REAL EXCHANGE RATES AND MANUFACTURING INDUSTRY IN CHINA

Ping HUA

Université Clermont Auvergne, CNRS, IRD, CERDI, F-63000 Clermont-Ferrand, France

Email: ping.hua@uca.fr

Abstract

This paper argues that, besides well-known traditional negative effect, real appreciation of exchange rate may exert positive effects on manufacturing and proposes a manufacturing model to capture them. Three renminbi real exchange rates are specially calculated for manufacturing at macro, product and sector levels to estimate their impacts on manufacturing value added in the case of China. The obtained results showed that, besides their traditional negative effect on the size of tradable sector and employment as well as positive effect on capital intensity, the real appreciation of exchange rates improves the efficiency of workers and staffs, encourages schumpeterian "creative destruction," stimulates innovation and high technology industries. These positive productivity effects on manufacturing are however still too small to offset its negative effects on the size of the most dynamic tradable sector and employment.

Key words: Manufacturing value added, real exchange rates, China

1. Introduction

The development of exports outward-oriented manufacturing industry has been the main objective of the Chinese government since the "open door" policies launched in the end of 1978. The success of this development strategy is incontestable. The real manufacturing value added increased at an annual average growth rate of 12% over the period from 1983 to 2016, and its share in GDP (2010 constant price) increased from 16% in 1983 to 31% in 2016. It has allowed China to become the biggest world manufacturer by real manufacturing value added in 2009, to realize the GDP growth of nearly 10 %, to become a middle-income country and to lift more than 800 million people out of poverty. However, China's manufacturing industry arrived at turning point in 1994. The annual growth rate of real manufacturing value added decreased from 28% in 1994 to 5.9% in 2016, which is the lowest level[1] since 1983.

It is interesting to observe that China's manufacturing decelerations correspond to the periods of the real appreciation of the renminbi, while its accelerations during the periods of the strong devaluation of the renminbi. In fact, the real depreciation of the renminbi has been an active tool of China's labour-intensive export promotion strategy during the period 1979-1993 during which the Chinese government has systematically devalued the renminbi *vis-à-vis* the dollar, in 1994 it decided to stabilize and in 2005 to revalue it. This policy led to a depreciation of real effective exchange rate of the Chinese currency of 51% against the currencies of its trade partners from 1984 to 1993, then an appreciation of 50% over the period from 1994 to 2016.

Literature often cited China as a recent example for the success of its export-led industrialization thanks to its active real devaluations (Guillaumont Jeanneney and Hua, 1996, Kroeber 2011, Rodrik 2008). However, no studies have explained how China have kept an average growth rate of real manufacturing valued added of 10% during the period of real appreciation. This study completes this gap by proposing a manufacturing model, which allows identifying some potential positive effects of real appreciation on manufacturing productivity besides its traditional negative impact on the size of tradable sector,

Real appreciation of exchange rate negatively acts on manufacturing industry by acting on its traditional determinants identified in the literature. They are the development of manufactured exports (Fu and Balasubramanyam, 2005; Kraay, 2006 and Hua, 2007), foreign

[1] Except for 1989 and 1990 years of the social movement when the industrial activities almost stagnated.

direct investments (Qi *et al.,* 2009, Anwar and Sun, 2018) and the promotion of the private sector in disfavour of the sector of state-owned enterprises (Jefferson and Su*,* 2006; Dougherty *et al.,* 2007). The real appreciation of the renminbi, which exerts negatively exports, FDI and the development of private sector, deteriorates international competitiveness of local enterprises and influence thus negatively manufacturing industry through these channels.

Besides these well-known effects, real appreciation moreover increases the cost of labor (expressed in tradable goods), decreases the profitability of manufacturing and reduces the incentives to produce and to innovate; resources are thus allocated to non-tradable sector, in particular to the real estate sector in China. The increase of housing price rises in return the living cost, damaging manufacturing competitiveness.[2] China's manufacturing labor costs have been rising steadily and very quickly. "Made in China" is not yet so cheap as its reputation, but just 4% less than in the U.S. if China's productivity is adjusted (Daco and Leonard, 2016). The minimum wage in Shenzhen is about US$4032 per year, which are more than double that in several Southeast Asian countries (Leng, 2018). China has clearly losing its comparative advantage in low cost labor-intensive industry. She has no choice than upgrading its manufacturing industry if she wants to avoid middle-income trap.

Real appreciation of the renminbi may help industrial upgrading through its potential positive effects via reduced cost of imports relative to labour cost, innovation, productivity improvement and manufacturing structural change and upgrading. It firstly decreases the cost of imported machines and equipment relative to wages, thus favours capital-intensive manufacturing industry, and even push labour-intensive industry to be more capital intensity. Ce phenomena is particularly important in Chinese textile and clothing societies, which have no choice either to close down or to upgrade product lines via robotic and automated technology or delocalize in other developing countries. Chinese manufacturing enterprises use more and more robots in the production to avoid the increasing labor costs. According to BBC, Apple and Samsung supplier Foxconn in China has reportedly replaced 60 000 factory workers with robots (Wakefield, 2016). Only one factory has "reduced employee strength from 110 000 to 50 000 thanks to the introduction of robots", according to the South China Morning Post (30 may, 2016).

Real appreciation exerts positive action on efficiency of workers and managers, as it improves the real remuneration of workers, known as "X-efficiency" (Leibenstein, 1957, 1966),

---

[2] Huawei left Shenzhen due to high housing prices (China Banking News, 4 July, 2018).

pushes management effort near to its optimum (Krugman, 1989) and exacerbates competition via Schumpeterian "creative destruction" benefiting to the most performing manufacturing enterprises[3]. It slows down brain drain and allows hunting brain to satisfy the needs of enterprises to employ qualified workers and to develop high technology products. These positive effects[4] push up Chinese labor productivity improvement as a kind of virtuous circle: the renminbi real appreciation has boosted the growth of labour productivity while, according to the Balassa-Samuelson effect, productivity growth tends to push up the real appreciation (Guillaumont Jeanneney and Hua, 2010).

There is significant economic literature regarding the negative impact of real exchange rate overvaluation on per capita growth rates, particularly for developing countries; and this negative effect is mainly seen in the size of the tradable sector (especially manufacturing industry) (Rodrik, 2008) and its related employment (Hua 2007, Chen & Dao, 2011). Dollar (1992) and Benaroya & Janci (1999) argued that the relative undervaluation of the Asian currencies compared with those in Latin America and Africa explained the higher growth in the Asian region. Hausmann, Pritchett & Rodrik (2005) showed that real exchange rate depreciation is one of the factors associated with acceleration of growth. Eichengreen (2008) explained that a depreciated real exchange rate together with low volatility favors the growth process. Rodrik (2008) and Berg & Miao (2010) argued that not only are overvaluations bad, but undervaluation is good for growth, particularly in developing countries. MacDonald & Vieira (2010) found that a depreciated (appreciated) real exchange rate helps (harms) long-run growth, especially in developing and emerging countries. Hua (2012) found that real appreciation exerts negative effects on the economic growth of the Chinese provinces, stronger in coastal provinces than in inland provinces. All these studies analyzed the impact of real exchange rate on economic growth in which the contribution of the tradable sector can be very different from one country (province) to another. To avoid potential sectorial heterogeneity

[3] Schumpeter (1942) first used the term of "creative destruction" which describes the process of industrial mutation that incessantly revolutionizes the economic structure by destroying the old one and creating a new one.

[4] These positive effects of the real appreciation are studied in Harris (2001) in the case of Canada, in Gebre-Ebziabher (2009), Redi (2009) and Sonobe, Akoten & Otsuka, 2009) in the case of Ethiopian shoe industry and in Guillaumont Jeanneney and Hua (2011), Hua (2012), Zhou et al. (2017) and Dai et al. (2018) in the case of China.

problem, the recent literature emphasizes the importance of manufacturing value added in terms of industrialization in the processes of development. Rodrik (2016) showed that Asian countries perform better their industrialization than other developing countries, which on contrary deindustrialize. No study, to our knowledge, has analyzed the impact of real exchange rate on manufacturing value added. The objective of this study is to complete this gap.

This article is organized as follows: first, we present the evolution of China's manufacturing industry compared to that of real exchange rate during the last forty years. Second, we argue how theoretically real appreciation may affect (positively or negatively) manufacturing value added, either directly or through its traditional factors, and thus to conclude that the sign of the total effect is theoretically ambiguous and only an empirical analysis can reveal it. To this objective, we define a function of manufacturing value added which includes real exchange rate besides input factors (employment and capital intensity) and factors influencing the size of tradable sector (such as exports, FDI and the development of the private manufacturing sector) which are themselves supposed to depend on the real exchange rate. Third, we estimate the function by using three real exchange rates calculated for manufacturing at macro, product and sector levels. The obtained results show a positive effect of real appreciation on manufacturing, while is still smaller than the negative effect. In conclusion, we draw some economic and political implications.

2. Evolution of China's manufacturing industry compared to that of real exchange rate

2.1. Evolution of Chinese manufacturing industry

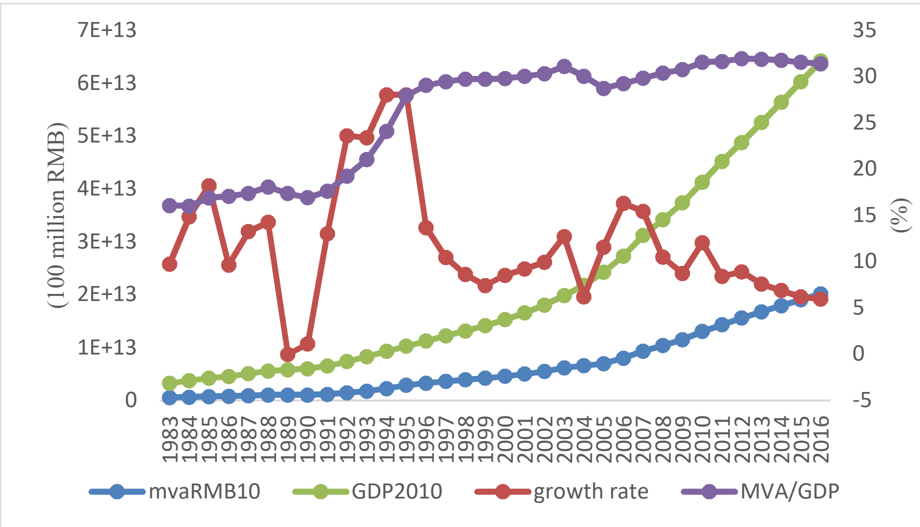
The *United Nations* define manufacturing industry as the transformation from materials into new products. It is a part of industry, which moreover includes mining and quarrying, production and distribution of electricity, gas and water. It corresponds to divisions 10-33 of *International Standard Industrial Classification* (ISIC revision 4). Value added is net output of the manufacturing sector, calculated after adding up all the outputs and subtracting the intermediate inputs. It is more relevant than production as a measure of manufacturing performance because it is net of intermediate inputs, which can be imported, particularly in processing exports. The domestic produced value added represented around 50-60% of China's exports, but is much low in sophisticated products (Koopman et al., 2008) and different according to the types of enterprises (Ma et al. 2015).

