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# China's Exports and the Oil Price

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**Abstract:** The increase in oil prices in recent years has occurred concurrently with a rapid expansion of Chinese exports in the world markets, despite China being an oil importing country. In this paper we develop a theoretical model that explains the positive correlation between Chinese exports and the oil price. The model shows that Chinese growth can lead to an increase in oil prices that has a stronger impact on its export competitors. This is due to the large labor force surplus of China. We then examine this hypothesis by estimating a reduced form equation for Chinese exports using Rodrik (2006)'s measure of export competitiveness, together with the oil price, productivity, real exchange rate, and foreign industrial production over the monthly 1992-2005 period. The results suggest a stable relationship and yields slightly positive values for the price of oil and elastic coefficients for export competitiveness, along with the expected negative elasticity for the real exchange rate.

**JEL Classification Numbers:** F14, F43.

**Keywords:** China, Oil prices, Competitiveness, Exports, Productivity.

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# China's Exports and the Oil Price

## 1. Introduction

The increase in oil prices is one of the most substantive recent developments in the world macroeconomic environment. Rather than being a temporary hike, commentators have argued that higher oil prices are here to stay. One of the main reasons behind this hypothesis is that China's economic growth is driving the increase in the demand for oil and its price hike [e.g., CNN, May 24<sup>th</sup> 2004, and Roeger, 2005].<sup>1</sup> However, given that China is an oil importing country, this increase in the price of oil should have a negative impact on China's exports expansion as it increases production costs. A visual inspection of the data shows that this does not appear to be happening. On the contrary, it appears that China's exports do not suffer from the increase in the price of oil. This can be seen in Figure 1, which suggests a strong positive correlation between China's exports and the real price of oil. Both variables have been rising substantially in recent times. In our monthly sample from 1992 to 2005, the correlation coefficient between Chinese manufactured exports (in USD) and the real price of WTI oil is 0.85 and 0.91 between exports and the nominal price of oil.

[Figure 1 here]

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<sup>1</sup> This situation has become stronger in September of 2006 as reported in The Wall Street Journal (2006): "China, the world's second biggest oil consumer, imported a record volume of crude last month, underscoring that petroleum demand here and in other developing economies, such as India and the Middle East, continues to rise despite lofty petroleum prices." Further, the run-up of oil towards the \$ 145 level in the summer of 2008 has provided additional evidence that China may influence oil prices when they decline as well. For example, the Chinese government raised its base price for gasoline by 17% and diesel by 18% in June of 2008. This caused global oil traders to quickly conclude that (the Chinese action) "could diminish the country's voracious appetite for fuel. Benchmark crude oil on the New York Mercantile Exchange fell \$ 4.75 a barrel, or 3.5%, to \$131.93 as reported in The Wall Street Journal (2008).

Another stylized fact is that China's share in the world's exports is also increasing as discussed in Rodrik (2006). See also Schott (2005) for a related approach. According to Lai (2004) Chinese foreign trade success lies in the market-oriented reforms of the economy, appropriate exchange rate and trade policies and the active participation of foreign invested enterprises.<sup>2</sup> Zhang and Zhang (2005) show that the significant improvement of international competitiveness in China's manufacturing sector is due mainly to total factor productivity<sup>3</sup> and labor productivity. China has become one of the world's biggest trading powers accounting for 6% of global trade flows, becoming the world's fourth largest exporter in 2002. This has been coupled with a phenomenal success in terms of the growth rate of output. Since 1980 China has grown at an average rate of around 10% per year [Srinivasan, 2004]. Table 1 shows the GDP growth rates for the world, developing countries, Latin America and Caribbean, Asia and China. The growth of China is well above other regions, averaging 11.45% in the period 1991-2003.

In this paper we advance a plausible explanation for this set of facts relating Chinese export expansion, output growth, and the oil price. Our hypothesis is that China's growth has been a driving force behind the oil price increase. However, given the elastic labor supply due to the large reserves of workforce of the Chinese economy, the oil price increase harms China's export capacity less than that of its competitors. The rapid expansion of Chinese exports, on the other hand, has to do with its phenomenal

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<sup>2</sup> See also Zhang and van Witteloostuijn (2004). Chuang and Hsu (2004) find that the presence of foreign ownership has a positive and significant effect on domestic firms' productivity. Feenstra and Hanson (2005) observe that export oriented MNEs in China tend to split factory ownership and input control with local managers, generally with foreign factory ownership and Chinese control over input purchases.

