# Real exchange rate and manufacturing employment in China

Ping HUA[*]

CERDI, CNRS-Université d'Auvergne

**Abstract**

The impacts of the real exchange rate on employment and its channels are investigated. A real appreciation, 1) by decreasing the cost of imported inputs and increasing real wages expressed in tradable goods (technological channel), 2) by decreasing exports (export volume channel), 3) by exerting pressure on efficiency improvement (efficiency channel), exerts a negative effect on employment. Using the panel data of the 29 Chinese provinces for the period 1993-2002, the econometric results confirm the negative effects of the real appreciation of the Renminbi on manufacturing employment. The three channels are statistically significant, the technological channel being the most important.

Keywords: Real exchange rate, employment, China

JEL classification: F16, J23

[*]CERDI-CNRS, Université d'Auvergne, 65, boulevard François Mitterrand, 63000 Clermont-Ferrand, France. Tel: 00 33 1 39 14 81 25; Fax: 00 33 4 73 43 12 28, Email: P.Hua@u-clermont1.fr.

## 1. Introduction

We know that China's exchange rate policy matters. Currently, China is under considerable pressure from industrialized countries in favor of re-evaluation and a more flexible exchange rate regime of the Renminbi[1]. The stable parity around 8.27 yuans/US$ since 1998 is considered as a price advantage for Chinese products on the markets of developed countries. China's exchange rate policy is held to be responsible for the increasing trade deficit in these countries towards China and for the unemployment in their manufacturing sectors (Holtz-Eakin, 2003; Goldstein, 2004). The recent appreciation of the Renminbi against the US dollar (2.1%) and the change in China's exchange rate regime in July 2005 have received a warm welcome in these countries.

However, one effect which was perhaps not expected is that, since the 1990s, China has lost more manufacturing jobs than the United States and other major countries. From 1995 to 2002, China lost 15 million manufacturing jobs, compared with 2 million in the U.S. (Xu, Spiegelman, McGuckin, Liu and Jiang, 2004). Moreover, it lost manufacturing jobs in those industries where the U.S. and other major countries have also seen jobs disappear, such as textiles. The U.S. lost 202,000 textile jobs between 1995 and 2002, but China lost far more jobs in this sector (1.8 million). All told, 26 of China's 38 major industries registered job losses between 1995 and 2002.

Where it differs from developed countries is that China is gaining jobs in service industries which created 42 million during the same period. This means that the share of employment in the tertiary sector relative to total employment increased from 25% in 1995 to 29% in 2002, while that of manufacturing employment decreased from 14% to 11%. However, these job creations in services are not sufficient to resolve the unemployment problem which has become so serious that the development of labor-intensive manufacturing industries has regained prominence on the Chinese government's agenda, whereas they were

[1] The name of the Chinese currency is the Renminbi and its unit is the yuan.

previously discouraged in favor of capital- and technology-intensive industries (China Daily, 2003). While the number of registered unemployed persons in urban areas increased from 3.5 million in 1991 to 8 million in 2003 (with an unemployment rate of 3.6% and 4.3% respectively), the real unemployment situation is more serious. Using data from a unique survey conducted in five large Chinese cities, Giles, Park and Zhang (2005) find that unemployment rate was 14% for urban permanent residents in 2002. They estimated, for China as whole, that the urban permanent unemployment rate increased from 6.1% to 11.1% from January 1996 to September 2002.

This loss of Chinese manufacturing jobs coincided with a period of real appreciation of the Renminbi[2] which increased at an average rate of 4.1 % per year from 1993 to 2002. As Chinese manufacturing goods are sensitive to the real exchange rate (Guillaumont Jeanneney and Hua, 1996; Hua, 1996), manufacturing exports increased at a lower annual average rate (13%) during this period of real appreciation than during the previous period from 1981 to 1993 (19%) when the real exchange rate of the Renminbi depreciated at an annual average rate of 7.8%. These decreasing manufacturing exports resulting from the real appreciation exert a negative effect on manufacturing employment. The level of employment in the Chinese manufacturing sector decreased at an annual average rate of -2.3 %, from 93 million in 1993 to 83 million in 2002. China lost 10 million manufacturing jobs during the period of real appreciation. Inversely, during the previous period, the increased manufacturing activities stimulated by the real depreciation of the Renminbi allowed firms to employ more workers. The employment level in the Chinese manufacturing sector increased at an average of 3.9% per year on average, from 53 million in 1978 to 93 million (figure 1). China created 40 million manufacturing jobs during the period of real depreciation.

[2] The real effective exchange rate is calculated as the nominal effective exchange rate multiplied by the ratio of consumer prices between China and its foreign partners. During the period of double exchange rates, a weighted official and swap exchange rate is calculated instead of the official rate (Guillaumont Jeanneney and Hua, 2001). An increase means an appreciation. For details of China's exchange rate policy, see 3.2.1.

This negative relationship between real appreciation and manufacturing employment is also evident at provincial levels. All the Chinese provinces experienced a real appreciation[3] during the period 1993-2002, ranging from an annual average rate of 1.6 % in Yunnan to 5.9 % in Beijing municipality (figure 2). At the same time, most of the Chinese provinces (all but five) saw the number of jobs in the manufacturing sector fall. The level of manufacturing employment decreased at an annual average rate from –9.4% in Jilin province to –0.02% for Shangdong province. Among the five provinces, the level of manufacturing employment in Fujian, Guangdong and Zhejiang provinces increased at an annual average rate of 2.9 %, 1.4% and 1% respectively, despite an annual average real appreciation of 4%, 3,2% and 4,4% respectively. This indicates that the real exchange rate is one of the determinants of manufacturing employment.