National Bureau of Statistics of China publishes in different editions of *China Statistical Yearbooks* the data on manufacturing value added only since 2004 and only in nominal terms.

The Database of Groningen Growth and Development Centre (GGDC) publishes the data from *GGDC 10-Sector* over the period from 1952 to 2011 in nominal and real terms. The United Nation Statistics Division (UNSD) publishes the Chinese manufacturing value added over the period from 2005 to 2016 in nominal and real terms[5]. In this study, we use the data from GGDC and UNSD to obtain the Chinese manufacturing value added.

Chinese manufacturing industry increased very quickly. Its real manufacturing value added (in 2010 constant RMB) increased from 521 billion in 1983 to 20 168 billion in 2016, and its share in real GDP passed from 16% to 31% respectively (Fig. 1). The manufacturing value added increased at an annual average growth rate of 12% over the period 1983 to 2016, which is higher than that of real GDP (9.5%). The manufacturing industry suffered from 1988-1989 social movement in China when the industrial activities stagnated. It was strongly recovered until the 1997-1998 Asian financial crisis when the industry was seriously challenged by the competitiveness of other Asian countries, then by the 2008-2009 international financial crisis when the world demand for Chinese manufactured goods sensibly decreased and recently by the strong increase of labor costs in China. In 2016, the growth rate dropped to 5.9%, the lowest level since 1983 except 1988 and 1989. The share of MVA in GDP increased from 17% in 1983 to 29% in 1995 and then around this level to arrive 31% in 2016.

Figure 1. Evolution of real manufacturing added value, its growth rates and share in GDP (2010 constant yuans)

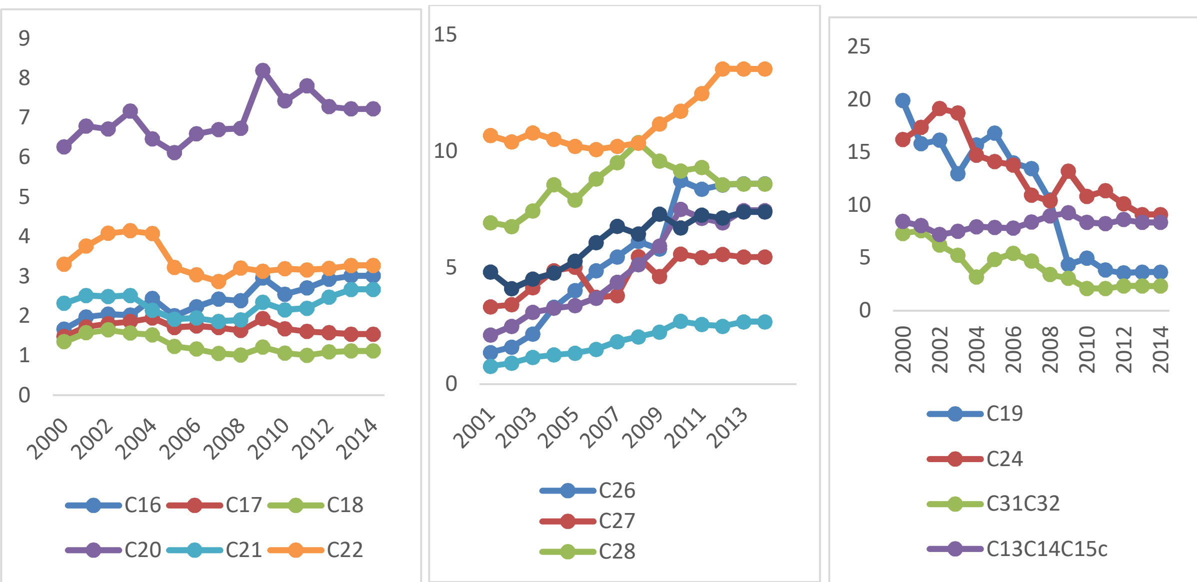


[5] See section 4.2 for more discussion on the data.

Source: *GGDC 10-Sector Database*, Groningen Growth and Development Centre (GGDC) and United Nation Statistics Division (UNSD).

Very recently (published in February 2018), World Input-Output database published sectorial value added according to ISIC 4 classification over the 2000 to 2014, which show different sectorial evolution of value added. Among the 18 manufacturing sectors, the share of the value added of computer, electronic and optical products in total MVA increased from 1% in 2000 to 9% in 2014, following by motor vehicles, trailers and semi-trailers its share passed 2% in 2000 to 7% in 2014. On contrary, the share of coke and refined petroleum products decreased from 20% in 2000 to 4% in 2014, and from 16% in 2000 to 9% in 2014 for basic metals. The share of furniture and other manufacturing also decreased from 7% in 2000 to 2% in 2014. The share of textiles, wearing apparel and leather products stayed stable around 8% during the period.

Figure 2. Evolution of sectoral share of manufacturing value added from 2000 to 2014

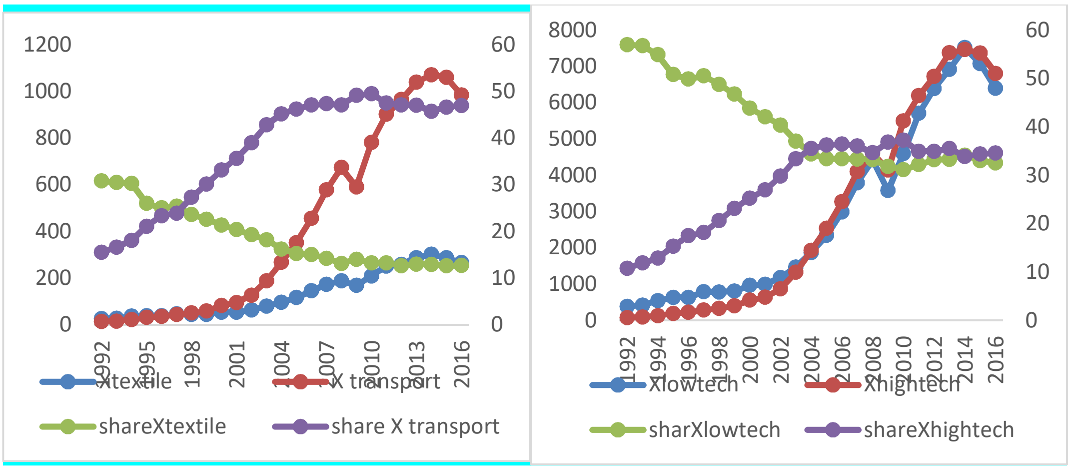


Note: according to ISIC 4 classification (see annex 4).

Source: World Input-Output database.

Chinese manufacturing structure is changing. The share of labor-intensive manufacturing goods decreased in favor of that of capital or high technology products. In China, the export shares of textiles and clothing and low technologies decreased from 31% and 45% in 1992 to 13% and 30% in 2016 while that of machine and transport equipment and high technologies increased from 15% and 8% to 47% and 32% respectively.

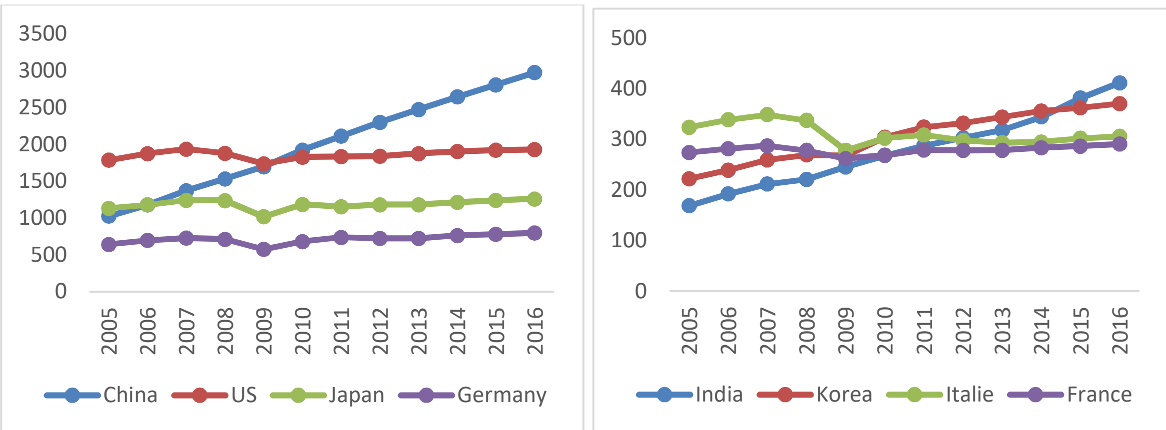
Fig 3. Evolution of exports of machine and transport equipment, textile and clothing, low tech and high tech contents goods and their shares in exports of manufactured goods



Source: UNComtrade.

In 1978, China ranked 14th by real manufacturing value added (2005 US$) which represented only 1.1% of the world total. Its fast growth rate allows China to displace Germany to become the third biggest one in 2002, and then the second one in 2006 by over taking Japan and the biggest one in 2009 by displacing the United States (Figure 2a). Its share in the world total represented 24% against 15% for the United-States in 2016. It is interesting to observe from Fig 2b that India seems following China's steps and became the fifth most important manufacturing country in 2016 by displacing France in 2010, Italy in 2012 and Korea in 2014.

Figure 4. Evolution of manufacturing value added (2010 US$) of eight top countries*



Note: * according to real MVA (2010 US $) in 2016

Source: United Nation Statistics Division (UNSD).

