E/O industries, the increase in the pace of contraction per year in their share of value added , employment and hours worked during the 2000s, compared with their rate in the 1990s, is significantly higher than for the other three groups. Specifically, value added , employment and hours worked declined per year by 6.5 % , 3.3% and 5.3% more after 2000 compared with the 1990s.

Again, these results confirm the pattern of deindustrialization associated to the trade effect for ICT sectors with high exposure to Chines imports. In summary, the sharp acceleration of deindustrialization of ICT manufacturing through the trade effect played a key role in explaining the process of structural change in OECD countries during the years 2000s.

Table 2: Decomposition of Structural Change And Trade Effect

	(1) Growth in share of Value Added (%)	(2) Growth in share of Employment (%)	(3) Growth in share of Worked Hours (%)
	b/se	b/se	b/se
Difference in average yearly growth rate Low exposure Non E/O sectors After and before 2000			
$\Delta_L = \hat{S}_{2000s} - \hat{S}_{1990s}$			
$\beta_1 : \delta_t^{2000}$=1	-0.001	-0.007***	-0.012***
	(0.00)	(0.00)	(0.00)
Difference in Difference between Non E/O and E/O among low exposure $\Delta\Delta_L = \Delta_L^{E/O} - \Delta_L^{NonE/O}$			
$\beta_2 : \delta_{ij}^{E/O}$=1 $\times \delta_t^{2000}$=1	-0.016	-0.002	0.005
	(0.01)	(0.01)	(0.01)
Difference in Difference for high and low exposure among Non E/O $\Delta\Delta^{NonE/O} = \Delta_H^{NonE/O} - \Delta_L^{NonE/O}$			
$\beta_3 : \delta_{ij}^{ImEx_{EO}\geq 50\%}$=1 $\times$ δ_t^{2000}=1	-0.010	-0.004	0.003
	(0.01)	(0.00)	(0.01)
Difference in Diff in Diff for E/O and Non E/O industries $\Delta\Delta\Delta = \Delta\Delta_H^{E/O} - \Delta\Delta^{NonE/O} - \Delta\Delta_L$			
$\beta_4 : \delta_{ij}^{E/O}$=1 $\times$ $\delta_{ij}^{ImEx_{EO}\geq 50\%}$=1 $\times$ δ_t^{2000}=1	-0.038*	-0.020**	-0.049***
	(0.02)	(0.01)	(0.01)
Industry Country fixed effect	Yes	Yes	Yes
Observations	3353	3366	1748

7 Concluding Remarks

In line with previous results obtained in the literature (Autor et al. (2013), Acemoglu et al. (2016) and Pierce and Schott (2012)) we found a significant effect of exposure to imports from China on sectoral employment. Our results extend to OECD countries the results previously obtained for the US.

Our main contribution has been to emphasize the relationship between external trade and structural change, specifically the decline of the share of employment and value added in the manufacturing sectors. The exposure to imports from China was the main identifying instrument, as such exposure surged in correspondence to the entry of China into the WTO. Entry into the WTO is thus the exogenous treatment that allows us to estimate the post WTO-entry relative to pre-WTO entry.

Using a simple model of structural change with two sectors (manufacturing and services), we stressed the fact that in a closed economy structural change derives from faster productivity growth in manufacturing. This effect, the so-called Baumol effect, in general cannot be easily separated from the external trade effect. However, a clear implication of the Baumol effect is that the employment share of manufacturing declines whereas the share of manufacturing in total value added remains constant. The potential difference in the behavior of employment and value added shares gives us a channel to identify the trade versus the productivity effects. Indeed, in our estimations we find that the decline in employment shares is significant in all sectors, irrespective of their exposure to import competition. As long as the exposure to Chinese imports is small, the share of value added does not accompany the fall in the share in employment. It is only when the exposure to Chinese imports becomes quantitatively large that the share in value added falls.

This confirms that the trade channel became relevant in the 2000s, following the surge in Chinese exports to OECD countries. Furthermore, we uncovered another effect on structural change associated to trade with emerging economies, an effect that derives from the changing sources of productivity change in manufacturing in emerging economies. Indeed, if productivity growth is associated to a process of rapid technological change, which induces scrapping of old productions, the trade effect becomes stronger. We find empirical evidence of this channel: after 2000, in advanced economies, ICT sectors more exposed to Chinese imports display a stronger decline in both employment and value added relative to non-ICT sectors. Our conjecture is that in these sectors the depreciation of capital is faster in emerging economies. As a consequence, wages in emerging economies do not catch up with productivity changes, as part of output produced has to cover the depreciation of capital.

We plan to extend the work in the paper in several directions. First, it would be interesting to extend the model to a framework in which productivity and trade interact. Indeed, in general we cannot take exposure to trade and productivity change as independent processes. For instance, as shown by Bloom et al. (2016) and Autor et al. (2016), exposure to trade with China has an effect on innovation by US firms. The model can thus be extended to a framework with heterogeneous firms, in the spirit of a Melitz-Chaney[9]. In the model with heterogeneous firms, the participation by firms in international trade depends on their productivity.

Second, along the lines explored in (Coricelli et al., 2013) to analyze the relationship between the German huge and persistent current account surplus and structural change, we plan to extend both the theoretical and the empirical analysis to a framework with unbalanced trade. This extension is relevant as OECD countries are characterized by significantly different positions in terms of trade balances.

In summary, our analysis indicates that extending models of structural change to an open economy context is crucial to understanding the process of sectoral reallocation of resources in advanced economies in the last decades.

[9] First proposed byMelitz (2003) and then extended by Chaney (2008).

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