Despite this observed negative relationship between the real appreciation of the Renminbi and manufacturing employment, there are no studies, to our knowledge, which analyze the effect of real exchange rate on Chinese manufacturing employment. This is not very surprising. In fact, the literature which analyzes the employment response to real exchange rate movements for developing countries is just emerging. Using panel data for Hungarian exporting firms from 1992-1996, Koren (2001) found significant industry-specific impacts of the real exchange rate on employment. Frenkel (2004) also shows a significant influence of the real exchange rate on employment in Argentina, Brazil, Chile and Mexico. Filiztekin (2004) finds significant effects of exchange rate fluctuations on Turkish manufacturing employment using panel data of manufacturing industries over the period 1981-1999.

Even for developed countries, the analysis of the effects of the real exchange rate on employment only began in the late of 1980s following the strong fluctuation of the U.S.

[3] The real effective exchange rate differs from one province to another because the provinces has a different swap rate in 1993 (Khor, 1993), as well as different rates of inflation and different foreign trading partners (Guillaumont Jeanneney and Hua, 2002).

dollar. Most of them focus on manufacturing employment, because almost every industrialized country has experienced a declining share of manufacturing employment in the last half century (Fisher, 2004). Using industry-level data from 1970 to 1986, Branson and Love (1986, 1987) find a significant effect of the real exchange rate on U. S. manufacturing employment. In contrast to their results, Campa and Goldberg (2001) find a very weak relationship between employment and the exchange rate in U.S. manufacturing industries for the period 1972-1995. Burgess and Knetter (1988) found that the elasticity of employment relative to exchange rates differs considerably between industries and countries in the G-7 group. Revenga (1992) finds that the appreciation of the dollar caused a fall in the level of employment, especially in industries facing stronger competition from imports. Dekle (1998) shows a significant impact of the real exchange rate changes on Japanese manufacturing employment. Using French firm-level data, Gourinchas (1999) finds that exchange rate appreciations reduce employment growth.

The objective of this paper is to measure the impact of China's real exchange rate on its manufacturing employment. We firstly develop an extended labor demand function in which the effects of the real exchange rate on employment are analyzed. These effects are then estimated in section 3, using panel data for the 29 Chinese provinces over the period 1993-2002. We estimate the level of manufacturing employment as a function of the real exchange rate, of the variables representing the channels through which the real exchange rate affects employment and of industrial production. The chosen period is limited here by the available data on provincial manufacturing employment. We begin our provincial statistical analysis in 1993 and end it in 2002, because the *China Statistical Yearbook* published the manufacturing employment for provinces for this period only.

## 2. Theoretical analysis of employment effect of the real exchange rate of the Renminbi[4]

[4] The analysis in this paper is limited to employment in the tradables sector. However, the effect of the real exchange rate on employment is not restricted to the tradables sector, but also in the non-tradables sector. Non-tradable activities are not exposed to international competition, but relative prices also affect the relative use of labor. If capital goods used in the non-tradables sector have a significant import component, the competition

The Chinese economy has gradually opened up to international trade and foreign direct investments since 1979. China has now become the third most important exporting country in the world and the second largest beneficiary of foreign direct investments. China's exchange rate policies have played an important role in this commercial and financial openness (Hua, 2002). It is therefore important to quantify to what extent the Chinese labor force is exposed to these external market conditions. Our analysis begins with a base labor demand function which is extended by taking into account the effects of the real exchange rate on labor demand.

### 2.1. Labor demand function

Following Greenaway, Hine and Wright (1999), Milner and Wright (1998) and Fu and Balasubramanyam (2005) who developed a model analyzing the employment effect of trade, we begin our analysis by writing a Cobb-Douglas production function:

$$Q_{it} = A^{\gamma} K_{it}^{\alpha} N_{it}^{\beta} \qquad (1)$$

where i and t denote provinces and time respectively. Q is real output, K is capital stock, N is labor input used. α and β represent the factor share coefficients and γ allows for efficiency growth in the use of labor in the production process.

Assuming that economic agents are profit-maximizing, the marginal product of labor equals the wage (w) and the marginal product of capital equals its user cost (c). This gives:

$$w_{it} = A^{\gamma} K_{it}^{\alpha} \beta N_{it}^{\beta-1} \qquad (2)$$

$$c_{it} = A^{\gamma} \alpha K_{it}^{\alpha-1} N_{it}^{\beta} \qquad (3)$$

Solving this system simultaneously to eliminate capital from the express for output allows us to obtain the following equation:

$$Q_{it} = A^{\gamma} \left( \frac{\alpha N_{it}}{\beta} * \frac{w_{it}}{c_{it}} \right)^{\alpha} N_{it}^{\beta} \qquad (4)$$

forces in local markets will drive firms to reduce their relative use of labor in the case of real appreciation, and to increase it in a context of real depreciation. This will be analyzed in a future paper.

Taking logarithms and rearranging equation (4) allows us to derive the base labor demand equation as fellows:

$$\ln N_{it} = \phi_0 + \phi_1 \ln Q_{it} + \phi_2 \ln(\frac{c_{it}}{w_{it}}) + \varepsilon_{it} \qquad (5)$$

where: $\phi_0 = -\alpha(\ln\alpha - \ln\beta)/(\alpha+\beta)$; $\phi_1 = 1/(\alpha+\beta)$; $\phi_2 = \alpha/(\alpha+\beta)$; $\varepsilon_{it}$ is a disturbance term which varies across provinces and time and possesses the usual properties.

**2.2. Extended labor demand function: impacts of the real exchange rate on employment**

We extend the above base labor demand function into an open economy to analyze the impacts of the real exchange rate on employment. Three channels through which the real exchange rate affects employment are identified.

1. The *technological channel* measures the impact of the real exchange rate on employment via the cost modification of imported inputs and workers, thus via capital/labor intensity. A real appreciation of the exchange rate decreases the cost of imported inputs and leads to higher real wages expressed in tradable goods. It is unfavorable to employment by increasing labor productivity. The effect is the inverse for real depreciation.