2.2. Evolution of China's exchange rate policies

China's exchange rate regime is the fruit of a long evolution from two exchange rates to a unique rate, which remains tightly managed until now. During the first years of 1980s, the exchange rate policy played a little role, because foreign trade was largely planned. It is only since 1984 that national foreign trade societies should take international prices into account to fix the sale price of imported goods and the purchasing price of exported goods (Guillaumont Jeanneney and Hua, 1996).

From 1985 to 1993 the export societies have benefited from a foreign exchange retention system[6]. They could sell some of their foreign exchanges obtained from exports at an administrated rate of the dollar higher than the official rate (simultaneously applied to planned importations and capital transactions). At the end of 1986, the administrated rate became a swap market rate, which was determined in the foreign exchange market, even still under the State's control. The export societies continued to deliver one part of the foreign currencies obtained from their exports to the People's Bank of China at the official rate, and sold another part, proportional to their retention quota, to the foreign exchange market at the swap rate. The foreign exchange retention rate has progressively increased up to 80% in 1993, so well that the swap rate became the principal rate for trade transactions at this time.

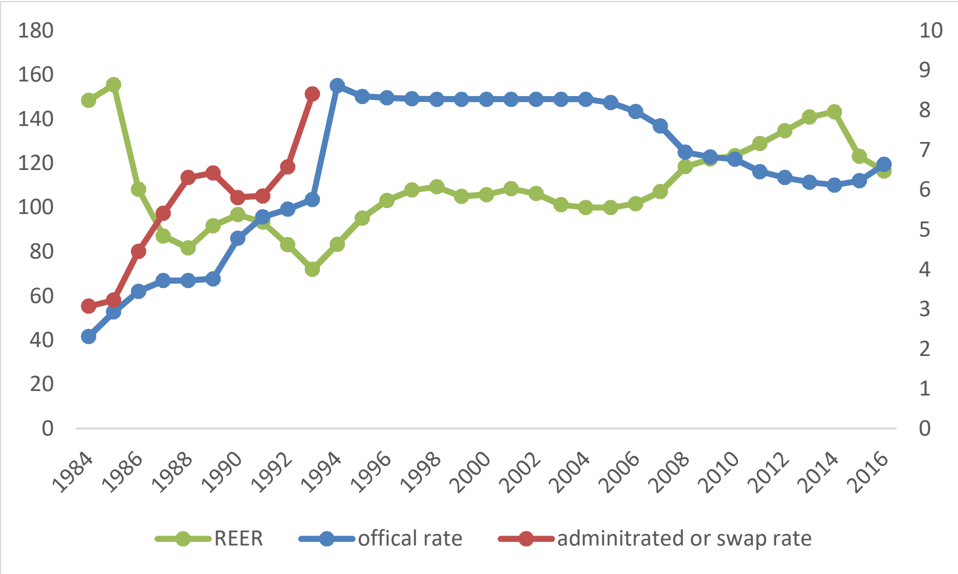
From 1985 to 1993, the Chinese government devalued the two exchange rates against the dollar several times. These devaluations were not realized simultaneously most of the time. Often, one of the two rates stayed stable and played the role of a monetary anchor. It contributed thus to slow down inflation, and favoured the real depreciation of exchange rate (Guillaumont Jeanneney and Hua, 1996, Guérineau and Guillaumont Jeanneney 2000). The nominal and real depreciations vis-à-vis the dollar were in fact large (respectively 53 % and 37% for the official rate over the period from 1990 to 1993) (Figure 5).

On 1st January 1994, China radically changed its policy. The double exchange rate system was suppressed; the swap rate became the unique official rate for all transactions. The last one was officially a managed floating, but in fact strictly pegged to the dollar and maintained stable since then. On 21 July 2005, the Chinese authorities decide to revalue the

[6] Initiated in 1981

renminbi of 2.1% *vis-à-vis* the dollar, to switch from the dollar peg to a basket[7], and to allow the currency to float more freely[8]. Since this date, the renminbi was progressively revalued against the dollar. From 2005 to 2016 the renminbi appreciated 23% in terms of dollars (Figure 5). The Chinese authorities have undertaken several reforms to improve the functioning of the exchange market permitting some flexibility in the short run, but the rate until now remains tightly managed. This exchange rate policy led the evolution of the real effective exchange rate marked by a period of depreciation of 51% from 1984 to 1993 and a period of appreciation of 50% from 1994 to 2016.

Figure 5. Official and administrated/swaps rates and real effective exchange rate in China



NB: here a rise of official or administrated rates means a depreciation of the renminbi against dollar and *vice-versa.* A rise of real effective exchange rate (REER) means a real appreciation of the renminbi against its main exports partners and inversely.
Source: *International Financial Statistics* IMF, *China Statistical Yearbooks*.

2.3. Statistical relationship between real exchange rates and manufacturing value added

Figure 6 shows a negative relationship between real appreciation of the renminbi and growth rate of real manufacturing value added and its real value. It suggests that China's

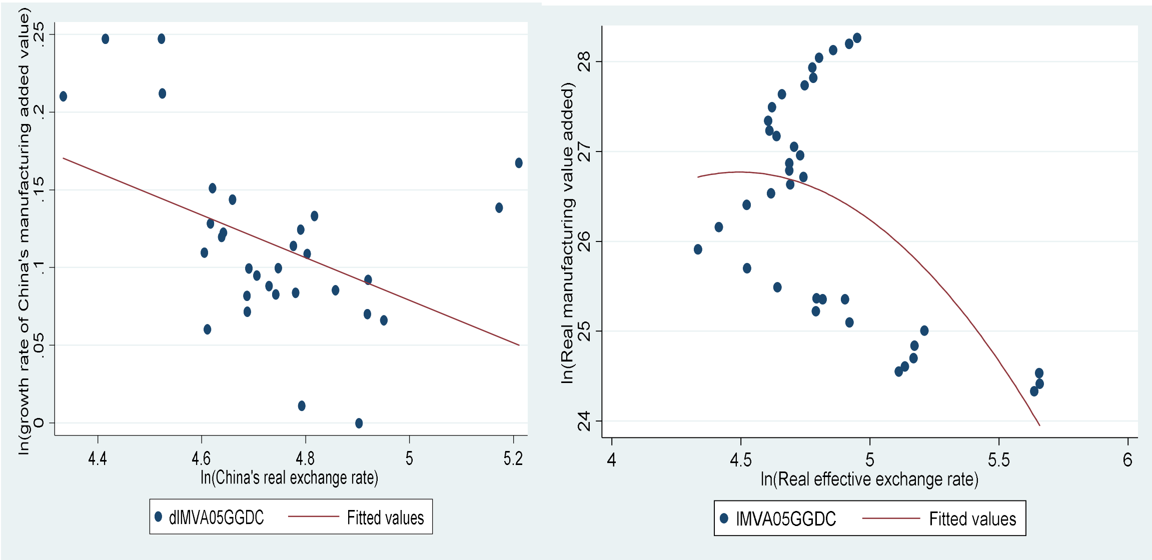
[7] The basket of currencies is undefined (like Singapore does). The four main currencies in the basket are the US dollar, the euro, the yen and the won.

[8] The US dollar against the RMB is allowed to float within a band of 0.3% around precedent daily rate.

manufacturing industry accelerated during the periods of the real depreciation while decelerated during the period of appreciation, and that China's manufacturing value added may increase when the renminbi appreciation is weak.

However, this simple statistical relationship does not take the other determinants of manufacturing value added into account and does not allow to identify the transmission channels through which real exchange rate may act on. Only an econometric investigation can do it.

Figure 6. Statistical relationship between real exchange rate and growth rate of manufacturing value added in China over the period from 1984 to 2016



Source: *International Financial Statistics* IMF, GGDC, UNSD.

3. An econometric model of the impacts of real exchange rate on manufacturing in China

A manufacturing production function augmented of real exchange rate is proposed to analyze the different impacts of real exchange rate on manufacturing value added.

3.1. Manufacturing productions function

According to the methodology of growth accounting, manufacturing value added growth is essentially divided into a component that can be explained by input growth and a 'residual' which captures changes in productivity. Literature argues that China's manufacturing industry has been led by capital intensity mode of production. Consider the following Cobb-Douglas manufacturing production function as following

$$MVA = A(K/L)^{\alpha} L^{\beta}$$

Where MVA represents real manufacturing value added, A is total factor productivity, thus K/L is capital intensity, which is the ratio between real capital stock (K) and employed population (L) in manufacturing sector.

The main factors which improve total productivity A are the size of the tradable sector which are represented by the development of manufactured exports (Fu & Balasubramanyam 2005, Kraay 2006), foreign direct investments and the promotion of the private sector against the interests of state-owned enterprises (PRIV) (Jefferson & Su 2006, Dougherty et al 2007). The above function can be written as follows (with the expected signs):

$$MVA = f(\underset{+}{X}, \underset{+}{FDI}, \underset{+}{PRIV}, \underset{+}{KL}, \underset{+}{L})$$

Where, X represents exports of manufactured goods, FDI foreign direct investments in manufacturing, PRIV relative importance of private enterprises in manufacturing sector. The expected signs of these factors are positive.

3.2. Manufacturing productions function augmented of real exchange rate

Real exchange rate can affect manufacturing value added via its impacts on the factors identified above, which can be considered to be the transmission channels (called here indirect effects), and via its direct effect on work efficiency by changing the real remuneration of workers, on productivity improvement and increasing competition via Schumpeterian "creative destruction" (called here direct effects). From the above equation, the transmission channels considered are three variables impacting productivity and two input variables.

3.2.1. Impact of real exchange rate appreciation on size of tradable sector

The traditional argument in favor of a negative effect of real exchange rate appreciation on the size of the tradable sector is based on the assumption that real exchange rate appreciation causes deterioration in the international competitiveness of domestic enterprises relative to their foreign competitors and leads to a reduction in exports of manufactured goods and an increase in imports.

This deterioration reduces the profits of the export sector of manufactured goods. It decreases industrial self-financing and the will to invest in the industrial sector, and more generally in the tradable goods sector. The real appreciation of the renminbi incites more Chinese manufacturing enterprises, especially labor-intensive ones, to invest in the estate sector or delocalize in other developing countries instead of investing in manufacturing. If the tradable goods sector is the most efficient and innovative sector, real exchange rate appreciation may affect manufacturing industry negatively, in addition to its impact on exports-led firms.