<sup>3</sup> Studying the impact of exports on aggregate productivity growth in China for the period 1990-97, Fu (2005) finds no evidence of significant productivity gains at the industry level resulting from exports.

competitiveness as advanced by Rodrik's (2006) measure of relative competitiveness. As a consequence, we observe that both oil prices and China's exports increase over time.

Of course, there are other possible explanations for the simultaneous increase in China's exports and oil prices. For instance, another hypothesis, not necessarily opposed to ours, is that Chinese exports are not energy intensive, that is, oil is not a significant input in its production and, therefore, increases in oil prices have little effect in production costs and exports' prices. Whether or not this hypothesis makes sense is not the object of this paper. Our aim is to test the idea that China's growth has an impact on oil prices that affects more its export competitors given the large labor force surplus of China.

This hypothesis is backed by evidence in Eichengreen et al. (2004), which shows that Chinese exports crowd out the exports of other Asian countries mainly in markets for consumer goods. Roland-Holst and Weiss (2005) find that China's exports are eroding the market share of its regional neighbors in the U.S. and Japan [see also Lall and Albaladejo (2004)]. Phelps (2004) argues that China's exports growth is detrimental for less advanced economies, especially Latin America, since Chinese competition has drastically worsened terms of trade, decreasing Latin America's comparative advantage.<sup>4</sup>

Another factor behind Chinese exports' strength lies in the productivity gains of its work force. Xiaodi and Xiaozhong (2004) show that labor-intensive products form the largest ratio of Chinese exports, which is due to China's almost unlimited supply of

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<sup>4</sup> Lall and Weiss (2005), however, maintain that Latin America's trade structure is largely complementary to that of China, while Mollick and Wvallye-Vázquez (2006) dispute the idea that employment in Mexican maquiladoras falls considerably as Mexican wages increase relative to Chinese wages.

labor.<sup>5</sup> One implication of the excess of supply of labor is that China can increase substantially the employment of its work force in the exports sector without inflating wages. Also, the productivity gains in the export sector are less likely to raise wages, which increases substantially the supply of exports and its competitiveness. Hence, exogenous increases in productivity brought about by factors such as foreign technology adoption or FDI have a positive impact on output growth and export competitiveness. This in turn leads to increases in oil prices, which helps explain the strong and positive correlation between oil prices and China's exports suggested by Figure 1.

We present a stylized theoretical model that takes into account all these factors. The model is able to explain how an exogenous increase in total factor productivity (TFP) can generate a positive correlation between Chinese growth and the oil price. We then examine empirically the implications of the model by estimating a reduced form equation for Chinese exports derived from the theoretical model. This equation takes into account the measure of competitiveness developed by Rodrik (2006) (*expy*), together with the oil price, productivity, real exchange rate, and foreign industrial production. We make use of the flexibility offered by the autoregressive distributed lag (ARDL) methodology to explain Chinese manufactured exports over the monthly period 1992-2005. The estimates yield positive values for the coefficient of the oil price and very large coefficients for *expy*. The empirical model thus offers strong support for our conjecture. Labor productivity also has a positive effect, in agreement with the theory. Negative values for the real exchange rate are also consistent with the theoretical priors, while the effect of foreign industrial income is positive but weaker.

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<sup>5</sup> According to Rima (2004) and Fu and Balasubramanyam (2005), the Chinese case illustrates Adam Smith's and Myint (1958) vent for surplus theory, since trade provides effective demand for the output of the surplus labor resources in China.

The paper is structured as follows. Next section presents the theoretical model, along with the comparative statics analysis. The data and empirical estimations appear in sections 3 and 4, respectively. Section 5 concludes.

## 2. The Model

The stylized open economy macro model for China takes into account the labor, goods and money markets, as well as the international oil market and China's exports market.

In the labor market, due to China's population size, we assume that labor supply is infinitely elastic for a real wage ( $w/p$ ) above the agricultural sector equilibrium wage:

$$\frac{w}{p} = \bar{w}, \quad (1)$$

where  $w$  is the nominal wage and  $p$  the domestic price level.