2. The *export volume channel* emphasizes the impact of the real exchange rate on employment via export activities. A real appreciation of the exchange rate is unfavorable to employment by decreasing the levels of exports. Inversely, a real depreciation of the exchange rate stimulates exports, and thus favors employment.

3. The *efficiency channel* analyses the employment impact of the real exchange rate via efficiency change in the use of labor. A real appreciation exerts pressure on efficiency improvement by increasing international competition and real wages. This pressure may be dampened by its negative effect on export penetrations which improve efficiency. The effect is the inverse for the real depreciation.

While the first and second channels have to a certain extent been explained in Frenkel[5] (2004) and Koren[6] (2001), the third channel remains unexplored.

**2.2.1. The technological channel**

From equation 5, we can see that the effect of the real exchange rate on employment depends on the cost of imported inputs and workers as this determines the imported inputs/labor relative price. It is thus an important factor of the capital/labor goods relative price in the countries where imported components represent a significant part of capital goods. A real appreciation decreases the cost of imported inputs which has a positive effect on capital/labor intensity and thus a negative effect on employment. Inversely, a real depreciation reduces capital/labor intensity by favoring labor-intensive activities.

On the other hand, the real exchange rate determines the value of wages measured in international currency which is the most relevant labor cost in internationally tradable activities. A real appreciation means an increase in the real labor remuneration expressed in tradable goods, which again has a positive effect on capital/labor intensity and a negative effect on employment. This effect depends on the substitution possibilities between capital and labor, which are quite considerable in China (Zhang, 2004).

To measure the effect of capital/labor intensity on employment, the ratio between the capital user cost and wages in the previous equation (5) is replaced by capital/labor intensity as follows:

$$\ln N_{it} = \phi_0 + \phi_1 \ln Q_{it} + \phi_2 \ln KL_{it} + \varepsilon_{it} \qquad (6)$$

where KL denotes capital intensity.

The Chinese reforms launched at the end of 1978 were implemented with a view to achieving the objective of "industrialization of the Chinese economy." Investments were geared towards the adoption of modern, labor-saving technologies (Fu and Balasubramanyam,

[5] Frenkel (2004) distinguishes the macroeconomic channel, the development channel and the labor intensity channel.

[6] Koren (2001) distinguishes two channels through which the exchange rate affects labor demand: one is through the positive effect of a real depreciation on exports, the other is through production costs.

2005). They were encouraged by China's exchange rate policies. Since then, those imports corresponding to the objective of industrialization were financed at the official rate during the period of real depreciation from 1980 to 1993, while others were financed at the higher swap rate. The real appreciation after the unification of exchange rates in 1994 reduced the cost of imports. Imports of machinery and transport equipment rose from 5 billion US dollars in 1980 to 193 billion in 2003, representing 39% and 57% of the imports of manufactured goods respectively.

As a result, increased investment in fixed assets did not stimulate many job opportunities. During the period of real appreciation of the Chinese currency from 1993 to 2002, capital/labor intensity increased at an annual average rate of 12%, while manufacturing employment decreased at an annual average rate of -3.8%. During the period of real depreciation, capital/labor intensity increased at lower annual average rate (6.4%) and manufacturing employment increased at an annual average rate of 2.9%. At the level of the Chinese provinces, the annual average growth rate of capital intensity varied from 6.5% in Heilongjiang to 16.7% in Tianjin for the period 1993-1992, while the corresponding annual average growth rates of manufacturing employment varied from -7.7% to -6.8%.

**2.2.2. The export volume channel**

The traditional argument involves the diminishing competitiveness of domestic firms on the world markets resulting from an appreciation of the real exchange rate, and inversely the improved competitiveness resulting from a real depreciation. In fact, real appreciation decreases exports due to an increase in the relative prices of non-tradable goods and consequently weaker demand on domestic activities and lower levels of output and employment. Inversely, a real depreciation of the real exchange rate favors the activities of tradable goods that may not been profitable before. It induces a shift of production factors into the export sector (Feder, 1983). This shift is particularly important for China's labor-intensive export sector of manufactured goods which corresponds to the comparative advantage of

China (Yue and Hua, 2002). The share of manufacturing goods in the total rose from 50% in 1980 to 92% in 2003.

In fact, since the beginning of China's transition towards a market economy, exports (in current dollars) have increased rapidly. However, the annual export growth fell slightly during the 1990s. It dropped from an average of 15% during the period 1980-1993, when the real exchange rate depreciated, to 12.8% during the period 1993-2003 when, on the contrary, the real exchange rate appreciated. The decreasing export activities resulting from the real appreciation exerts a pressure on manufacturing employment.

To capture the effects of export activities on job opportunities, we follow here Fu and Balasubramanyam (2005) by allowing exports to affect employment. As real output (Q) is equal to the sum of net real domestic output (DQ) and real exports (X), the above labor demand equation (6) can be written as:

$$\ln N_{it} = \phi_0 + \phi_{11} \ln DQ_{it} + \phi_{12} \ln X_{it} + \phi_2 \ln KL_{it} + \varepsilon_{it} \qquad (7)$$

The labor demand elasticities of exports and domestic production may differ because of their different industry structures and the highly FDI-funded nature of the export sector.

The inflow of foreign direct investments has created job opportunities via export activities. In China, as in other developing countries, foreign investments are concentrated in the sector of tradable goods, mainly in industry. Most of them focus primarily on labor-intensive, processing or assembly production activities such as clothing, textiles, footwear, toys and processing and assembly of electronic consumer goods. The inflows of foreign direct investments have reinforced the labor-intensive exports of manufactures to such an extent that exports of these goods represent 60% of the total manufacturing exports in 2003. The establishment of foreign firms or joint ventures has created new jobs within these firms. In 2003, foreign-funded firms employed almost 9 million people in China.