Real exchange rate appreciation is particularly bad for growth in developing countries, because it does not allow promotion of their small and efficient tradable sectors, which suffer disproportionately from institutional and market failures (Rodrik, 2008). The recent strong real appreciation of 20% of the renminbi since 2010 strongly decreased the manufacturing benefits (Lang, 2015) and discouraged the development of the manufacturing industry whose annual growth rate decreased from 13% in 2010 to 5.9% in 2016, as well as exports of manufacturing goods whose growth rate decreased from 28% in 2010 to 8% in 2016.

The negative effect of real appreciation on the size of tradable sector is also seen in the decrease in foreign direct investments (FDI). In China, as in other developing countries, foreign investments are concentrated in the tradable goods sector. Foreign firms bring technological improvements and their know-how to China. This positive action occurs through the creation of foreign companies or joint-ventures which are more productive than domestic firms, suppliers or customers of the foreign enterprises (Sun, 1998). Several studies show that this positive effect exists in China, in particular in the manufactured goods sector where most foreign direct investments are made. Sun, Hone & Doucouliagos (1999) showed that trade and financial openness is a factor of industry efficiency. Li, Liu & Parker (2001) and Buckley, Clegg & Wang (2002) showed the diffusion effect of FDI on Chinese manufacturing enterprises, and Liu, Parker & Wei (2001) on electronic enterprises; an FDI spill over effect was shown in Madariaga & Poncet (2007). Liu and Daly (2011) and Lovely and Huang (2018) argue that FDI favor the upgrading from low tech to high tech manufacturing. If the foreign investment mainly focused in manufacturing sector, its share increased from 70% in 2002 to 28% in 2016.

Finally, real appreciation exerts a negative impact on the size of the tradable sector by decreasing the relative importance of private enterprises, which are the most dynamic enterprises in the manufacturing sector.

The above arguments concerning the negative effects of real exchange rate appreciation on the size of the tradable sector can be therefore captured by the following equations (with the expected waited signs):

$$X = f(\underset{-}{RER}),\ \ FDI = f(\underset{-}{RER}),\ PRIV = f(\underset{-}{RER})$$

3.2.2. Impact of real exchange rate appreciation on input factors

As well as the negative effects on the size of the tradable sector, real appreciation has an impact on the production input factors in the equation 1, such as capital intensity and employment.

A real appreciation reduces the relative cost of imported capital goods and increases wages relative to the price of capital. It encourages more capitalist forms of production and technological innovations (Leung & Yuen, 2005) and so increases manufacturing growth. The real appreciation may have favored investment-led manufacturing industry in China since the 1990's.

Second, a real exchange rate appreciation has negative effects on employment by decreasing the cost of imported inputs relative to real wages, by deteriorating the international competitiveness of a nation's firms and by exerting pressure on efficiency improvement (Hua 2007). The negative effect of real appreciation on employment extends even beyond the tradable sector in China, due to the importance of services as an intermediate input in export production (Chen & Dao, 2011).

The above arguments concerning the effects of real exchange rate appreciation on capital intensity and employment can be therefore resumed by the following equations with expected signs as follows (with the expected signs):

$$EM = f(\underset{-}{RER}),\ KL = f(\underset{+}{RER})$$

3.2.3. Impact of real appreciation of exchange rates on productivity

A real exchange rate appreciation increases the real remuneration of unqualified workers as expressed in tradable goods. Guillaumont and Guillaumont Jeanneney (1992) show that this increase causes efficiency improvements by workers in a country where the wages of unskilled workers relative to living costs are still low. A labor remuneration that is too low might make workers unhealthy and reduce their capacity for work. The motivation of workers has an effect on efficiency, known as "X-efficiency" (Leibenstein 1957, 1966).

Second, a real appreciation could push firms to improve their technical efficiency in a context of monopoly or collusive oligopoly (Krugman, 1989). The argument is the following: managers only benefit from a part of the profit induced by a better management or a stronger effort since a part of the profit goes to the owners of the enterprise. In the case of monopoly, managers do not choose the exertion, which maximizes the profit for such reasons as a preference for leisure over work, involvement in seeking out other profitable opportunities, and the power and satisfaction gained from having an excess number of employees (Baldwin, 1995). As Marshall said, the better profit of a monopoly is a quiet life. In a situation of oligopoly (due to foreign competitors), the managers will choose a higher level of effort by eliminating excess labour or possibly by introducing labour-saving techniques that were not fully exploited prior to the competitive disturbance. They do so not only because this behaviour may increase the profit in the short run, but also because the decrease of costs dissuades competitors from entering into the market and thus avoids a fall in the price. Due to this strategic yield, there exists an additional benefit induced by the effort, which may push management effort near to its optimum[9].

In a more general manner, in any market structure, the intensification of foreign competition due to currency real appreciation is favourable to the productivity of manufactured firms as some of them are obliged to close their poorer performing factories, or even to close down completely; it is a kind of Schumpeterian "creative destruction" which benefits the enterprises which perform best. This argument is realistic for China: under the pressure of the renminbi appreciation since 1994, and notably since China joined the WTO in 2001, Chinese firms have been more and more exposed to foreign competition, and a large number of firms were obliged to reform their management or to close down. It is reported that more than 4000 enterprises were closed in 2014 in Dongguan, a key manufacturing city in southern China's Guangdong province (Salvacion, 2015). The intensification of foreign competition due to appreciation is also favorable to innovation and creation of new products (Alfaro et al., 2018; Dai et al. 2018).

[9] Voir Krugman (1989) p. 133.

The positive effect of the real exchange rate on work efficiency can be captured by adding real exchange rate into the equation as follows:

$$MVA = f(\underset{+}{RER}, \underset{+}{X}, \underset{+}{FDI}, \underset{+}{PRIV}, \underset{+}{KL}, \underset{+}{L})$$

As all the control variables are added into the equation, the coefficient of the real exchange rate measures only the effects that are not captured by the intermediary variables and notably the direct effects on work effort. Its expected sign is positive.

Table 1 summarizes the multiple effects that the real exchange rate variation is assumed to exert on manufacturing in China. It distinguishes the direct effects of real exchange rate variations from those passing through intermediary variables, which are themselves affected by the real exchange rate. Two effects of the appreciation of the real exchange rate on manufacturing are positive - work effort and capital/labor ratio, while the others - exports, foreign direct investments, the importance of private enterprises and employment, are negative (see Table 1, Column 3). The overall effect of the real appreciation of exchange rate on manufacturing is therefore uncertain. An econometric estimation may reveal it.

Table 1: Expected impacts of real exchange rate appreciation on manufacturing

<table>
<tr><td>Direct impacts</td><td colspan="3">Via « work effort » of workers and managers</td><td>$\xrightarrow{+}$</td></tr>
<tr><td rowspan="6">Indirect impacts via transmission channels</td><td colspan="2">Impact of real exchange rate appreciation on intermediary variables (a)</td><td>Impact of intermediary variables on manufacturing (b)</td><td>Impact of exchange rate on manufacturing (c)=(a)*(b)</td></tr>
<tr><td rowspan="3">Size of tradable sector</td><td>$\xrightarrow{-}$ Exports</td><td>$\xrightarrow{+}$</td><td>$\xrightarrow{-}$</td></tr>
<tr><td>$\xrightarrow{-}$ FDI</td><td>$\xrightarrow{+}$</td><td>$\xrightarrow{-}$</td></tr>
<tr><td>$\xrightarrow{-}$ Private ratio</td><td>$\xrightarrow{+}$</td><td>$\xrightarrow{-}$</td></tr>
<tr><td rowspan="2">Inputs</td><td>$\xrightarrow{-}$ employment</td><td>$\xrightarrow{+}$</td><td>$\xrightarrow{-}$</td></tr>
<tr><td>$\xrightarrow{+}$ Capital intensity</td><td>$\xrightarrow{+}$</td><td>$\xrightarrow{+}$</td></tr>
<tr><td colspan="4">Net impact of real exchange rate</td><td>$\xrightarrow{?}$</td></tr>
</table>

4. Econometric model and estimation

We present an econometric model, its estimation strategy and results.

4.1. Econometric model to be estimated

To estimate the different effects of real exchange rates on manufacturing value added, we proceed in two steps. First, we estimate the following equation, which is written in estimation form as follows:

$$\ln MVA_t = a_0 + a_1 \ln RER_t + a_2 \ln X_t + a_3 \ln FDI_t + a_4 \ln PRIV_t + a_5 \ln K/L_t + a_6 \ln L_t + \varepsilon_t \quad (1)$$

The variables are expressed in logarithms so that the coefficients represent elasticities with positive expected signs. As all variables of transmission channels are introduced in the equation, a_1 captures the direct effect of real exchange rate on manufacturing value added.

In the second step, we look for the effect of the real exchange rate, which is exerted indirectly via the other variables that we have assumed to explain the manufacturing growth: exports, foreign direct investments, private enterprises, capital intensity and employment. With this objective in mind, we need to estimate the impact of the real exchange rate on these factors. We estimate separately the following equations.

$$\ln X_t = b_0 + b_1 \ln RER_t + \varepsilon_{t1} \quad (2)$$

$$\ln FDI_t = c_0 + c_1 \ln RER_t + \varepsilon_{t3} \quad (3)$$

$$\ln PRIV_t = d_0 + d_1 \ln RER_t + \varepsilon_{t4} \quad (4)$$

$$\ln KL_t = e_0 + e_1 \ln RER_t + \varepsilon_{i5} \quad (5)$$

$$\ln EM_t = f_0 + f_1 \ln RER_t + \varepsilon_{it7} \quad (6)$$

The expected elasticity signs of all equations are negative except equation 5. The estimation results allow knowing if these channeling variables are effectively the transmission channels, through which real exchange rate affects manufacturing.

The indirect effect of the real exchange rate on manufacturing value added is calculated by multiplying the manufacturing value added elasticity relative to the real exchange rate (a_1 in equation 1) respectively by the elasticities of the determinants of manufacturing value added relative to the real exchange rate (b_1, c_1, d_1, e_1, f_1, in equations 2 to 6). In this way we can evaluate precisely the contribution of each intermediary variable to the effect exerted by real exchange rate on manufacturing value added (Table 2).

