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The Effect of the Real Exchange Rate on Technological Progress. An Application to the Textile Industry in China

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Abstract

Technological progress in the textile and clothing sectors is measured for 26 Chinese provinces using panel data by sector and the stochastic frontier method. The impact of the real exchange rate on this technological progress, as well as its transmission channels, are respectively estimated. The technological progress is positive for both sectors, and the real depreciation of the Chinese currency contributes to this improvement. Due to the dominant non state-owned enterprises in the clothing sector, both technological progress and the effect of real depreciation on the increase of technological progress are twice as high as in the textile sector. The principal transmission channel of the impact of the exchange rate on technological progress is through imported equipment, but not through openness.

JEL: D24, F31, O30, O53

Keywords: real exchange rate, technological progress, stochastic frontier method, China.

Introduction

In the literature, in order to test the export-led growth hypothesis, exports are often introduced into a standard production function as an additional factor of production, supposing a positive effect on the total productivity of factors in the economy[1] (Feder, 1983; Ram, 1985; Salvatore & Hatcher, 1991; Greenway and Sapsford, 1994, etc.). In fact, export-oriented policies promote allocative efficiency by reorienting production factors in favor of the export sector in which the economy possesses a comparative advantage in trade. Then, the sales on foreign markets allow the exploitation of economies of scale. In addition, an increase in exports alleviates serious foreign exchange constraints and allows the import of productive intermediate goods that are not available on the local market. Finally, the intensified contacts with foreign competitors oblige the exporting firms to improve their production technologies and management techniques in the face of strong international competition.

This outward-oriented policy is often accompanied by an active exchange rate policy in developing or transition countries. Indeed, real depreciation allows firms in these countries to earn foreign exchange more easily thus increasing their ability to import new equipment. Therefore, it should have a positive impact on technological progress. This effect depends, however, on the firm's strategy. If enterprises are passive (such as state-owned enterprises which have less autonomy in investment decisions), they may profit from their competitive improvement to increase production only by using their inputs more intensively but without investing, so the impact on technological progress is very low or nill. On the contrary, when enterprises are active, they use the newly available foreign exchange to invest in foreign equipment and so to improve their technological level; therefore the effect of real depreciation on technological progress is positive.

[1] This hypothesis remains at the theoretical level. In fact, these studies did not measure the total productivity of factors, nor estimate empirically the impact of exports on TPF.

This theoretical hypothesis about the short-term impact of real depreciation on technological progress has not yet been econometrically estimated[2]. Thus, the aim of this study is to fill this gap by testing this relation in the textile industry in China[3]. Indeed, this industry has quickly succeeded in reorienting its production from national toward international markets[4], in particular supported by a highly dynamic exchange rate policy (Guillaunmont and Hua, 1996, Hua, 1996) and by the modernization of obsolete equipment. It would, therefore, be interesting to verify whether the dynamism of this industry is a consequence of a catch-up process on international technological norms and to what extent the exchange rate policy helped this process. As the textile sector is constrained in its transition by state-owned enterprises, while the clothing sector is dominated by foreign and collective enterprises[5], it would seem to be more interesting to identify their different strategies concerning technological progress individually, as well as the different effects of real depreciation on technological progress[6]. Moreover, by making a study by sector, one can use the available data on capital stock[7] directly and ensure the exogeneity of the exchange rate as an independent variable.

This paper is organized in the following way. In the first section, we will present the stochastic frontier method in order to calculate technological progress in the textile and clothing sectors. In the second section, we will try to analyze the relations between the exchange rate and technological progress after having summarized the exchange rate policy reforms in both sectors. In the third section, we will analyze the theoretical hypothesis about the short-term impact of the exchange rate on technological progress. Econometric results will be presented in the last section.

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[2] On the contrary, there are many studies that analyze the long term effect of productivity on the equilibrium exchange rate (Edwards, 1989 ; Hinkle and Montiel, 1999) or test the validity of the Balassa-Samuelson effect (Guillaumont and Hua, 2001 for a survey).

[3] In this study, the textile industry is broken down into textile and clothing sectors.