In order to capture the effect of FDI on employment, we extend the model of Fu and Balasubramanyam (2005) to divide real exports into those from foreign-funded firms and domestic real exports. We introduce the FDI stocks to capture its effects on exports of foreign-funded firms. The previous equation (7) is written as:

$$\ln N_{it} = \phi_0 + \phi_{11} \ln DQ_{it} + \phi_{121} \ln DX_{it} + \phi_{122} \ln FDIS_{it} + \phi_2 \ln KL_{it} + \varepsilon_{it} \qquad (8)$$

where DX denotes exports by Chinese firms, FDIS denotes the real stocks of foreign direct investments. The labor demand elasticities of domestic exports may be different from those of exports from foreign-funded firms because domestic exports are more ordinary products, while the exports realized by foreign-funded firms are processing and assembly goods.

**2.2.3. The efficiency channel**

The real exchange rate influences efficiency in the use of labor in two ways. The first is through openness (Greenaway, Hine and Wright, 1999; Fu and Balasubramanyam, 2005). In fact, the export sector is generally considered more efficient than non-export sector; and its efficiency in the use of labor is probably higher than in the heavy industry, the agricultural or the service sectors.

This argument is based on a dualistic view of the economy according to which the marginal productivity of labor is unequal in different sectors. This assumption seems to be relevant here, as the Chinese workers cannot freely choose their place of work. The relative advantage in terms of efficiency of labor use in the manufacturing sector in China may have been progressively increased by the learning-by-doing effect and by economies of scale due to market expansion. This advantage was probably still present several years after the beginning of the transition of China towards a market economy, thus in the 1990's. Moreover, the export sector provides external economies to the whole manufacturing economy through improved management and labor training. This export-induced efficiency improvement in the use of labor reduces job opportunities. Using the data for the 28 manufacturing sectors in the 29 provinces, Sun and Doucouliagos (1999) effectively show that the openness of the Chinese provinces towards the outside was a factor of efficiency for industry.

Second, the real exchange rate also has a direct influence on efficiency in the use of labor. A real appreciation increases real labor remuneration expressed in tradable goods which improve workers' efficiency, particularly in a country where the wages of unskilled workers are still very low. Leibenstein (1957) stressed that in developing countries too weak a remuneration of labor might spoil workers' health and their working capacity and showed that the motivation of workers acts on efficiency, in what he called the "X-efficiency" (Leibenstein, 1966). This hypothesis seems pertinent in the case of China where, in 2001, 46.7% of the population lived with less than two dollars per day and 16.6% with less a dollar[7]. However, skilled workers are also concerned by the increase of remunerations induced by a real appreciation of the exchange rate. We may suppose that the latter slows down the emigration of this type of worker (Harris, 2001). In fact, China has suffered a significant brain drain. We have observed the return of some Chinese workers since 1990s thanks to the improved remuneration of skilled labor[8]. This growth in efficiency induced by a real appreciation of the exchange rate allows firms to maintain the same production level with lower employment, or to increase production without increasing employment. It therefore exerts a negative effect on employment.

Furthermore, a real appreciation exerts a positive effect on the efficiency of industrial firms because it heightens foreign competition (Caves and Krepps, 1993). In the case of real appreciation, firms may be compelled to close their less efficient factories and improve their efficiency (Krugman, 1989; Guillaumont and Guillaumont Jeanneney, 1992). Consequently, real appreciation may raise labor productivity and reduce employment.

[7] More precisely 2.15 and 1.08 dollars by measuring the expenditure using 1993 international prices, cf. World Bank, World Development Indicators, 2004.

[8] An appreciation may increase the return to skilled labour in a Stolper-Samuelson effect if the tradables sector is human-capital intensive relative to the non-tradables sector (Harris, 2001, p.13)

More precisely, managers benefit from only a part of the profit induced by better management or a stronger effort since a part of the profit goes to the company owners. In the case of monopoly, managers do not choose the exertion that maximizes profit, for such reasons as a preference for leisure over work involved in seeking out all profitable opportunities and the power and satisfaction they gain from an excess number of employees (Baldwin, 1995). As Marshall said, the best profit of a monopoly is a quiet life.

Then, in a situation of oligopoly, given some rent-threatening disturbance such as increased international competition (due to new foreign competitors and, in the case of China, due to competitors localized in the other provinces), the managers will choose a higher level of effort by eliminating excess labor or possibly by introducing labor-saving techniques that were not fully exploited prior to the competitive disturbance. They do so not only because this behavior may increase the profit in the short run, but also because the reduction in costs dissuades competitors from producing and thus avoids a fall in the price. Fewer firms mean lower employment. Due to this strategic yield, there exists an additional benefit induced by the effort which may push the management effort closer to its optimum. This improved efficiency means that employment can be kept to a minimum. Guillaumont Jeanneney and Hua (2005) provide evidence of this positive efficiency effect resulting from the real appreciation of the Chinese currency.

To capture the effect of the real exchange rate on efficiency change, we extend the model of Greenaway, Hine and Wright (1999) and Fu and Balasubramanyam (2005) by allowing exports and the real exchange rate to affect efficiency in labor use. Therefore, we may hypothesize that the parameter A varies over time and with the above factors, such that:

$$A_{it} = e^{\delta_0 T_i} XY^{\delta_1} ER^{\delta_2} \qquad (9)$$

where T is the time trend, XY is export penetration indices measured by the domestic export-output ratio and ER the real exchange rate of the Renminbi (an increase means an appreciation). We expect for the negative signs of the estimated coefficients of export ratio and the real exchange rate which represent their efficiency effects in the use of labor, such that $\delta_1 > 0\ \delta_2 > 0$.