Table 2: Direct and indirect effects of real exchange rate appreciation on manufacturing

Effects		Coefficients	Long-run	Short-run
Direct effects		a_1	0.29	0.17
tradable sector	ordinary exports	a_2b_1	-0.06	-0.01
	FDI	a_3c_1	-0.17	-0.07
	private sector	a_4d_1	-0.23	-0.02
Inputs	employment	a_5e_1	-0.31	-0.08
	capital intensity	a_6f_1	0.13	NS
net effects		$(a_1+a_2b_1+a_3c_1+a_4d_1+a_5e_1+a_6f_1)$	-0.35	-0.01

Finally, the net effect of real exchange rate is the sum of direct and indirect effects. This is $(a_1 + a_2b_1 + a_3c_1 + a_4d_1 + a_5e_1 + a_6f_1)$ in which a_1 and a_5e_1 are positive, while the other are negative.

4.2. Estimation period, definition and calculation of variables

The equations from 1 to 6 are estimated using data for the period from 1984 to 2016 for China. The beginning year is 1984; because it is only since this year that real exchange rates began to play a role in the Chinese economy (Guillaumont Jeanneney and Hua, 1996). The data of several variables are available only since this year.

The data on China's real manufacturing value added are obtained from *GGDC 10-Sector Database* published by the Groningen Growth and Development Center (Timmer et al. 2014) over the period 1978-2004 and completed by the data published by in *China Statistical Yearbooks* and United Nation Statistics Division (UNSD), which publishes the data since 2004. The homogeneity of the three databases is checked. China publishes data on industry sector, which is the sum of manufacturing, mining and production and supply of electricity, gas and water. The share of manufacturing value added in total industry value added expressed in 2010 yuans represents around 79% in 2016 in China.

The real manufacturing value added increased from 0.6 billion yuans in 1984 to 20 billion yuans in 2016 at an annual average growth rate of 12% (Fig. 1). The Chinese manufacturing industry suffered three major events, the social movement in 1989 and 1990 when the industrial activities almost stopped, the Asian financial crisis in 1997 when the competitiveness of the Chinese goods deteriorated and the financial crisis in 2008 and 2009 when total demand for the Chinese goods decreased. The Chinese manufacturing growth rate arrived at its lowest level in 2016 (5.9%) since 1984 except for 1989 and 1990 when the industrial activities totally stopped. The share of real manufacturing value added in real GDP increased from 16% in 1984 to 31% in 2016 (Fig 1).

We do not use real effective exchange rate published by IFS, IMF, which includes all economic sectors. Instead, we have calculated three manufacturing real exchange rates. 1) A macro manufacturing real effective exchange rate indices, which are calculated on the basis of year 2010=100, as the ratio of the consumer price index of China to the average consumer price index of its main exports partners of manufactured goods, all prices being converted into the same currency. 2) A micro manufacturing product real effective exchange rate of the renminbi is the weighted product of 188 product real effective exchange rates in function of their importance in the total exports of 188 products at HS4 level (see annex 3). These 188 products are the most important products exported by China. Each product real effective exchange rate is calculated as the product of consumer price of China and the weighted consumer price of the ten most important exporters of the product in world market in function of their share in the total exports of ten exporters, expressed in the same currency. If USA is the first trade partner in the calculation of macro real exchange rate, it is first partner only for 23 products among 188 products in the calculation of product real exchange rate. 3) The micro manufacturing sector real effective exchange rates of the renminbi for 18 manufacturing sectors according to ISIC revision 4 (see annex 4). Each sector real effective exchange rate is calculated as the product of consumer price of China and the weighted consumer price of its eighteen export partners. The macro real exchange rate is used in the baseline estimation. The two micro exchange rates are employed in robustness tests. Given that from 1984 to 1993, China used two exchange rates (the official rate and the swap rate), the renminbi/dollar exchange rate is calculated for this period as a weighted average of these two exchange rates, taking the part of imports financed by the swap exchange market for weighting (Guillaumont Jeanneney and Hua, 2011).

Manufacturing employment comes from *China statistical yearbook 2009* for the period from 1984 to 2002 *and from GGDC* for the period from 2003 to 2011. The manufacturing employment from 2012 to 2016 is from China Statistical yearbooks, national bureau of statistics. The Chinese manufacturing employment increased from 1978 to 1996, and increased again from 2002 to 2005. Fig 3 shows that manufacturing industry have created many jobs in

1980 and a first half of 1990 corresponding the development of labor-intensive industry during this period.

Manufacturing capital intensity is the ratio of capital stock relative to employment in manufacturing sector. We use the permanent inventory method to calculate the capital stock as $KR_t = (1-0.05)KR_{t-1} + IR_t$, where KR and IR represent respectively the capital stock and the investment in constant prices and the annual depreciation rate is assumed to be 5% as in Lin & Liu (2008) and Zheng & Hu (2006). We assume that the initial capital stock in 1963 is equal to the real investment in that year. This hypothesis does not influence capital stock calculation after 1984, because all the capital stock in 1963 had been amortized in 1983. The data on manufacturing investments are published by National Bureau of Statistics of China over the period from 2003 to 2016. For the period from 1981 to 2002, they are calculated as the amount of the manufacturing investment of sate-owned enterprises divided by its share in total manufacturing investment. For the rest of the period from 1963 to 1980, we suppose that the share of the manufacturing investment in fixed capital formation is equal to that in 1981. The manufacturing investment is deflated by two series of prices (2005=100), which are available: the "price index of gross fixed capital formation", drawn from the historical data of China's *National Accounts* available up to 1995, and the "price index of investment in fixed assets" available since 1990 in *China Statistical Yearbook*. The first series is used for the period from 1972 to 1989, and the second series for the following years. This combination is not a drawback, because in the overlapping years the two price series differ only marginally, as also observed in Holz (2006).

The importance of non-SOE enterprises in manufacturing industry is the ratio of manufacturing employment in non-state owned enterprises to the total manufacturing employment. The ratio of non-SOE manufacturing employment increased from 59% in 1984 to 99% in 2016. Real exports of manufactured goods are nominal exports of manufacturing exports deflated its unit value (2010=100), both are taken from UNCTAC statistic. FDI is the stock in manufacturing sector, published in *China Statistical Yearbooks*. Fig 6 shows that FDI mainly increased since 1992 to 2011 and then decreased since 2012.

4.3.Econometric tests and estimation method

We firstly test the unit roots of studied variables. The results show that they are not stationary at absolute level I (0), but are integrated at first difference I (1) (table 3). Consequently, regressing manufacturing value added on its explanatory variables at absolute level is an appropriate estimation strategy if and only if the obtained regression error terms or residual is stationary I (0) (Eberhardt and Teal, 2011; 2013a, b). The Johanson cointegration test is thus used. The obtained results show that manufacturing value added and its explanatory variables are cointergrated I (0) and the estimation residuals are stationary I (0). Consequently, the regression of manufacturing value added at absolute level is not spurious and there is a long run relationship between the studied variables. Second, as all variables are stationary at I(1), the growth rate of manufacturing value added can be regressed on growth rates of its explanatory variables to obtain short-run effects. Finally, an error correction model (ECM) is applied to distinguish short-run from long-run behaviour, to test if the error correction term is statistically significant and to check the speed of adjustment to the long-run equilibrium. The obtained results reported in columns 5 and 6 table 4 shows the error correction term coefficient lagged one period is negative and statistically significant, meaning that there exists an adjustment to long-run equilibrium.

Table 3. ADF stationarity test

	Absolute level		First difference	
	ADF	P-value	ADF	P-value
Real manufacturing value added in 2005$	0.3087	0.3087	-3.391	0.0013
Real exchange rate 2005=100	0.2281	0.2281	-8.058	0.0000
Real export of manufactured goods in 2005 US $	0.7913	0.7913	-6.26	0.0000
Real ordinary exports of manufactured goods	-1.678	0.7604	-5.984	0.0000
Real FDI in manufacturing sector in 2005 US$	0.6010	0.6010	-4.260	0.0036
Share of private enterprises in manufacturing (%)	0.3146	0.3146	-4.087	0.0010
Capital intensity in 2005	0.9884	0.9884	-4.420	0.0001
Manufacturing employment	0.9067	0.9067	-4.478	0.0001

Source: Author's calculation.

4.4. Baseline empirical results

The first four columns in Table 4 report the results of the effects of the real exchange rates on manufacturing value added in long-run (first two columns) and in short-run (three and four columns). When exports are introduced in the regressions 1 and 3, FDI is not statistically significant; its effect is captured by exports. When only ordinary exports are introduced instead of total exports[10], FDI is statistically significant. Our comments are based on the regressions 2 and 4. All control variables are statistically significant. The more China exports manufactured goods, attracts FDI, develops private sector, uses capital intensity form of production and employs the persons in manufacturing sector, the more China products manufactured goods; their estimated coefficients are respectively 0.55, 0.11, 0.29, 0.41 and 0.55 in long-run term and 0.36, 0.16, 0.19, 0.37 and 0.36 in short-run term. The coefficient of real exchange rate is statistically significant and positive (0.29 in long-run term in and 0.17 in short-run term); it confirms the hypothesis that the real renminbi appreciation improves efficiency of the workers and staffs in manufacturing production.

Then to know the net effect of real appreciation on manufacturing value added, the real appreciation is regressed on variables of transmission channels (table 5). As waited, the real appreciation of the renminbi exerts negative effects on exports, FDI, the importance of private sector and employment in manufacturing sector, which themselves influence positively manufacturing; consequently, the indirect effects of the real exchange rate via ordinary exports of manufactured goods, FDI ratio and the importance of private sector are negative and equal respectively to -0.06, -0.17, -0.23 and -0.31 in long-run term and -0.01, -0.07, -0.02 and -0.08 in short-run term. Inversely, the real exchange rate exerts a positive long run effect on capital intensity, which itself influence positively on manufacturing; this leads to a positive impact of the real exchange rate which is equal to 0.13.

Calculation of the total effect of the real exchange rate on productivity growth is given in Table 2. The negative effects (-0.77 in long-run term and -0.17 in short-run term) are superior to the positive long-run effects (0.42 and 0.17), leading a net negative effect of real appreciation on manufacturing value added (-0.35 and -0.01). In summary, the negative effects of the real exchange rate through exports, foreign direct investments, private sector and employment prevail over the positive impacts of a real appreciation through the capital intensity and work efforts of workers and managers, and this mainly through long-run effects.

Not only the coefficients of the real exchange rate are significant, but the elasticity values also show that the results are economically relevant. For instance, during the period of

---

[10] China's customs distinguish two kinds of exports: ordinary exports by Chinese enterprises and processing exports mainly by foreign-funded societies.

from 2005 to 2016, the renminbi appreciated at an annual average rate of 4.28%, which has led a decrease of the manufacturing growth rate of 1.5% per year on average.