[4] The textile industry plays a primary role in Chinese foreign trade. In 1999, its exports were 22 % of total Chinese exports (*China Statistical Yearbook*) and the country was the first world producer, as well as the first exporter, in this industry. In 1998, China was fourth in the textile sector behind Germany, Hong Kong and Italy with 8.49 % of world exports, and first in the clothing sector with 16.73 % (WTO).

[5] In 1995, the value added from the state-owned enterprises represented 35 % and 6 % of the total in the textile and clothing sectors respectively (*National Industrial Census of the PRC)*.

[6] Bach et al. (1996) estimated the impact of Chinese trade liberalization and concluded that it is positive in the clothing sector but negative in the textile sector.

[7] Only capital flux, and not capital stock, exists when the total factor productivity is estimated at national or provincial level.

1. Technological progress estimation in the textile and clothing sectors

Technological progress is a component of the total factor productivity (TFP), so its computation depends on that of the TFP.

In the literature, one may distinguish a traditional approach, which only assumes the TFP as the difference between output and input growth, and a second approach which breaks down the TFP into technical efficiency[8] and technical progress.

The first approach is easy to calculate and only two observations are needed, but it assumes that all firms are technically efficient. However, it seems to be difficult to affirm that firms are efficient in a transition country such as China. That's why we have chosen to use a Malmquist index allowing a break-down of the TFP into technical efficiency change and technological progress:

$$TPF = TP.ET \qquad (1)$$

A TPF value less than, equal to or greater than one will indicate a negative, nill or positive TFP growth respectively. Technological progress may be represented by an upward shift in the production frontier and the technical efficiency change by a convergence toward the frontier.

Two processes allow the estimation of technical efficiency and the Malmquist TFP: deterministic and stochastic methods. In the first one, all deviations from the frontier are assumed to be the result of technical inefficiency; Data Envelopment Analysis (DEA) is the most popular method (Färe et *al*, 1994). It uses linear programming models. There are several problems for the DEA method. In fact, it cannot be used to conduct conventional statistical tests of hypotheses and the most important is that no account is taken of the possible influence of measurement errors and statistical noise. The Chinese economic reforms may have

[8] Technical efficiency reflects the ability of a firm to obtain a maximum output from a given set of inputs (Farrell, 1957)

produced such problems and the TFP estimation for China would then be biased. This encourages us to choose the stochastic frontier method, which breaks the residual down into two parts, one accounting for the measurement errors and statistical noise and the other for the technical efficiency.

The general stochastic frontier production function is written as:

$$\begin{aligned} Log\ y_{it} &= f(x_{it}, t, \beta) + \varepsilon_{it} \\ où \quad \varepsilon_{it} &= v_{it} - u_{it} \end{aligned} \tag{2}$$

where ε_{it} is the error term combining the random error v_{it} and the term associated with technical inefficiency, u_{it}. v_{it} is assumed to be distributed independently of the u_{it}.

The model can be estimated by the maximum likelihood method using the computer software, Frontier 4.1 (Coelli, 1994). Then, the technical efficiency measure of the firm i in period t is computed as the conditional expectation of $e^{-u_{it}}$ with respect to ε_{it} [9]:

$$ET_{it} = E(\exp(-u_{it}) / \varepsilon_{it}) \tag{3}$$

We will use the parametric stochastic method to compute a Malmquist TFP index (Battese and Coelli, 1997). The technical efficiency change is:

$$\frac{TE_{it+1}}{TE_{it}} \tag{4}$$

and the technological progress :

$$TP = \left\{ \left[1 + \frac{\partial f(x_{it}, t, \beta)}{\partial t} \right] \left[1 + \frac{\partial f(x_{it+1}, (t+1), \beta)}{\partial (t+1)} \right] \right\}^{0,5} \tag{5}$$

(4) and (5) may be multiplied together to obtain a Malmquist TFP index, as defined in (1).