### 2.2.4. Extended labor demand function

The previous labor demand equation (7) can therefore be written as follows, once the export ratio and the real exchange rate are modeled in:

$$\ln N_{it} = \phi_0 + \delta_0 T_i + \phi_{11} \ln DQ_{it} + \phi_{12} \ln X_{it} + \phi_2 \ln KL_{it} + \delta_1 \ln XY_{it} + \delta_2 \ln ER_{it} + \varepsilon_{it} \qquad (10)$$

If the exports ratio is broken down into a domestic and foreign export ratio, the precedent equation (8) is written as:

$$\ln N_{it} = \phi_0 + \delta_0 T_i + \phi_{11} \ln DQ_{it} + \phi_{21} \ln DX_{it} + \phi_{122} \ln FDIS_{it} + \phi_2 \ln KL_{it} + \delta_{11} \ln DXY_{it} + \delta_{12} \ln FXY_{it} + \delta_2 \ln ER_{it} + \varepsilon_{it} \qquad (11)$$

Equations 10 and 11 allow us to identify the three channels through which the real exchange rate affects employment: the technological channel, the export volume channel and the efficiency channel. A part of the detrimental employment effects of real appreciation results from the decreasing cost of imported capital and the export volumes, as well as from higher real wages. Moreover, a real appreciation encourages improved efficiency in labor use in the face of heightened international competition. These detrimental effects may be dampened by the negative effect of real appreciation on export penetration, source of improved efficiency.

## 3. Econometric estimation of the model

Equations 7, 8, 10 and 11 presented in section 2 are estimated using panel data for the twenty-nine Chinese provinces for the period 1993-2002. Equation 6 is basic labor demand equation which is determined by industrial production and capital/labor intensity. It allows us to capture the technological effect on employment. Then, in equation 7, industrial production is broken down into domestic production and exports allowing us to capture the export volume effect on employment. In equation 8, exports are further broken down into those from domestic firms and those from foreign-funded firms in order to analyze their different effects on employment. Finally, in equation 10, we introduced export penetration indices and the real exchange rate to capture their efficiency effect on employment. The export ratio is then broken down into the domestic export ratio and the foreign export ratio in equation 11.

### 3.1. Estimation method

As capital/labor intensity, real exports and export penetration are introduced into equation 10, the coefficient of the real exchange rate measures its direct effect which is not transmitted by intermediate variables, only by its direct impact on efficiency. The exchange rate elasticity of labor demand is expected to be negative where an increase means a real appreciation of the Chinese currency.

At the same time, the employment effect of the real exchange rate is also transmitted through capital/labor intensity, real exports and export ratio. Thus, in order to estimate the total effect of the real exchange rate on employment, we process our estimation in two steps. First, capital intensity, real exports and export ratio respectively are regressed on real exchange rate. We then calculated the residuals of these estimations which represent the shares of these variables not explained by the real exchange rate. We replace these variables by their residuals in equation 10. Thus, the coefficient of the real exchange rate now measures its total effect on labor demand. The only consequence of this substitution of the residuals for the variables themselves is the modification of the coefficient associated with the real exchange rate which henceforth captures the total effects of the real exchange rate on employment.

### 3.2. Data and source

All data come from the *China Statistical Yearbook*, unless otherwise indicated. All indices are based in 1995, i.e. 1995=100.

### 3.2.1. China's exchange rate policy and calculating the real effective exchange rate indices

The exchange rate policy pursued by China since the beginning of the economic liberalization in 1979 has been quite complex, as, from 1981 to 1993, it involved a double exchange rate regime, whose nature has, moreover, changed over time. Since 1979, planned imports have been supported by priority exchange allowances, while non-planned imports have been financed either by foreign capital or through a system of foreign exchange retention. The latter, which has been progressively expanded since 1981, allows firms to use a part of the foreign exchange earnings derived from exports to finance their own imports or to sell them at an administrated rate, which was higher than the commercial rate applied to planned imports. Previously foreign exchange earnings had to be entirely presented to the central government. In 1985, the commercial rate was replaced by an official rate previously used for non-commercial operations, and in late 1986, the administrated rate became a swap market rate.

Until their unification in January 1994, the differential between the two rates applied to commercial operations fluctuated between 10% and 70%. Both rates depreciated considerably. In contrast, the unified exchange rate, now subject to a controlled floating regime, only slightly depreciated (compared to the dollar) in 1994, and then slightly appreciated in 1995 and 1996. This rate has remained stable at around 8.28 Renminbi/US dollar since 1997. In July 2005, the Renminbi was depreciated by 2.1% against the US dollar and, moreover, the peg of the Renminbi changed from the US dollar to a basket of major currencies. These various changes explain the highly contrasted evolution of China's real exchange rate over time.

The size of the variation in the real value of the Renminbi can be inferred from the evolution of real exchange rate indices of the Renminbi relative to the currencies of China's main trading partners. Weights are modified each year (Paasche index) to allow for the rapid change in the geographical structure of Chinese foreign trade over the period. The real effective exchange rate indices of the Chinese provinces are calculated, on the base 1995 =100, as the nominal effective exchange rate indices multiplied by the ratios between the consumer price index of each province and the average of consumer price indices of its fifteen most important trading partners[9] (defined according to the geographical origin of the imports of each province in 1998[10]). An increase in the real effective exchange rate corresponds to an appreciation of the Renminbi. For 1993, an export-weighted average of the official and swap rates of the Renminbi is used to calculate the real effective exchange rate indices, because the swap rate is different for each province (Khor, 1993). Even though the Chinese provinces have the same nominal exchange rate against dollar for the rest of the estimation period, their real effective exchange rates have evolved differently due to disparities in their inflation rates and the diversity of their foreign trade partners (see figure 2 in the introduction, Guillaumont Jeanneney and Hua, 2001, 2002).