Table 4. Effects of macro real exchange rate on manufacturing value added: 1984-2016

	1	2	3	4	5	6
	Long-run	Long-run	Short-run	Short-run	ECM	ECM
Ln(Real effective exchange rate)	0.32*** (3.69)	0.29*** (3.98)	0.20** (2.02)	0.17* (1.95)	0.31*** (3.06)	0.24*** (3.40)
Ln(Capital intensity in manufacturing)	0.51*** (6.54)	0.41*** (5.07)	0.46*** (5.05)	0.37*** (5.00)	0.47*** (6.72)	0.37*** (6.45)
Ln(Employment in manufacturing)	0.61*** (3.05)	0.55*** (3.09)	0.40** (2.74)	0.36** (2.46)	0.43*** (3.20)	0.36** (2.80)
Ln(Real exports of manufactured goods)	0.22** (2.34)		0.16** (2.23)		0.15** (2.30)	
Ln(Real ordinary exports of manufactured goods)		0.16*** (3.57)		0.17*** (3.31)		0.13** (2.44)
Ln(Real FDI in manufacturing)	0.02 (0.28)	0.11* (1.74)	0.12 (1.52)	0.16* (1.87)	0.11* (1.69)	0.15** (2.38)
Ln(Private share in total manufacturing)	0.32*** (5.16)	0.29*** (5.22)	0.22*** (3.03)	0.19*** (3.25)	0.22*** (3.18)	0.22*** (3.40)
EC coefficient$_{t-1}$					-0.50* (-1.94)	-0.60** (-2.09)
Constant	4.01 (1.22)	3.21 (1.07)	-0.004 (-0.21)	0.005 (0.32)	-0.01 (-0.35)	0.01 (0.65)
observation numbers	31	31	31	31	31	31
ADF unit root test for residual	I(0)**	I(0)***				
Johansen cointegration tests	1	1				

Note: 1. Variables are at absolute level for long-run regressions (columns 1 and 2), and at first difference level for short-run regressions and error correction estimation (columns 3, 4, 5, 6).
-*, ** and *** indicate significance at the 10%, 5% and 1% levels of confidence, respectively.

Table 5: Estimation of the channelling variables of the real exchange rate to manufacturing value added: 1984-2016

	7	8	9	10	11	12
Long-run regressions	Export of manufactured goods	Ordinary export of manufactured goods	Manufacturing FDI	Private share in manufacturing	Manufacturing Capital intensity	Manufacturing employment
Real effective exchange rate	-0.54*** (-4.04)	-0.35*** (-3.42)	-1.58*** (-5.97)	-0.81*** (-3.67)	0.31*** (3.00)	-0.56*** (-6.08)
Trend	0.17*** (61.3)	0.16*** (53.5)	0.17*** (30.5)	0.11*** (14.3)	0.10*** (43.1)	0.01*** (3.58)
Constant	25*** (41.7)	24.3*** (47.5)	28.2*** (22.6)	3.40*** (2.85)	7.46*** (14.8)	20.9*** (52.9)
Short-run regressions	13	14	15	16	17	18
Real effective exchange rate	-0.55*** (-3.09)	-0.05*** (-3.23)	-0.44* (-1.74)	-0.10 (-0.42)	0.005 (0.04)	-0.21* (-1.93)
Constant	0.15*** (8.53)	0.12*** (5.33)	0.18*** (7.04)	0.11*** (4.55)	0.11*** (9.35)	0.01 (0.96)
Number of observations	30	30	30	30	30	30

Notes: -*, ** and *** indicate significance at the 10%, 5% and 1% levels of confidence, respectively.

Robustness tests

The impact of real exchange rate can be different according to products and sectors (Dhasmana, 2015). As robustness tests, we have calculated two micro manufacturing real effective exchange rates at product and sector levels. These micro real exchange rates have advantage to reduce potential endogeneity issues relative to the aggregated macro manufacturing real exchange rate. Using product and sectorial data allows in fact controlling for unobservable product and sectorial level effects, which capture different characteristics of products and sectors, which are likely to influence their response to exchange rate changes. The estimation controls for product/sectorial characteristics to capture heterogeneity in response to exchange movements.

We repeated the same estimations by replacing macro real exchange rate by micro product real exchange rate. The obtained confirmed again that the real appreciation of the renminbi exerts a positive effect on manufacturing value added beside its negative effect on the variables of tradable sector and employment and its positive effect on capital intensity.

The micro manufacturing sector real effective exchange rate of the renminbi is calculated for each sector as the product of consumer price of China and the weighted consumer price of its eighteen export partners. As we can see from figure 1, the real effective exchange rate of the renminbi appreciated of 55% over the period from 2006 to 2015. It is interesting to estimate the impact of real appreciation during this period on manufacturing. The publication of WIOD on value added, employment and capital stocks at industrial sectors during this period allows us to estimate panel data on 18 manufacturing sectors over the 2006 to 2014 period. We introduced only export variables because sectorial FDI and private share in manufacturing are unavailable. All variables are legged one period to avoid potential endogeneity issue. The obtained results confirmed the positive effect of the renminbi appreciation on manufacturing productivity improvement besides its negative effect via its impact on exports of manufactured goods (Table 8).

Table 7. Effects of micro product real exchange rate on manufacturing value added: 1994-2016

	1b	2b	3b	4b	5b	6b
	Long-run	Long-run	Short-run	Short-run	ECM	ECM
Ln(Real effective exchange rate)	0.60*** (4.33)	0.48** (2.11)	0.42* (1.77)	0.35* (1.95)	0.57*** (3.59)	0.52*** (3.03)
Ln(Capital intensity in manufacturing)	0.35*** (4.23)	0.38*** (3.46)	0.36 (1.36)	0.31 (1.11)	0.44** (2.49)	0.47** (2.43)
Ln(Employment in manufacturing)	0.60*** (4.33)	0.65*** (3.97)	0.49* (1.82)	0.46* (1.79)	0.59*** (3.33)	0.28** (3.35)
Ln(Real exports of manufactured goods)	0.34** (4.52)		0.25** (2.52)		0.30** (4.61)	
Ln(Real ordinary exports of manufactured goods)		0.25*** (3.18)		0.17* (1.95)		0.21** (3.58)
Ln(Real FDI in manufacturing)	-0.02 (-0.42)	0.02 (0.35)	-0.02 (0.18)	0.02 (0.22)	-0.04 (-0.66)	-0.04 (-0.53)
Ln(Private share in total manufacturing)	0.14** (2.31)	0.25*** (4.30))	0.18* (1.63)	0.21 (1.72)	0.18** (2.52)	0.28*** (3.35)
EC coefficient$_{t-1}$					-1.12*** (-4.29)	-1.02** (-4.11)
Constant	0.47 (0.17)	0.71 (0.21)	0.11 (0.31)	0.02 (0.59)	-0.01 (-0.35)	0.01 (0.65)
Number of observations	21	21	31	31	31	31
ADF unit root test for residual	I(0)**	I(0)***				
Johansen cointegration tests	1	1				

Note: 1. Variables are at absolute level for long-run regressions (columns 1 and 2), and at first difference level for short-run regressions and error correction estimation (columns 3, 4, 5, 6).
-*, ** and *** indicate significance at the 10%, 5% and 1% levels of confidence, respectively.

Table 8. Impact of renminbi real appreciation on manufacturing value added of 18 industrial sectors over 2006-2014 period

	MVA	MVA	ln(Exports of manufactured goods)	ln(capital intensity)	Ln(manufacturing employment)
Ln(Real effective exchange rate)$_{-1}$		2.14* (1.87)	-1.76*** (-3.27)	0.61** (2.01)	-0.68** (-1.93)
Ln(Exports of manufactured goods)$_{-1}$	0.21* (1.86)	0.21* (1.93)			
Ln(Capital intensity)$_{-1}$	1.64*** (7.93)	1.49*** (6.82)			
Ln(manufacturing employment)$_{-1}$	2.14*** (12.8)	2.05*** (11.8)			
Number of observations	144	144	144	144	144
Number of groups	18	18	18	18	18

5. Conclusion

In this paper, the impact of the real exchange rate on manufacturing value added is theoretically underpinned and empirically estimated by using different data. We showed that the real appreciation of the renminbi exerts on the one hand positive effects on manufacturing value added by improving the work efficiency of workers and staffs, keeping the best performing enterprises via a kind of Schumpeterian "creative destruction" and favouring capital intensive production; and on the other hand negative effects via its transmission channels such exports, FDI, private importance in manufacturing sector and employment, leading finally a net negative effect. The real appreciation of the renminbi of 43% during the period 2005-2016 has led a decrease of 15% of manufacturing value added.

These results suggest that the Chinese government should gradually revalue the renminbi in function of manufacturing productivity improvement to avoid the serious deceleration of manufacturing industry when its negative impacts on the size of tradable sector and resource allocation to non-tradable sector is superior to the positive effects of productivity improvement. This allows China to upgrade its manufacturing industry from low cost labour intensive industry to capital intensive one based on innovation and technologies and moving China from low value chain up to high value chain to realize the objective of "Made-in-China 2025 strategy."

References

Alfaro, L, A Cuñat, H Fadinger and Y Liu 2018. "The real exchange rate, innovation and productivity: Regional heterogeneity, asymmetries and hysteresis," NBER, Working Paper 24633.

Chen R. and D. Mai. 2011. "The Real Exchange Rate and Employment in China," IMF Working Paper 11/148.

Dollar, D. 1992. "Outward-oriented developing economies really do grow more rapidly: Evidence from 95 LDCs, 1976–1985. Economic Development and Cultural Change 40(3): 523–544.

Dougherty, S. H. Richard and P. He. 2007. "Has a private sector emerged in China's industry? Evidence from a quarter of a million Chinese firms". China Economic Review 18 (3): 309-334.

Eberhardt, M. and F. Teal 2011. Econometrics for grumblers: A new look at the literature on cross-country growth empirics. Journal of Economic Surveys, 25(1):109-155.

Eberhardt, M. and F. Teal 2013a. No mangoes in the tundra: Spatial heterogeneity in agricultural productivity analysis. Oxford Bulletin of Economics and Statistics, 75(6):914-939.

Eberhardt, M. and F. Teal, 2013b. Structural change and cross-country growth empirics. Policy Research Working Paper Series 6335, The World Bank.