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[9] Cf. Jondrow et *al* (1982)

We specify a translog production function, which facilitates the measurement of non-neutral technological progress by the cross products of a trend, t, and inputs. Hence, the production function is:

$$LnY_{it} = \beta_0 + \beta_K LnK_{it} + \beta_L Ln_{it} L + \beta_t t + \frac{1}{2}\beta_{LL}(LnL_{it})^2$$
$$+ \beta_{LK} LnL_{it}.LnK_{it} + \beta_{Lt} LnL_{it}.t + \frac{1}{2}\beta_{KK}(LnK_{it})^2 \quad (6)$$
$$+ \beta_{Kt} LnK_{it}.t + \frac{1}{2}\beta_{tt} t^2 + (v_{it} - u_{it})$$

$$u_{it} = \delta_0 + \delta_1 t + w_{it} \quad (7)$$

Where Y, K and L represent the value added, net fixed assets and number of employed persons respectively.

w_{it} is defined by the truncation of the normal distribution with zero mean and variance σ^2 , such that the point of truncation is $-(\delta_0 + \delta_1 t)$, i.e., $w_{it} \geq -(\delta_0 + \delta_1 t)$. Thus, u_{it}s are non-negative and obtained by truncation at zero of the normal distribution with mean $(\delta_0 + \delta_1 t)$ and variance σ^2. The v_{it} are iid N(0, σ_v^2) random errors, and are assumed to be distributed independently of the u_{it} .

According to Grifell-Tadjé and Lovell (1995), a Malmquist TFP index does not correctly measure TFP changes when variable returns to scale are assumed because it does not properly reflect the influence of scale. The restrictions required to impose constant returns to scale are:

$$\beta_L + \beta_K = 1$$
$$\beta_{KK} + \beta_{KL} = \beta_{LL} + \beta_{KL} = 0 \quad (8)$$
$$\beta_{Lt} + \beta_{Kt} = 0$$

In our study, these restrictions are imposed in devising the value added and net fixed assets by number of employed persons.

Another problem is that the Malmquist TPF is not transitive, so computation of cumulative index is biased. Measurement of technical efficiency change is transitive but technological progress is not transitive unless technological change over time is neutral: $d_o^t(y,x) = A(t)d_o(y,x)$. In our study, we will focus on geometric means so the problem of transitivity will not occur.

The stochastic frontier model explained above is applied to the panel data of twenty-six Chinese provinces during the periods 1980, 1984-1985, 1988-1994 and 1997 for the textile and clothing sectors in China. This discontinuous period is due to a lack of data. Indeed, the necessary data for TPF estimations, such as the value added as output, net fixed assets and number of employed persons as inputs, are drawn from the *China Industrial Economic Statistical Yearbook* which was only published from 1988 to 1995, and in 1998. For years 1980, 1984 and 1985 we have used the 1985 *National Industrial Census of the PRC*. Hainan, Tibet, Ningxia and Qinghai are not retained in our study because the data pertaining to them are incomplete. The data concern only companies with an independent accounting system (*duli hesuan*) at and above the township level. Thus, the data include all forms of ownership but exclude village-level enterprises, individual enterprises, and establishments without their own profit and loss accounts; those being part of a larger conglomerate, e.g. a military establishment, universities, etc. (Jefferson *et al,* 1999). Due to the lack of deflators by sector, value added and net fixed assets are calculated at constant 1990 prices by using the provincial GDP deflator.

The maximum-likelihood estimates of the parameters of the stochastic frontier, defined by equations (6), (7) and (8) are given, for each sector, in Table 1. Labor parameters are calculated using the constant returns to scale restriction in equation (8), thus t-ratios are not reported. We note that the estimate for $\gamma = \sigma^2/(\sigma_V^2+\sigma^2)$ is lower than one: there are random errors in the production function and the stochastic method seems to be better than the deterministic method. The positive sign of δ_1 implies that technical efficiency decreases during the period.