**3.2.2. Other variables**

Manufacturing employment (N) refers to the people who are engaged in social working and receive remuneration or earn business income in the manufacturing sector. Real industrial GDP (Q) is calculated as the nominal industrial GDP divided by its deflator. Real exports (X) are equal to nominal exports divided by the GDP deflator. Exports are established by the *General Administration of Customs of the People's Republic of China* and classified (according to international practice) by production origins. Real domestic industrial GDP (DQ) is equal to real industrial production net of real exports. Real domestic exports are equal to nominal domestic exports deflated by the GDP deflator. Real FDI is equal to nominal FDI deflated by price indices of investment in fixed assets. The real stock of foreign direct

[9] Unfortunately, we have to eliminate several countries form the ex-Soviet Union for which we do not have the exchange rate data. The consumer price indices of foreign partners are obtained from IMF, *International Financial Statistics*. The price indices of each province are taken from the *China Statistical Yearbook*.

[10]The import origins for the different provinces are not officially published. We bought the data for this year from *China's Customs General Administration*.

investments (FDIS) is equal to the sum of all previous years' foreign direct investments in constant prices, net of depreciations (depreciation rate is assumed to be 5%). The export ratios of each province are equal to exports relative to its GDP. Domestic and foreign export ratios (DXY and FXY) are equal to exports realized respectively by domestic firms and foreign-funded firms relative to GDP. Capital/labor intensity (KL) is the ratio of capital in constant prices to employment.

There are no data on capital stock in China, as in many countries. *The National Bureau of Statistics of China* published two series on investments: 1. gross fixed capital formation for the period from 1952 to 1995 in *Zhongguo Guorei ShengShang Zongzhi Hesuan Lishi Ziliao;* 2. investments in fixed assets in the *China Statistical Yearbook*. While the price indices of gross fixed capital formation are available for the period from 1952 to 1995, the price indices of investments in fixed assets have only been available since 1992. We first estimate the initial capital stock in 1993 using the inventory permanent method, such that: $KR_t=(1-\alpha)KR_{t-1}+IR_t$, where KR, IR and α represent capital stock in real terms, investment in constant prices and its annual depreciation rate respectively. By assuming an annual depreciation rate α = 5% as in other studies (Wu, 1999; Lin and Liu, 2003; Zheng and Hu; 2004), the above formulation requires that we are aware of the investments during the preceding twenty years and leads us to consider that in 1973 capital stock is equal to its investment. The capital stock in 1993 ($KR_{93}$) is therefore equal to the sum of the past twenty years' investments in constant prices, net of depreciations, such that: $KR_{93}=\sum_{n=0}^{19} IR_{73+n}*0.95_{20-n}+IR_{93}$ where $KR_{73}=IR_{73}$. The data on gross fixed capital formation (GFCF) and its prices are used to estimate the capital stock in 1993.

Once the initial capital stock in 1993 has been estimated, and as the capital depreciation data for each province are available, the capital stock estimation for the period

1994-2002 is calculated, such that: $KR_t = KR_{t-1} + IR_t - DR_t$, where DR represents real depreciations calculated as nominal depreciations deflated by price indices of investment in fixed assets. In this way, the depreciation rates of capital stock are different for each province and for each year during the period of our estimation[11].

### 3.3. Econometric tests

We proceed with the panel estimation with all the variables expressed in logarithms. The Im-Pesaran-Shin stationnarity test of allows us to reject the unit root hypothesis for all variables in our estimation.

The results of the Breusch and Pagan LM test and Hausman specific test indicate that we cannot reject the hypothesis of one model with fixed effects (see table 3). The results of the DWH test do not allow us to reject the endogeneity of the production, the capital intensity export ratio, the ratio of foreign direct investments or the real exchange rate. The instruments used in DWH test consist of the variables themselves, with a lag of one year, and the gaps between the per capita product of each province and that of its respective foreign trading partners and of China as a whole are used as the instruments of real exchange rate as in Guillaumont Jeanneney and Hua (2003). The results of the Pagan/Hall heteroskedasticiy test, which is the most pertinent in estimation with instrumental variables, allow us to prefer a Generalized Moments Model with instrumental variables to a model with fixed effects (Baum, Schaffer and Stillman, 2003). The results of the Arellano-Bond test for AR(2) reject the existence of autocorrelation. Finally, the pertinence and the validity of the instruments are tested using the Sargan over-identification test. The results do not allow us to reject the hypothesis that the instruments are independent of error terms.

### 3.4. Econometric results

[11] Wu (1999) and Lin and Liu (2003) assumed a fixed annual depreciation rate for each province and for each year. Zheng and Hu (2004) first calculated capital stock for China as whole and then assumed that the ratio of each province's capital stock relative to the national level is the same as the ratio of each province's GDP relative to national GDP.

Column 1 in table 1 reports the estimated results for the base labor demand specification equation 6; columns 2 and 3 the results of extended equations 7 and 8 including export volume as a part of output; and columns 4, 5 and 6 the results of equations 10 and 11 where export penetration indices and the real exchange rate are added. All the estimated coefficients have the expected signs and are statistically significant at the level of 1%. The signs and significance of capital/labor intensity and output variables are consistent in the base and extended specification equations. This indicates the robustness of the specification.

Evidently, industrial activities create manufacturing employment. A 10% domestic industrial growth leads an increase of 7.4% in manufacturing employment (column 4). Capital intensity does not favor manufacturing employment. A 10% increase in capital intensity leads to 5% reduction in manufacturing employment.

The estimated coefficient of the export volume variable is positive and significant at a 1 % level. A 10% increase in export volume increases employment by 12.8% (column 4). More precisely, the increase in domestic export volume creates more job opportunities than an increase in foreign export volume, because their coefficients are estimated at 1.2 and 0.67 respectively. The estimated coefficient of the export-penetration variable is negative and significant at the 1% level. This fact suggests that export orientation really does induce increased efficiency in the use of labor when labor is drawn from the non-export sector to the export sector, as in Greenaway, Hine and Wright (1999) and Guillaumont Jeanneney and Hua (2005). This result is contrary to that found by Fu and Balasubramanyam (2005). More precisely, the efficiency improvement in domestic export firms causes the loss of more job opportunities than in foreign-funded firms, because their coefficients are estimated at -0.67 and -0.18 (columns 6) respectively.