Eichengreen, Barry. 2008. The Real Exchange Rate and Economic Growth. Commission on Growth and Development Working Paper, No. 4, the World Bank

Mary E. Lovely M. E. and Z. Huang 2018. "Foreign Direct Investment in China's High-technology Manufacturing Industries," China & World Economy / 104–126, 26 (5).

Felipe J., A. Mehta and C. Rhee 2018. "Manufacturing matters…but it's the jobs that count," *Cambridge Journal of Economics*, 19 February.

Fu, X. and V. N. Balasubramanyam. 2005. "Exports, Foreign Direct Investment and Employment: The Case of China". The World Economy 28(4): 607-625.

Gebre-Egziabher, T. (2009) "The development impact of Asian drivers on Ethiopia with emphasis on sall-scale footwear producers, The World Economu, 32(11), 1613-1637.

Guillaumont, P. and Sylviane Guillaumont J. 1992. "Exchange Rate Policies and the Social Consequences of Adjustment in Africa" Pp. 12-24, in Economic Reform in Sub-Saharan Africa, edited by Ajay Chhibber and Stanley Fischer, the World Bank, Washington D.C.

Guillaumont Jeanneney S. and P. Hua. 2001. “How Does Real Exchange Rate Influence Income Inequality between Urban and Rural Areas in China?” Journal of Development Economics 64 (2): 529-545.

Guillaumont Jeanneney S. and P. Hua. 2011. “How does Real Exchange Rate influence labour productivity in China?” China Economic Review 22(4): 628–645.

Harris, R. G. 2001. “Is There a Case for Exchange Rate Induced Productivity Declines?” Pp. 277-309,in Re-Visiting the Case for Flexible Exchange Rates, edited by Lawrence Schembri, Bank of Canada, Ottawa.

Holz C. A., 2006. “New capital estimates for China”. *China Economic Review* 17, 2, 142-185.

Hua, P. 2007. “Real exchange rate and manufacturing employment in China”. China Economic Review 18 (3): 335-353.

Jefferson, G. H. and J. Su. 2006. “Privatization and restructuring in China: Evidence from shareholding ownership, 1995-2001”.Journal of Comparative Economics 34(1): 146-166.

Khor, H. E. 1993. “China’s Foreign Currency Swap Market”. IMF Paper on Policy Analysis and Assessment PPAA/94/1. December.

Koopman R., Z. Wang and S-J Wei (2008) How Much of Chinese Exports Is Really Made In China? Asseing Domestic Value-Added When Processing Trade is Pervasive, June NBER Working Paper 14109, http://www.nber.org/papers/w14109.

Kraay, A. 2006. “Exports and economic performance: Evidence from a panel of Chinese enterprises”. Pp. 139-160, in Global Integration and Technology Transfer, edited by Hoekman, Beata and Smarzynska Javorcik, Washington DC: The World Bank.

Kroeber, A R (2011), “The renminbi: The political economy of a currency,” *Foreign Policy*, 7 September.

Leng S. (2018) “China’s once-booming textile and clothing industry faces tough times, ” South China Morning post, 30 April 2018.

Leung D. and T. Yuen. 2005. “Do Exchange Rates Affect the Capital-Labour Ratio? Panel Evidence from Canadian Manufacturing Industries”, Bank of Canada.

Leibenstein H. 1957. Economic Backwardness and Economic Growth, New-York, Wiley.

Leibenstein H. 1966. “Allocative Efficiency versus X-Efficiency”. American Economic Review 56(3): 392-415.

Li, X., X. Liu and David P. 2001. “Foreign Direct Investment and productivity Spillovers in the Chineses Manufacturing sector”. Economic System 25(4): 305-321.

Lin, J. Y.F. and Liu P.L. (2008). “Development Strategies and Regional Income Disparities in China”. in Guanghua Wan (ed), *Inequality and Growth in Modern China*. (New York:Oxford University Press), 56-78.

Liu, X., David P., Kirit V., Y. Wei. 2001. “The impact of foreign direct investment on labor productivity in the Chinese electronics industry”. International Business Review 10(4): 421–439.

Ma H., Z. Wang and K. Zhu (2015), “Domestic content in China’s exports and its distribution by firm ownership, Journal of Comparative Economics.

MacDonald, R. R. and F. V. Vieira. 2010. A Panel Data Investigation of Real Exchange Rate Misalignment and Growth, May 1. CESifo Working Paper Series 3061.

Madariaga, N. and S. Poncet. 2007. “FDI in Chinese Cities: Spillover and Impact on Growth”. World Economy 30(5): 837-862.

Moxnes, A., Ekholm, K. & U. M., Karen Helene. 2012. Manufacturing Restructuring and the Role of Real Exchange Rate Shocks: A Firm-Level Analysis. Journal of International Economics. 86. 101-117. 10.1016/j.jinteco.2011.08.008.

Qi J. H., Zheng Y. M., Laurenceson J. and Li H., 2009. “Productivity Spillovers from FDI in China: Regional Differences and Threshold Effects”. *China & World Economy* 17, 4, 18-35.

Redi, O. (2009) “From ashes, an industry reborn, Fortune (Addis Ababa) March 22.

Rodrik, D. 2008. “The Real Exchange Rate and Economic Growth,” Brookings Papers on Economic Activity 2, 365–412. Rodrik, Dani. (2016), “Premature deindustrialization,” *Journal of Economic Growth*, 21:1–33

Salvacion M. 2006. More Foreign Firms Expected to Close, Move Out of Dongguan Oct 26, 2015 07:40 AM EDT

Schumpeter, J. 1942. Capitalism, Socialism, and Democracy. New York: Harper & Bros.

Sonobe T., Akoten J.E. and Otsuka K. (2009) An exploration into the successful development of the leather-shoe industry in Ethiopia, Review of Development Economics, 13(4) 719-734.

South China Morning Post 2016. Rise of the robots, 30 may.

Timmer M.P., G.J. de Vries and K. de Vries 2014 “Patterns of structural change in developing countries.” GGDC research memorandum, 149.

Vaz P. H. and W. Baer 2014. Real exchange rate and manufacturing growth in Latin America, Latin American Economic Review, 23:2.

Wakefield J. 2016, Foxconn replaces '60,000 factory workers with robots' BBC News, 25 may.

Zheng J. H. and Hu A. G. (2006). “An Empirical Analysis of Provincial Productivity in China, 1979-2001”. *Journal of Chinese Economic and Business Studies* 4, 3, 221-239.

Zhou Yi, C.F. He and S.J. Zhu, (2017) “Does Creative Destruction Work for Chinese Regions? Growth and change, Volume48, Issue3, September, 274-296.

Annex 2: Definitions and sources of variables

Names of variables	Calculation method	Source
Real manufacturing value added	Real manufacturing value added expressed in 2010 yuans	*GGDC 10-Sector Database*, Groningen Growth and Development Centre (GGDC) for 1984-2011 and United Nation Statistics Division (UNSD) for 2011 to 2016.
Manufacturing real effective exchange rate	Ratio of China's consumer price index (2010=100) to the average consumer price index of its 18 manufacturing export partners, converted into the same currency.	- IMF, *International Financial Statistics*
Capital intensity in manufacturing sector	Capital stock divided by employed population. The inventory permanent method is used to calculate the capital stock deflated by the "price index of gross fixed capital formation," and the "price index of investment in fixed assets" available since 1990. The first series is used for the period from 1972 to 1990 and the second for the following years.	- Historical Data on China's Gross Domestic Production Accounts (*Zhongguo Guorei ShengShang Zongzhi Hesuan Lishi Ziliao*) -*China Statistical Yearbook, several editions*
Real exports of manufactured goods	Exports of manufactured goods divided by export unit value	*China Statistical Yearbook, UNCTAD statistics*
Real ordinary exports	Ordinary Exports of manufacturing goods divided by export unit value	*China Statistical Yearbook, UNCTAD statistics*
Real FDI	Foreign direct investments divided by gross formation of fixed capital	*China Statistical Yearbooks*
Private importance	Private share in total manufacturing employment	*GGDC, China Statistical Yearbooks*

Annex 3: list of products at HS4 level

HS4	product names	weights	HS4	product names	weights
8471	Automatic data processing,magnetic,optical read	10,94	8482	Ball or roller bearings	0,23
8525	Transmission apparatus for radio,TV,with or wit	6,05	8526	Radar,radio navigational aid apparatus,remote c	0,23
8517	Electrical telephonic,telegraphic,for carriers-	4,98	8532	Electrical capacitors,fixed,variable or adjusta	0,23
8473	Parts suitable for use solely or principally wi	3,13	6103	Men's or boys' suits, ensembles, etc, knitted o	0,22
8542	Electronic integrated circuits and microassembl	2,38	3907	Polyethers and epoxide resins; polyesters, in p	0,22
8443	Printing machinery;machines for used ancillary	2,09	8429	Self-propelled bulldozers,graders,levellers,scr	0,22
8541	Diodes,semi-conductor devices,light emitting di	1,81	8703	Motor cars and other motor vehicles principally	0,21
8529	Accessory parts for the apparatus in heading 85	1,67	7321	Non electric domestic appliances,stoves,parts t	0,21
8504	Electrical transformers,static converters and i	1,65	4412	Plywood, veneered panels and similar laminated	0,21
8528	Television receivers(including video monitors a	1,60	8538	Parts suitable for the apparatus of headings 85	0,21
6110	Jerseys, pullovers, cardigans and similar artic	1,56	8419	Machinery,plant or lab equipment for all purpos	0,21
9504	Articles for funfair,special tables for casino,	1,56	9001	Optical fibres,opticalfibre bundles,other than	0,20
4202	Trunks, suit-cases...; handbags... and similar	1,45	2941	Antibiotics	0,20
9403	Other furniture and parts thereof	1,44	3920	Other plates..., of plastics, not reinforced, e	0,20
6204	Women's or girls' suits, ensembles, jackets, bl	1,42	8450	Household,laundry-type washing machines,includi	0,20
9013	Liquid crystal devices not constituting article	1,24	8712	Bicycles and other cycles(including delivery tr	0,19
9401	Seats whether or not convertible into beds,and	1,22	8426	Ships'derricks;cranes;mobile lifting frames,str	0,19
6402	Other footwear with outer soles and uppers of r	1,16	4203	Articles of apparel and clothing accessories of	0,19
8544	Insulated wire,cable,other insulated electric c	1,15	9603	Brooms,brushes,hand/machine floor sweepers,tuft	0,19
8516	Electric instantaneous,domestic appliances,othe	1,13	5402	Synthetic filament yarn, nprs (incl. synthetic	0,19
8708	Parts and accessories of the motor vehicles of	1,11	8424	Mechanical appliances for projecting,stem,sand	0,19
6403	Footwear, with rubber, plastics, leather... sol	1,09	3105	Mineral or chemical fertilizers, nes; other fer	0,19
9503	Other toys;reduced-size models,recreational mod	1,04	8409	Accessory parts suitable for engines of heading	0,18
9405	Lamps,lighting fittings,not elsewhere specified	0,99	3808	Insecticides, rodenticides... and similar produ	0,18
3926	Other articles of plastics, nes	0,96	4901	Printed books, brochures, leaflets and similar	0,18
8536	Electrical apparatus for making connections,vol	0,93	7202	Ferro-alloys	0,18
8534	Printed circuits	0,91	4819	Cartons, boxes, etc; box files, etc, of paper,	0,18