Firms demand for labor is given by the equalization between labor marginal costs and marginal productivity  $F_N$ , where  $N$  is labor and  $O$  is oil:

$$\frac{w}{p} = F_N(N, O) \quad (2)$$

Aggregate supply,  $y$ , is represented by a production function that uses labor  $N$  and oil  $O$  as production inputs:

$$y = F(N, O) \quad (3)$$

If UIP holds, the growth rate of the nominal exchange rate ( $\dot{e}/e$ ) equals the difference between domestic ( $i$ ) and foreign nominal interest rate ( $i^*$ ):

$$\frac{\dot{e}}{e} = i\left(\frac{M}{p}, y\right) - i', \quad (4)$$

where  $e$  is the nominal exchange rate – the value of one dollar in units of domestic currency, the Yuan – and a dot over a variable denotes its first difference. However, the nominal exchange rate in China not allowed to freely float. With occasional re-adjustments, it is a heavily intervened exchange rate regime. We hence assume that  $e$  is

constant,  $e = \bar{e}$ , which implies that:  $\frac{\dot{e}}{e} = 0$ . As a consequence equation (4) becomes:<sup>6</sup>

$$\frac{\dot{e}}{e} = i\left(\frac{M}{p}, y\right) - i' = 0 \Rightarrow i\left(\frac{M}{p}, y\right) = i' \quad (4')$$

Notice that in equation (4') the domestic nominal interest rate clears the money market where  $i$  increases with output  $y$  and decreases with real money balances  $M/p$  along the LM curve.<sup>7</sup>

Assuming the expected inflation rate  $\pi^*$  corresponds to the actual inflation rate

$\dot{p}/p$  because of perfect foresight we have that:

$$\pi^* = \frac{\dot{p}}{p} \quad (5)$$

The Fisher equation holds, so the expression for the real interest rate ( $r$ ) is:

$$r = i - \pi^* \quad (6)$$

Aggregate demand  $A$  is an increasing function of output  $y$ , the real interest rate  $r$  and the real exchange rate ( $ep'/p$ ), where  $p'$  is the foreign price level. The time variation

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<sup>6</sup> It has to be noted that the exchange rate regime is completely inconsequential for the conclusions of the model in steady state.

<sup>7</sup> Despite the existence of capital controls, Cheung et al (2003, 2005), report results that indicate that the UIP condition holds for China with respect to other Pacific Basin countries and also the US. These studies also show shrinking interest rate differentials over time.



of the domestic price level  $\dot{p}$  is determined by the difference between aggregate demand and supply:

$$\dot{p} = \theta \left( A \left( \frac{ep'}{p}, r, y \right) - y \right) \quad (7)$$

We assume a constant growth rate of the economy:

$$\frac{\dot{y}}{y} = g \quad (8)$$

China's and the rest of the world's economic growth increase the demand for oil, pushing up its price  $P$ :

$$P = z \left( \frac{\dot{y}}{y}, \frac{\dot{y}'}{y'} \right) \quad (9)$$

The supply of exports decreases with production costs [the wage  $wN$  and oil  $PO$  bills] and with the competitiveness ( $Comp$ ) of China's main competitors. The supply of exports increases with labor productivity  $F_N$ :

$$X^s = f(wN, PO, Comp, F_N) \quad (10)$$

The demand for China's exports increase with the income of the rest of the world  $y'$  and with the real exchange rate

$$X^d = g(y', ep'/p) \quad (11)$$

The equilibrium export level is determined by the equality between supply and demand for exports:

$$X = X(wN, PO, Comp, F_N, y', ep'/p)$$

$$X_N > 0; X_P < 0; X_{Comp} < 0; X_{F_N} > 0; X_{y'} > 0; X_e > 0 \quad (12)$$

The equilibrium in the money and goods markets is as follows:

$$\dot{p} = \theta \left( A \left( \frac{ep'}{p}, r, y \right) - y \right) = 0 \Rightarrow A \left( \frac{ep'}{p}, r, y \right) = y \quad (7')$$

Therefore the system of 10 equations: (1), (2), (3), (4'), (5), (6), (7'), (8), (9), (12) determines the equilibrium values of ten unknowns:  $w/p$ ,  $N$ ,  $y$ ,  $p$ ,  $\pi^*$ ,  $r$ ,  $e$ ,  $\dot{y}$ ,  $P$ , and  $X$ .