Table 1: Estimation results of the stochastic frontier production function in the textile and clothing sectors in China

	Textile		Clothing	
	Coefficients	t-ratio	Coefficients	t-ratio
β_0	6.3961	4.9932	3.0086	4.0086
β_K	-1.1118	-16069	0.2927	0.5002
β_L	2.1118		0.7073	
β_t	-0.3679	-3.1326	-0.3999	-3.7635
β_{KK}	0.2761	1.4579	-0.0426	-0.1861
β_{LL}	0.2761		-0.0426	
β_{KL}	-0.2761		0.0426	
β_{tt}	0.0203	3.0374	0.0308	3.3807
β_{Kt}	0.0633	2.0039	0.0862	2.1026
β_{Lt}	-0.0633		-0.0862	
Sigma-squared	0.2273	7.0376	0.1822	10.0368
γ	0.7757	19.8888	0.7892	23.1609
δ 0	-3.8519	-4.7831	-3.5389	-5.4144
δ 1	0.4134	5.5554	0.4208	6.8836

Figures 1 and 2 report separately the evolution of the TFP and its components, the technical efficiency change and the technological progress in the textile and clothing sectors of China. The values for 1984, 1988 and 1997 are estimated as annual geometric means respectively for the periods 1980-1984, 1985-1988 and 1994-1997.

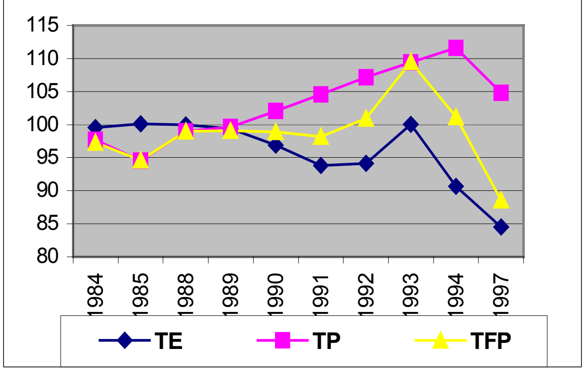

Figure 1. Growth inTFP and its components
- Chinese textile sector-

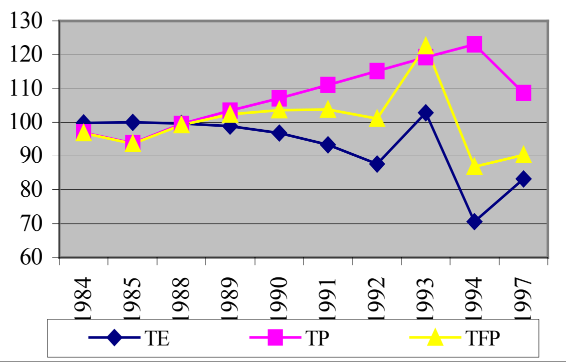

Figure 2. Growth in TFP and its components
- Chinese garment sector -

Since 1989, technical efficiency has declined, except in 1993, following an acceleration of the economic reform. It is technological progress which allowed TFP improvement in both sectors. It seems that there is a negative correlation between technological progress and technical efficiency change. Many studies concur with these results. According to Lee et *al* (1998), developing countries that have a rapid growth, such as Korea, do not have sufficient time to digest newly installed technologies. Therefore, in these countries or in dynamic sectors, it may be possible to observe a technical efficiency decline.

The clothing sector only recorded a TFP improvement during the period in coastal provinces (1.20 % as opposed to –1.5 % for non-coastal provinces). The TFP growth of the textile sector was smooth in coastal provinces while in non-coastal provinces it was negative (-2.09 %). However, this classification seems to be arbitrary in the sense that the productivity growth in several non-coastal provinces was positive, i.e. Hubei in the textile sector, and Hubei, Jiangxi, Guangxi, Anhui, Guizhou in the clothing sector.

Although technological progress was stronger in the clothing sector (7.4 % per year compared to 3 % in the textile sector), its technical efficiency decreased more than in the textile sector (-7.26 % as opposed to –4.21%). It seems to confirm the hypothesis that a dynamic sector has difficulty in using new technologies efficiently.

In the following section, we will focus on the impact of the exchange rate on technological change, due to the lack of data on control variables for studying its impact on technical efficiency change. We hope to get those data in the future.