Indeed, the real appreciation of the Renminbi improves the efficiency in the use of labor and is thus unfavorable to manufacturing employment. The estimated manufacturing employment elasticity of the real exchange rate is -0.69 (column 4). A 10% real appreciation of the Renminbi leads directly a fall of 6.9% in manufacturing employment because of higher international competition and higher wages.

The total impact of the real exchange rate on manufacturing employment obviously depends on the impact of the real exchange rate on the variables identified as channels of transmission. Table 2 presents the regressions of capital intensity, export volume and export ratio variables on the real exchange rate. The estimated results show that these variables are effectively the main transmission channels of the real exchange rate to manufacturing employment. As expected, a real appreciation exerts a positive effect on capital intensity, due to the relative price decrease of imported equipment goods, and a negative effect on the export volume and export ratio. Thus, capital intensity and export penetration variables are factors of lower levels of manufacturing employment, while export volumes exert a positive effect on manufacturing employment. Furthermore, capital intensity and export volumes are more important transmission channels than export penetration. The adjusted $R^2$ for capital intensity and export volumes regressions are estimated at 0.59 and 0.61 respectively, while it is only 0.14 for export ratio.

The residuals of these regressions are then substituted for these channeling variables for an employment estimation (column 4 in table 9). The results of the new estimation show the total (or net) impact of the real exchange rate on manufacturing employment. The total manufacturing employment elasticity of the real exchange rate increases from -0.69 (direct effect, column 4) to –1.74 (total effect, column 9). Thus, the indirect effect of the real exchange rate is -1.05 (-1.74+0.69). A 10% real appreciation of the real exchange rate via its direct effect on efficiency and its indirect effect on capital/labor intensity, export volume and export penetration variables leads to a fall of 17.4% in the manufacturing employment.

To measure the indirect effect of the real exchange rate via each channel variable, only the residual of the regression of capital intensity on the real exchange rate is substituted for capital intensity in column 7, while the residuals of capital intensity and export volume regressions are substituted for capital intensity and export volume in the column 8.

The real appreciation exercises a positive effect on capital intensity (table 2), and the latter exerts a negative effect on manufacturing employment (table 1). The introduction of the residual of capital intensity increases the coefficients of the real effective exchange rate (more negative). It allows the coefficient of the exchange rate to increase from -0.69 to -1.65 (column 7, table 1). In other words, the indirect effect of the real exchange rate via capital intensity is -0.96 (-1.65+0.69).

The appreciation of the real effective exchange rate has a negative effect on export volume which exercises a positive effect on employment, the introduction of the residual of export volume regression should increase the coefficient relative to the real effective exchange rate (making it more negative for manufacturing employment). As the indirect effect of the real exchange rate via both capital intensity and export volume causes the coefficients to increase to –2.33 (column 8, table 3), the indirect effect of the real exchange rate via export volumes is -0.68 (-2.33 + 1.65).

In the same way, the appreciation of the real effective exchange rate has a negative effect on the export ratio which exercises a negative effect on employment. The introduction of the residual of the export volume regression should decrease the coefficient relative to the real effective exchange rate (lead it less negative for manufacturing employment). As the indirect effect via capital intensity, export volume and the export ratio causes the coefficients to increase to –1.74 (column 9), the indirect effect of the real exchange rate via export ratio is there 0.59 (-1.74 + 2.33). From this analysis, it can be seen that the indirect effect of the real exchange rate via capital intensity is the most important.

**4. Conclusion**

This paper found that the real appreciation of the Renminbi exerts a statistically significant negative effect on Chinese manufacturing employment. A real appreciation exerts strong direct pressure on efficiency improvement in the use of labor. This negative effect of real appreciation on manufacturing employment is reinforced via its positive effect on capital/labor intensity and its negative effect on export volume, but is dampened via its negative effect on export penetration.

Given that the annual average growth of the real effective exchange rate appreciated from 1.6% to 5.9% in the different provinces for the period 1993-2002 manufacturing jobs were reduced from 3 to 10 points of percentage for an average annual growth of manufacturing jobs equal to -3.1%. As regards the possible impact of a new real appreciation of the Renminbi on manufacturing employment, the estimated results of our analysis do not favor a strong real appreciation, if the Chinese government considers its serious unemployment problem as priority.

Furthermore, Hua (2005) shows that a real appreciation of the Renminbi may lead to a redistribution within Asian exports towards developed countries to the detriment of Chinese exports. A real appreciation of the Renminbi may increase manufacturing employment in developed countries only if the currencies of other Asian countries appreciate simultaneously in real terms.

Finally, the interpretation of the results obtained is limited only to the manufacturing sector. However, the impact of the real exchange rate on total employment as a whole may be different due to the effects of job reallocation between the sectors when confronted with a changing exchange rate. The total employment responses to China's exchange rates require further study.