8901	Cruise ships,excursion/ferry-boats,similar for	0,86	6505	Hats and other headgear, kintted or crocheted..	0,18
8518	Microphones,headphones,earphones,speakers sets,	0,86	8301	Padlocks,locks of base metal;claps,frames,incor	0,18
6203	Men's or boys' suits, ensembles, jackets, blaze	0,80	7219	Flat-rolled products of stainless steel,of a wi	0,18
4011	New pneumatic tyres, of rubber	0,77	8716	Traillers;other vehicles,not mechanically prope	0,18
9506	Articles,equipments for general physical exerci	0,76	8428	Other lifting,handling,loading,unloading machin	0,18
8481	Tapes,valves,for pipes pressure reducing,thermo	0,74	8480	Moulding boxes for metal foundry,bases,patterns	0,17
8415	Air conditiong machines,with or without automat	0,73	3824	Prepared binders; chemical products, nes; resid	0,17
8414	Air or vacuum pumps,exhausting and compression	0,66	9004	Spectacles,goggles and the like,corrective,prot	0,17
6104	Women's or girls' suits, ensembles, etc, knitte	0,65	8474	Machinery for sorting,screening,agglomerating,f	0,17
8501	Electric motors and generators	0,60	8477	Machinery for working rubber or plastics/other	0,17
7308	Sructures and parts of structures(bridges and b	0,60	7013	Glass articles used for indoor decoration or si	0,17
8543	Electrical machines,apparatus with one function	0,58	3204	Synthetic organic colouring matter and preparat	0,17
8521	Video recording or reproducing apparatus,incorp	0,58	6908	Glazed ceramic flags and paving,hearth or wall	0,17
6109	T-shirts, singlets and other vests, knitted or	0,55	3102	Mineral or chemical fertilizers, nitrogenous	0,16
6404	Footwear with rubber, plastic, leather soles an	0,54	2936	Provitamins and vitamins, derivatives thereof u	0,16
7208	Flat-rolled products of iron/non-alloy steel, o	0,53	8503	Parts suitable for use solely or principally wi	0,16
8509	Electro-mechanical domestic appliances with sel	0,52	6301	Blankets and travelling rugs	0,16
8507	Electric accumulatlors including spearators,whe	0,52	5903	Textile fabrics impregnated, coated, covered or	0,16
8523	Prepared unrecorded media for sound,similar rec	0,49	7117	Imitations jewellery	0,16
6202	Woman's or girls' overcoats, and similar articl	0,49	8505	Eletro0magnets,permanent magnets,coupings,,brak	0,16
7304	Tubes,pipes and hollow profiles,seamless,of iro	0,48	7306	Other tubes,pipes and hollow profiles,of iron o	0,16
7326	Other articles of iron or steel	0,48	9032	Automatic regulating,controlling instruments an	0,15
8527	Reception apparatus for radio-relephony,reprodu	0,47	5209	Woven fabrics of cotton, with >=85% cotton, >20	0,15
3923	Articles for the of goods, of plastics; stopers	0,46	7616	Other articles of aluminium	0,15
8418	Refrigerators,freezers electric or other except	0,42	9019	Mechano-therapy appliances,other therapeutic re	0,15
7210	Flat-rolled products of iron/non-alloy steel, o	0,41	4016	Other articles of vulcanized rubber, nes (excl.	0,15
8539	Electtic filament,discharge lemps,ulta-violet,i	0,41	8430	Other moving,grading,machinery for earth,ores,s	0,15
9404	Mattress supports,articles of bedding,fitter wi	0,40	6107	Men's or boys' briefs and similar articles, kni	0,15
8302	Base metal mountings,fittings for furnitures,au	0,40	7228	Other bars and rods of alloy steel;angles etc.h	0,15
8508	Electro-mechanical tools for working in the han	0,40	6601	Umbrellas, sun umbrellas, garden umbrellas	0,15

6302	Bed linen, table linen, toilet linen and kitche	0,39	7225	Flat-rolled products of other alloy steel,of a	0,14
6002	Other knitted or crocheted fabrics	0,39	6105	Men's or boys' shirts, knitted or crocheted	0,14
5407	Woven fabrics of synthetic filament yarn	0,39	8506	Primary cells and primary batteries	0,14
8431	Accessary parts sutiable for machinery of headi	0,38	6406	Parts of footwear; removable in-soles, etc; gai	0,14
6201	Men's or boys' overcoats, and similar articles	0,37	3818	Chemical elements in disk form and compounds, d	0,14
7113	Jewelles and parts of precious metal,metal clad	0,37	7209	Flat-rolled products of iron/non-alloy steel, o	0,14
8413	Pumps for liquids,with or without measuringdevi	0,36	4810	Paper..., coated with kaolin (china clay), etc,	0,14
6307	Other made up articles (incl. dress patterns)	0,36	9002	Lenses,prisms,mirrors,other such elements of gl	0,14
3924	Tableware, kitchenware... and toilet articles,	0,35	8205	Hand tools not elsewhere specified;hand or peda	0,14
7323	Table,kitchen,other household articles,parts th	0,35	4421	Other articles of wood	0,14
6108	Women's or girls' panties and similar articles,	0,34	6303	Curtains (incl. drapes) and interior blinds; cu	0,14
5208	Woven fabrics of cotton, with >=85% cotton, but	0,32	8513	Portable electric lamps functin by their own so	0,14
6212	Brassieres, girdles, corsets, braces, suspender	0,32	6911	Tableware,kitchenware,other household,toilet ar	0,14
7318	Screws,bolts,nuts,screw hooks,rivets,similar ar	0,31	6112	Track-suits, ski-suits and swimwear, knitted or	0,13
8479	Machines,mechanical appliances having individua	0,31	2804	Hydrogen, rare gases and other non-metals	0,13
6205	Men's or boys' shirts	0,31	8470	Calculating machines;accounting machines,postag	0,13
8537	Boards,panels,consoles,desks etc.. other than s	0,30	2931	Other organo-inorganic compounds	0,13
6210	Garments, made up of fabrics of 56.02, 56.03, 5	0,29	8411	Turbo-jets,turbo-propellers and other gas turbi	0,13
9018	Medical instruments,veterinary equipments,elect	0,29	2922	Oxygen-function amino-compounds	0,13
2933	Heterocyclic compounds with nitrogen hetero-ato	0,29	8207	Interchangeable hand tools,whether not power op	0,13
6206	Women's or girls' blouses, shirts and shirt-blo	0,29	9003	Frames,mountings,goggles or the like and parts	0,13
8711	Motocycles,motor fitted cycles,with or without	0,28	8512	Electrical lighting/signalling equipment(exclud	0,13
8714	Parts and accessories of vehicles of headings 8	0,28	6405	Other footwear, nes	0,13
6115	Panty hose, tights, etc, and footwear, knitted	0,27	7019	Glass fibres(including glass wool) and articles	0,13
8522	Parts and accessories of apparatus of heading 8	0,27	2918	Carboxylic acids with oxygen function, etc, the	0,12
6211	Track suits, ski suits and swimwear; other than	0,26	8407	Spark-ignition reciprocating or rotary internal	0,12
8483	Transmission shafts,cranks,clutches,sahft coupl	0,26	8467	Tools for working in the hand,pneumatic/self co	0,12
9505	Festive,carnival,entertainment articles,conjuri	0,26	5205	Cotton yarn, with >=85% cotton, not put up for	0,11
9102	All types of portable watches other than those	0,25	7615	Domestic articles of aluminium,sanitary wares,p	0,11
8519	Record/cassette players,other sound systems,exc	0,25	3919	Self-adhesive plates, foil, tape, strip... of p	0,11

6111	Babies' garments and clothing accessories, knit	0,25	4418	Builders' joinery and carpentry of wood	0,11
8531	Electric sound/visual signalling apparatus othe	0,25	6116	Gloves, mittens and mitts, knitted or crocheted	0,11
8421	Centrifuges,centrifual dryers;filtering,purifyi	0,24	9608	Ball point,felt,porous-tipped pens,,markers,hol	0,11
8502	Electric generating sets and rotary converters	0,24	6702	Artificial flowers, foliage and fruit; articles	0,11
8704	Motor vehicles for the transport of goods	0,24	8533	Electical resistors(rheostats,potentiometers)ot	0,11
7307	Tubes or pipe fittings,of iron or steel	0,23	4820	Registers, account books, etc; albums for sampl	0,11
6802	Worked monumental stones or building stone and	0,23	3921	Other plates, sheets, film, foil and strip, of	0,11

Source: UN COMTRADE

Annex 4. List of sectors according to ISIC revision 4

Manufacture of food products, beverages and tobacco products	C10-C12
Manufacture of textiles, wearing apparel and leather products	C13-C15
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	C16
Manufacture of paper and paper products	C17
Printing and reproduction of recorded media	C18
Manufacture of coke and refined petroleum products	C19
Manufacture of chemicals and chemical products	C20
Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21
Manufacture of rubber and plastic products	C22
Manufacture of other non-metallic mineral products	C23
Manufacture of basic metals	C24
Manufacture of fabricated metal products, except machinery and equipment	C25
Manufacture of computer, electronic and optical products	C26
Manufacture of electrical equipment	C27
Manufacture of machinery and equipment n.e.c.	C28
Manufacture of motor vehicles, trailers and semi-trailers	C29
Manufacture of other transport equipment	C30
Manufacture of furniture; other manufacturing	C31_C32
Repair and installation of machinery and equipment	C33