2. The relationship between real exchange rate and technological progress

At the end of 1978, China was experiencing foreign exchange penury and a strong appreciation of the Yuan. In order to change this situation, a double exchange rate regime was developed from 1981 to 1993, whose nature has, moreover, changed over time (Guillaumont and Hua, 1996 and 2001). Since 1979, planned imports, such as imports of inputs for the textile industry, have been supported by priority foreign exchange allowances, while some non-planned imports have been financed either by foreign capital or through a system of foreign exchange retention (*waihui liucheng zhidu*) established in 1979. This system allows textile and clothing companies to retain a larger and larger part of foreign exchange earnings whereas previously, foreign exchange earnings had to be remitted in entirety to the central government. In order to encourage the exports of textiles and clothings, the retention rate has been higher for the textile and clothing sector, and moreover it has expanded progressively over time. These enterprises could sell a part of their foreign exchange earnings at an internal rate of trade (*maoye neibu jieshuan jia*), which was administrated, but higher than the fixed swap rate applied to planned imports. In 1985, this internal rate, more favorable to enterprises, became a market price, whereas the fixed swap rate was replaced by an official rate (previously applied to non-commercial operations). Until their unification in January 1994, the differential between the two rates (namely, between the internal rate and the fixed swap rate for the 1981-1984 period, and then between the official rate and the swap rate, which became a market rate at the beginning of 1987, for the 1985-1993 period) fluctuated between 10% and 70%. Both rates depreciated strongly. In contrast, the unified exchange rate, now subject to a controlled floating regime, depreciated only slightly (compared to the dollar) in 1994 and has since appreciated slightly. These various changes explain the highly contrasted evolution of China's real exchange rate over time.

In order to represent the international competition of the textile industry for the Chinese provinces, a real effective exchange rate for each province is calculated as the weighted geometric average of export real exchange rate indices of the Renminbi relative to the currencies of China's main trading partners, deflated by the ratio of consumer prices between each province and its trading partners. Export exchange rates are computed as the weighted average of the official rate (internal rate for 1981 and 1984 period, and the official rate for the rest) applied to commercial operations, and the market exchange rate (administrated rate until 1986 and then free) applied to the swap foreign exchange markets, the weighting of the two rates being based on the retention rate of exports of the textile and clothing sectors.

Figure 3 shows the average annual rate of depreciation of the real effective exchange rate from 1978 to 1998 for each province. Thus, although the Chinese provinces had the same nominal effective exchange rate, their real effective exchange rate evolved differently due to the disparities in their inflation rates. Over the whole of the estimation period 1978-1998, the average annual appreciation of the real exchange rates of the Chinese provinces ranged from 5.6 % for the municipality of Beijing to 8.6 % for the province of Henan (cf. figure 3).

Figure 3. Average annual rate of depreciaiton of the real effective exchange rate from 1978 to 1998

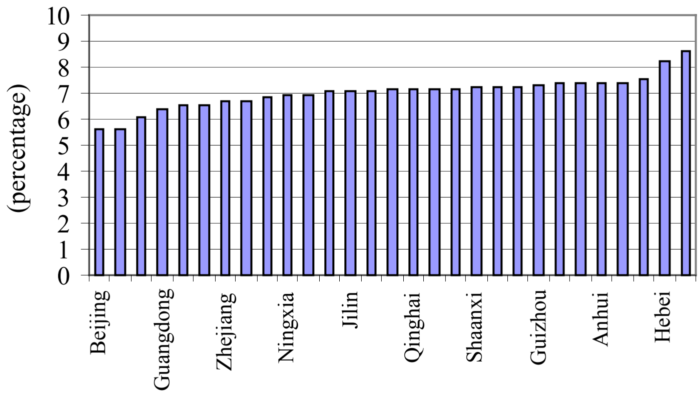

Figure 4 shows the relationship between the real effective exchange rate and technological progress in the textile and clothing sectors for the 1984-1997 period. Thus, after a slight appreciation in 1985, the real effective exchange rates increased (so depreciated) by 121 % from 1985 to 1993, With the unification of the exchange rates, the real effective exchange rate appreciated for the second time by 99 % from 1993 to 1997 (Figure 4). We observe that there is a positive relationship between the exchange rate and technological progress. The results of the simple regression from technological progress to the real effective exchange rate confirm this observation. In fact, the latter explains 54% and 50% of technological progress in the clothing and textile sectors (equations 1 and 2 of table 2).