It is important to stress that the system of equations is block recursive: Eq. (1) determines the real wage  $w/p$ , then (2) determines employment  $N$ , then (3) determines output  $y$ , then (4') determines domestic price level  $p$ , then (5) determines expected inflation  $\pi^*$ , then (6) determines the real interest rate  $r$ , then (7') determines the nominal exchange rate  $e$ , then (8) determines the time variation of output  $\dot{y}$ , then (9) determines the price of oil  $P$ , then finally eq. (12) determines China's exports  $X$ .

Within this context, we can explain the positive correlation between China's exports and oil prices by introducing an exogenous factor that increases total factor productivity (TFP). This exogenous TFP change can be related to productivity catch-up and spillovers from advanced economies that can come about through trade and FDI links.

We can re-write the production function (3) as:

$$y = F(N, O) = \Omega N^\alpha O^\beta, \quad (3')$$

where  $\Omega$  is technology or TFP. The impact of TFP on output is given

$$\text{by } y_\Omega \equiv \frac{\partial y}{\partial \Omega} = \frac{\partial F(N, O)}{\partial \Omega} = \alpha \Omega^{\alpha-1} N^\alpha O^\beta > 0.$$

Notice that TFP also affects aggregate demand through its impact on output:

$$A\left(\frac{ep'}{p}, r, y(\Omega)\right), \text{ therefore } A_{\Omega} \equiv A_y y_{\Omega} > 0 \text{ (7'').}$$

It follows from (3') that labor productivity increases with

$$\text{TFP: } F_{N\Omega} \equiv \frac{\partial F_N(N, O)}{\partial \Omega} = \alpha^2 [\Omega N]^{\alpha-1} O^{\beta} > 0. \text{ As a consequence, employment increases}$$

$$\text{with TFP, as is easy to see from eqs. (1) and (2): } \frac{dN}{d\Omega} = -\frac{F_{N\Omega}}{F_{NN}} > 0.$$

Notice that the monetary side of the model is not affected by TFP,

$$\text{since } \frac{dp}{d\Omega} = \frac{d\pi}{d\Omega} = \frac{dr}{d\Omega} = 0, \text{ therefore the impact of TFP on the nominal exchange rate}$$

$$\text{follows from (7''): } \frac{de}{d\Omega} = \frac{y_{\Omega} - A_{\Omega}}{A_e p' / p}, \text{ which is positive.}$$

Note also that from (3') the rate of growth  $g$  is a function of the growth rates of

$$\text{technology and population: } \frac{\dot{y}}{y} = g = \alpha \left( \frac{\dot{\Omega}}{\Omega} + \frac{\dot{N}}{N} \right), \text{ assuming for simplicity that the time}$$

evolution of TFP is a quadratic function of technology, such as:  $\dot{\Omega} = a\Omega^2$ , where  $a$  is a

positive constant. The impact of TFP on the growth rate  $g$  is:  $\frac{\partial g}{\partial \Omega} = a\alpha > 0$ . As a

consequence, from eq. (9) the impact of TFP on the price of oil is positive:

$$\frac{dP}{d\Omega} = \frac{\partial z}{\partial g} \frac{\partial g}{\partial \Omega} > 0.$$

The impact of TFP on China's exports affects the demand and supply of exports.

It affects the demand of exports through the real exchange rate. TFP affects the supply of exports through the increase in production costs, the increase in labor productivity and

the increase in China's competitiveness (which is equivalent to a fall in the competitiveness of China's competitors). TFP increases production costs since it raises the price of oil as well as labor employment. It is worth stressing that an increase in the price of oil decreases the competitiveness of China's direct competitors, which increases the supply of China's exports, it may also decrease foreign income, which decreases the demand for China's exports. Therefore the impact of TFP on China's exports is:

$$\frac{dX}{d\Omega} = X_N \frac{dN}{d\Omega} + X_P \frac{dP}{d\Omega} + X_{Comp} \left[ \frac{dComp}{dP} \frac{dP}{d\Omega} + \frac{dComp}{d\Omega} \right] + X_{FN} F_{N\Omega} + X_{y'} \frac{dy'}{dP} \frac{dP}{d\Omega} + X_e \frac{de}{d\Omega}$$