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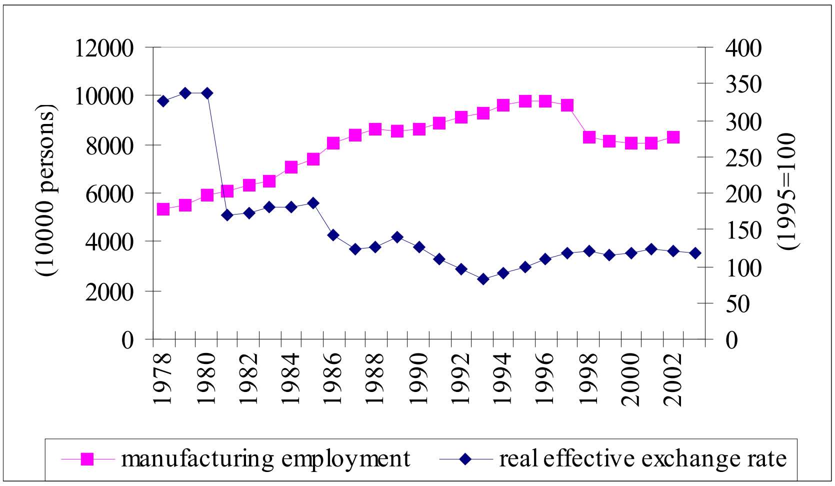
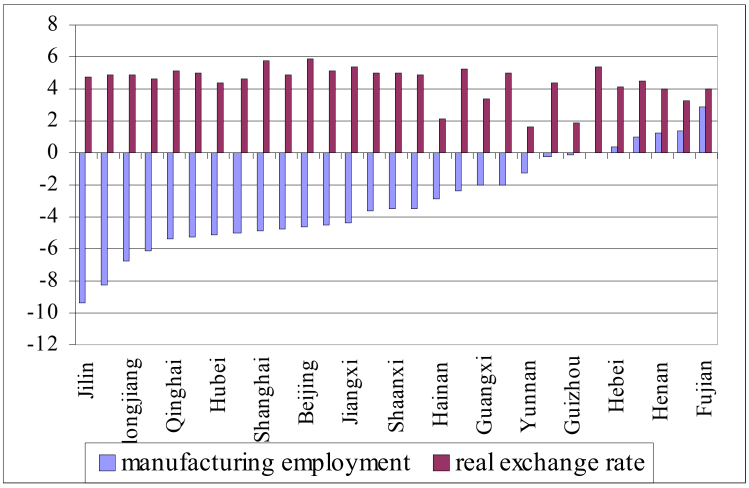
Figure 1. Real effective exchange rate and manufacturing employment in China




NB. An increase means a real appreciation of the Renminbi.

Figure 2. Annual average rates of the real effective exchange rate and manufacturing employment for the period 1993-2002




NB. A positive percentage means a real appreciation of the Renminbi.

Table 1. Estimation of impact of the real exchange rate on manufacturing employment, 1993-2002

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Real industrial GDP | 0.22*** (2.36) | | | | | | | | |
| Real domestic industrial GDP | | 0.39*** (4.34) | 0.39*** (3.91) | 0.74*** (5.55) | 0.69*** (5.26) | 0.81*** (4.80) | 0.74*** (5.55) | 0.74*** (5.55) | 0.74*** (5.55) |
| Real exports or its residual 8, 9 | | 0.28*** (5.98) | | 1.28*** (5.61) | | 1.28*** | 1.28*** (5.61) | 1.28*** (5.61) | 1.28*** (5.61) |
| Real domestic exports | | | 0.28*** (5.71) | | 1.20*** (5.33) | 0.90*** (3.06) | | | |
| Real FDI stock | | | 0.14** (2.46) | | 0.67*** (5.77) | 0.59*** (3.83) | | | |
| Capital intensity or its residual in columns 7, 8, 9 | -0.30*** (-13.0) | -0.50*** (-12.87) | -0.50*** (-9.86) | -0.50*** (-5.84) | -0.46*** (-5.38) | -0.50*** (-5.84) | -0.50*** (-5.84) | -0.50*** (-5.84) | -0.50*** (-5.84) |
| Export/GDP or its residual in column 9 | | | | -1.04** (-4.20) | -1.00*** (-4.07) | | -1.04** (-4.20) | -1.04** (-4.20) | -1.04** (-4.20) |
| Domestic export/GDP or its residual in column 9 | | | | | | -0.67** (-2.17) | | | |
| Foreign export/GDP or its residual in column 9 | | | | | | -0.18** (-2.03) | | | |
| Real effective exchange rate | | | | -0.69*** (-5.14) | -0.72*** (-5.31) | -0.69*** (-5.84) | -1.65*** (-8.40) | -2.33*** (-9.63) | -1.74*** (-9.01) |
| Time trend | | | | -0.07*** (-3.31) | -0.07*** (-3.37) | -0.04 (-1.26) | -0.07*** (-3.31) | -0.07*** (-3.31) | -0.07*** (-3.31) |
| Number of observations | 290 | 290 | 289 | 289 | 288 | 288 | 289 | 289 | 289 |
| Breusch and Pagan LM test | 649 | 700 | 693 | 566 | 534 | 590 | 566 | 566 | 566 |
| Hausman specific test | 53 | 158 | 100 | 54 | 21 | 45 | 54 | 54 | 54 |
| Arellano-Bond AR(2) test[b] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Pagan/Hall heteroskedasticity test[b] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| DWH test of endogeneity [b] | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sargan over-identification test [b] | 0.61 | 0.82 | 0.68 | 0.77 | 0.87 | 0.65 | 0.77 | 0.77 | 0.77 |

b. P value. Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level.

**Table 2: Estimation of the transmission channel variables of the real exchange rate to manufacturing employment, 1993-2002**

| | Capital intensity | Exports volume | Export/GDP ratio |
|---|---|---|---|
| | 9 | 10 | 11 |
| Real effective exchange rate | 1.67***<br>(21.7) | -0.34**<br>(-2.26) | -0.56***<br>(-3.87) |
| Constant | 17.8***<br>(50.3) | 12.2***<br>(16.4) | -0.33<br>(-0.46) |
| Time trend | | 0.09***<br>(10.8) | -0.001<br>(-0.18) |
| Number of observations | 290 | 290 | 290 |
| Adjusted $R^2$ | 0.64 | 0.51 | 0.17 |

* Significant at the 10% level. ** Significant at the 5% level. *** Significant at the 1% level.