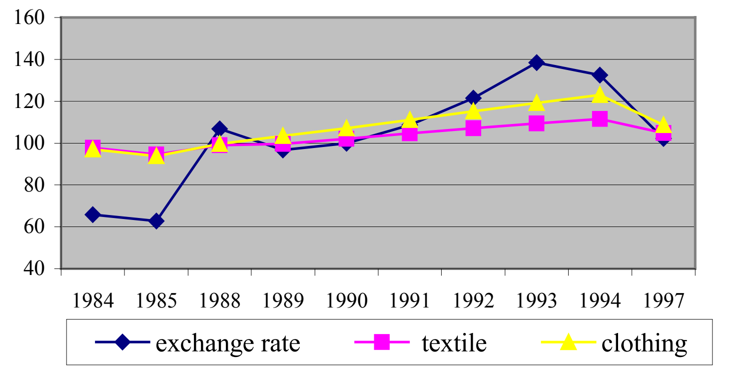

Figure 4. Relationship between real effective exchange rate and technological progress in the textile industry in China

Several theoretical hypotheses allow us to understand the mechanisms by which the real exchange rate influences technological progress. First, an increase in foreign exchange earnings from exports, facilitated by real depreciation, allows enterprises to buy new machines in foreign countries. This should produce a positive effect on the technological progress not only of these enterprises, but of the other enterprises as well due to a contagious effect (Findlay, 1978 ; Balasubramanyam et al., 1996). Thus, a more outward-looking policy, again facilitated by real depreciation, should increase the intensity of international competition, which should in turn oblige the enterprises in the clothing and textile sectors to improve their technologies. Finally, these two effects should depend on the strategy of enterprises. When the Chinese enterprises had to remit all foreign exchange earnings to the central government, they were passive and could profit from the improved competitiveness of their goods due to real depreciation only to accomplish the obligatory exports. During the period of exchange rate reforms, the enterprises were authorized to retain a larger and larger part of their foreign exchange earnings. They became more and more aggressive, and tried to use these earnings to improve their production equipment and to gain a larger share of the international market. Thus, we observe an increase in imported equipment investment and an improvement in technological progress.

In the case where the presence of non-state enterprises is more important in the clothing sector than in the textile sector, we expect a greater effect of real depreciation on technological progress in this sector.

3. Determinants of technological progress

In addition to the real effective exchange rate (REER), we will introduce several control variables, which may have an impact on the technological progress.

First, we introduce capital intensity (CI), calculated as the ratio of capital to employment, as a control variable. Before 1978, the main aim of the textile and clothing sectors was to provide employment and, thus, the principle “no technological progress in this industry” was applied. At the beginning of the reforms, the State relied on these sectors to increase exports (Damon, 1999). However, to sell their products on the international markets, the quality and technological level of these articles had to be improved to catch up with international standards. But, the increase of capital intensity with the equipment produced locally was not high-performance. Consequently, companies had to import them or make agreements with foreign firms. Despite this constraint, the ratios of net fixed assets to workers have increased from 3931 yuans in the textile sector and 1270 yuans in the clothing sector in 1980 to 18033 and 10859 respectively in 1997. Capital intensity (CI), which is usually referred to in literature as a “capital deepening” indicator of an economy (Sun et al., 1999), represents the technological level used in the production process. Therefore, it should be positively correlated with technological progress. However, in China, companies with a soft budget constraint, particularly state-owned enterprises, make non-productive investments (Kornai, 1980, Raiser, 1997). Furthermore, rural enterprises use locally made equipment, with a low technological level, but which are cheap, either because they are constrained by foreign exchange, or because they do not have access to financial institutions. Thus, in Chinese industry, there is reason to believe that capital intensity has a negative impact on technological progress inasmuch as some firms accumulate capital, which does not allow an increase in their production or their technological level.

Moreover, we will introduce firm size by using the average value of output per enterprise as an independent variable (SIZE). This indicator is imperfect because it does not take potential disparity into account. For example, the firm size may be high because of the presence of a very large enterprise, which hides the activities of many smaller firms. In China, large state-owned enterprises and joint ventures import new technologies from abroad (Jefferson and Rawski, 1999). Indeed, the activity of a firm has to be sufficient to recoup the cost relative to the use of this equipment. We expect a positive effect on technological progress.