Assuming negligible impact of oil prices on the income of the rest of the world,

$\frac{dy'}{dP} = 0$ , the impact of TFP on China's exports is positive if:

$$\begin{aligned} \frac{dX}{d\Omega} &= X_{Comp} \left[ \frac{dComp}{dP} \frac{dP}{d\Omega} + \frac{dComp}{d\Omega} \right] + X_{FN} F_{N\Omega} + X_e \frac{de}{d\Omega} > 0 \Leftrightarrow \\ X_{Comp} \left[ \frac{dComp}{dP} \frac{dP}{d\Omega} + \frac{dComp}{d\Omega} \right] + X_{FN} F_{N\Omega} + X_e \frac{de}{d\Omega} &> - \left[ X_N \frac{dN}{d\Omega} + X_P \frac{dP}{d\Omega} \right] \end{aligned}$$

Note that the term  $X_{Comp} \left[ \frac{dComp}{dP} \frac{dP}{d\Omega} + \frac{dComp}{d\Omega} \right]$  is positive. Hence, when we

observe increasing oil prices related to China's demand due to Chinese growth, and at the same time we observe increasing exports, both can be related to an increase in TFP as long as the net effect of TFP on China's exports is higher than the impact of increases in oil prices.

### 3. The Data

The data set runs from 1992 to 2005 with monthly frequency, including part of the recent spikes in the price of oil. The data from Chinese manufactured exports, the price of oil, the Chinese real exchange rate, and GDP per capita are all from *DATASTREAM*. Chinese exports are in USD and its extraordinary growth, especially after 2002, can be seen in Figure 1. The oil price series used is the crude oil WTI near month FOB USD per barrel. It is deflated by the U.S. CPI index (1982-84=100) from the U.S. Federal Reserve of St. Louis (series code: CPIAUNS). The WTI deflated by U.S. CPI is referred to as RWTI, as shown in Figure 1, in which the bottom-out period of commodities in late-1998 and the more recent oil price surge are visible. The Brent oil price was also studied with very similar properties to WTI: the correlation between nominal (real) Brent and WTI series is 0.996 (0.981).

We also require a measure of competitiveness of Chinese exports. For this reason, we use the concept of productivity level of exports developed by Rodrik (2006). Rodrik's exports productivity variable (*expy*) is calculated in two steps. First, a variable *PRODY*, which represents the weighted average level of income of countries exporting a certain commodity, is calculated for every commodity in the UNCTAD 6-digit Harmonized System of 1992 (HS1992), according to the equation

$$PRODY_k = \sum_j \frac{x_{jk}/X_j}{\sum_j (x_{jk}/X_j)} Y_j, \quad (13)$$

where  $x_{jk}$  represents the export of commodity  $k$  by country  $j$ ,  $X_j = \sum_k x_{jk}$  is the total exports of country  $j$ , and  $Y_j$  is the per capita GDP of country  $j$ . The numerator of the weight  $x_{jk}/X_j$  is the value-share of the commodity in the country's overall export basket.

The denominator of the weight  $\sum_j (x_{jk}/X_j)$  aggregates the value-share across all countries exporting the good. By using export share (instead of volume), the procedure tries to ensure that adequate weight is given to exports that are important to smaller and poorer countries.

The exports productivity level can now be calculated as:

$$expy_j = \sum_k \frac{x_{jk}}{X_j} PRODY_k . \quad (14)$$

The values of *PRODY* originally calculated by Rodrik (2006) were employed here in order to keep the historical data consistent with his own, but the series *expy* was extended using the most recent UNCTAD data, leading to a sample of yearly observations ranging from 1992 to 2005. We then employ a monthly interpolation to the annual series to obtain the monthly plot displayed in Figure 2.<sup>8</sup>

[Figure 2 here]

In order to proxy labor productivity that enters the supply of exports, we consider GDP per capita (GDP) from The Economist Intelligence Unit (Series Code CHYPCA), also from *DATASTREAM*. The increase in output per capita is from USD 412 in 1992 to USD 1,700 in 2005; current 2006 values are around USD 1,920, following China's very high output growth along with the steady population growth. A measure of the wage bill (wage times number of workers) was obtained as Total Wages (W) in national currency (billions of yuan) from the China Statistics Information and Service Center (Series Code CHWAGNAT). The series was then transformed into monthly series by interpolation as

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<sup>8</sup> We used several interpolation methods that yielded almost identical results. The estimates reported here were obtained by using a distribution procedure that changes the annual frequency to a monthly one while maintaining the sum each original period. This is done by solving a DP algorithm.

in EXPY and GDP. Its behavior is very similar to that of GDP per capita and we omit it from the econometric model.