Finally, there is a strong constraint on the availability of skilled workers and even managers (Damon, 1999). This is why we introduced three educational variables that represent the share of the population with only primary, secondary or university education (Edup, Edus, Eduu) respectively. These variables measure the level of human capital of each province. The higher the education level is, the greater the technological progress.

The panel data model is the following:

$TP_{it} = f(REER_{it}, CI_{it}, SIZE_{it}, Edup_{it}, Edus_{it}, Eduu_{it}, \mu_{it}, \xi_{it})$

μ_{it} = individual effects

ξ_{it} = error term

From this basic model, we have introduced an openness variable by sector, calculated by the ratio of the sum of exports and imports divided by value added in the textile and clothing sectors, to identify how the real effective exchange rate affects technological progress. In fact, the real exchange rate may only partially reflect the ability of companies to open up to foreign trade because real depreciation allows them to increase their exports. In this case, introducing an openness variable by sector should lower the coefficient of the real exchange rate. The openness variable by sector may also better represent the pressure of international competition. The more a province is open, the more companies are exposed to foreign competitors. Hence, to survive, these companies have to adapt to the environment by improving their technological level. In this case, introducing this variable should not influence the coefficient of the exchange rate.

Another effect of the exchange rate on technological progress comes from the fact that real depreciation makes exports easier and alleviates foreign exchange constraints. Companies take advantage of this opportunity to import new equipment thanks to the liberalization of exchange controls. Therefore, the increase of capital intensity thanks to real depreciation would correspond to a bigger amount of import equipment with a higher technological level. Thus, the interaction term between capital intensity and the exchange rate should be positive. Its introduction should noticeably lower the coefficient of the real exchange rate.

4. The estimation results

The model is estimated using a non-balanced yearly panel data of 26 provinces for the 1988-1994 and 1997 period, during which China practised a very active exchange rate policy. A fixed effect estimator is applied, which allows certain unobserved provincial heterogeneity to be taken into account. We use the Matyas and Sevestre (1996) procedure to deal with the heteroskedastic disturbances in unbalanced panels. Stata software is used for the estimation. With the exception of the data mentioned previously, export and import data for textiles and clothings per province are taken from the *General Customs Adminstration of China*, but are unavailable before 1988. Educational variables are estimated according to the permanent inventory method (Démurger, 1998) using the 1982 census (*China Statistical Yearbook)*.

Table 2. The determinants of technological progress in the textile and clothing sectors

	Clothing	Textile	Clothing	Textile	Clothing	Textile	Clothing	Textile	Clothing	Textile
	1	2	3	4	5	6	7	8	9	10
Real effective exchange rate	0.35*** (17.75)	0.19*** (15.86)	0.28*** (15.35)	0.15*** (14.36)	0.28*** (15.56)	0.15*** (14.60)	0.06 (1.25)	0.05* (1.91)	0.06 (1.13)	0.05* (1.76)
Capital intensity			-0.08* (-1.75)	-0.02* (-1.81)	-0.08* (-1.71)	-0.02** (-2.22)	-0.47*** (-4.39)	-0.11*** (-4.13)	-0.45*** (-3.97)	-0.11*** (-3.27)
Firm size			1.25*** (3.36)	0.40*** (5.27)	1.29*** (3.37)	0.41*** (5.40)	1.03*** (2.80)	0.32*** (4.04)	1.00*** (2.69)	0.33*** (4.13)
University education			4.55*** (3.47)	3.28*** (5.36)	4.45*** (3.35)	3.12*** (4.89)	5.06*** (4.30)	3.34*** (6.40)	5.15*** (4.43)	3.34*** (6.26)
Secondary education			0.16 (0.86)	0.12 (1.36)	0.16 (0.85)	0.16* (1.65)	0.24 (1.35)	0.20** (2.23)	0.23 (1.33)	0.20** (2.20)
Primary education			-0.81*** (-6.90)	-0.52*** (-6.97)	-0.73*** (-6.13)	-0.50*** (-6.36)	-0.73*** (-6.49)	-0.48*** (-7.07)	-0.76*** (-6.77)	-0.48*** (-7.04)
Rate of openness					0.26*** (2.71)	0.24 (1.34)	0.22** (2.45)	0.11 (0.58)	-0.42 (-0.52)	0.15 (0.16)
REER * capital intensity							0.40*** (3.99)	0.09*** (3.23)	0.38*** (3.62)	0.09*** (2.70)
REER * rate of openness									0.54 (0.82)	-0.03 (-0.04)
Observations	200	200	200	200	200	200	200	200	200	200
R^2	0.54	0.52	0.79	0.84	0.80	0.84	0.82	0.86	0.82	0.86

Notes : - t corrected for heteroskedasticity by the White process *** = significant at the 1 % level ; ** = significant at the 5 % level ; * = significant at the 10 % level

Table 2 presents the econometric results of technological progress in the textile and clothing sectors.

Capital intensity has a negative effect on technological progress, significant at 10 % (equations 3 and 4). This may be explained, as seen above, by a soft budget constraint problem, or by the development of rural enterprises which use cheap, locally-made equipment with a low technological level.

The coefficient of the firm size is positive and significant at 1 % for both sectors. As expected, the bigger the size, the more enterprises are able to improve their technological level.

With regard to education, the university and primary rates are statistically significant at 1 %, with a positive and a negative effect respectively. The secondary rate has a positive effect but is non-significant. These results suggest that a high level of education in the provinces makes technological progress easier.

As expected, real depreciation has a positive effect on technological progress, and is almost twice as high in the clothing sector, with a large number of foreign enterprises, as in the textile sector, more traditional and constrained in its transition by a large number of state-owned enterprises. A 10 % increase in the real exchange rate (i.e. a real depreciation) leads to 2.8 % and 1.5 % improvement in technological progress in the clothing and textile sectors respectively.

The aim of the further estimations is to analyze the way in which the real exchange rate influences technological progress. After checking that the real exchange rate is not correlated with the openness variable[10], the latter is added. It has a positive effect for both sectors, but it is only significant at 5 % for the clothing sector (equations 5 and 6). These results may be explained by the fact that the clothing sector is dominated by non-state owned

[10] The fact that the real exchange rate and the openness rate are not correlated may be explained by the positive and negative impact of the real exchange rate on imports and exports respectively.

enterprises, unlike the textile sector, and thus it is subject to more intensive international competition. As the introduction of this variable does not affect the value of the exchange rate coefficient, we may conclude that the real exchange rate impact on technological progress does not occur through openness.

The coefficients of the interaction term between the real exchange rate and capital intensity are positive and significant at 1 % for both sectors. Moreover, the exchange rate coefficient is no longer significant in the clothing sector (equation 7), and has decreased significantly in the textile sector from 0.15 to 0.05, nevertheless remaining significant at 10 % (equation 8). The fact that the coefficient of the interaction term is higher in the clothing sector (0.41) than in the textile sector (0.09) is again linked to its large number of state enterprises. Indeed, the latter has less investment autonomy. These results suggest that, in the textile and clothing sectors, the effect of real depreciation on the improvement of technological progress is transmitted principally through imported equipment.

Finally, the introduction of the interaction term between the exchange rate and openness has not modified the results (equations 9 and 10).

5. Conclusion

After measuring technological progress using the stochastic frontier method in the textile and clothing sectors of China, we estimated the impact of the real depreciation of the Renminbi on technological progress and then identified the transmission channels of this effect. Estimated results show that real depreciation has a positive impact on technological progress thanks more to the newly imported equipment than to openness. The exchange rate effect is almost twice as important in the clothing sector than in the textile sector, due to the dominant non-state enterprises.

These results suggest that real depreciation, until 1993, played an important role in the technological catch-up process of the textile and clothing sectors, and that a low real appreciation, after exchange rate unification in 1994, slowed this process down. This implies that the Chinese government, when it makes exchange rate policy decisions, has to take into account the effect of the real exchange rate on technological progress and not only on exports.

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