Figure 3 contains two other measures usually employed on Chinese export functions. The real effective exchange rate (REER) index is CPI-based; an increase means a yuan appreciation. In the early 1990s China adopted a managed-float regime by devaluing the nominal exchange rate from 5.7 per USD to 8.7 per USD. There have been real exchange rate appreciations in the late 1990s, together with current and capital account surpluses as well as USD depreciations in the early 2000s. Very similar patterns have been reported by studies on China such as Huang and Guo (2007). See also Xu (2000) and Wang (2005) for detailed analysis of Chinese real exchange rate fluctuations.

To capture world income, the index of industrial production of industrial countries from the IMF's IFS is used (series code: 11066.IZF). The economic downturns of the early 1990s and the more recent recession after 2001 can be seen from inspection of YIND in Figure 3.

[Figure 3 here]

#### **4. Specification and results**

Given that the series discussed earlier follow either I(0) or I(1) stochastic processes, we employ the following ARDL model embedded in an ECM-type methodology as proposed by Pesaran et al. (2001). This procedure allows a mixture of I(1) and I(0) series within an unrestricted error correction model. The estimated equation takes the form:

$$\Delta x_t = \alpha_0 + \alpha_1 t + \phi \text{seasonals} + \gamma \text{dum93:1} + \varphi x_{t-1} + \Psi z_{t-1} + \sum_{j=1}^{p-1} \beta_{xj} \Delta x_{t-j} + \sum_{j=1}^{q-1} \beta_{zj} \Delta z_{t-j} + \omega \Delta z_t + \varepsilon_t \quad (15)$$

where: “*seasonals*” include 11 monthly dummy variables to capture the month of the year, which seem to have an impact on Chinese exports and on foreign industrial production to a lesser extent; *dum93:1* is a dummy variable for the month of January of 1993;  $x_t$  captures Chinese manufactures exports (*xman*) and  $z_t$  is a vector that comprises the following series: [*rwti*, *expy*, *gdp*, *yind*, *reer*]. This baseline specification is in agreement with (12) above. Wages are omitted given its strong correlation with labor productivity (captured by GDP per capita or “*gdp*” here). Since both *expy* and *gdp* display a trend-like behavior we remove *gdp* from the vector in order to check the model sensitivity below. We chose the lag length ( $p$ ,  $q$ ) by minimizing the Akaike (AIC) and Schwarz information criteria (SC), with a maximum of 6 lags.

We also applied a general-to-specific methodology to obtain a parsimonious model that reduces over-parameterization as suggested by Pesaran et al. (2001). We thus estimate (15) by ordinary least squares for the general and parsimonious models. Model (15) allows testing for the absence of a long-run relationship between  $x_t$  and  $z_t$  by calculating the F-statistic for the null of  $\varphi = \Psi = 0$ . Under the alternative,  $\varphi \neq 0$  and  $\Psi \neq 0$ , there is a long-run stable relationship between  $x_t$  and  $z_t$ .<sup>9</sup>

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<sup>9</sup> The distribution of the test statistic under the null depends on the order of integration of  $x_t$  and  $z_t$ . “If the computed Wald or F-statistic falls outside the critical value bounds, a conclusive inference can be drawn without needing to know the integration/cointegration status of the underlying regressions. However, if the Wald or F-statistic falls inside these bounds, inference is inconclusive and knowledge of the order of integration of the underlying variables is required before conclusive inferences can be made. A bounds procedure is also provided (...) based on the t-statistic associated with the coefficient of the lagged dependent variable in an unrestricted conditional ECM.” Pesaran et al. (2001, p. 290).



As several of the series display a trend-like pattern we include a deterministic trend in all the estimations. The trend terms turned out to be statistically significant in both cases (general and parsimonious models) at the 1% level. Nevertheless, we checked for the effect of allowing only a constant term in the regression and the results did not change substantially.

Table 2 contains the results of the test for a long-run relationship. Under the general model, 3 lags are chosen for the ARDL model by the SC criteria. The F-statistics, including the deterministic terms first ( $\alpha = \varphi = \Psi = 0$ ) and then excluding them ( $\varphi = \Psi = 0$ ) do not indicate rejection of the null hypothesis of no long-run relationship. The t-ratio test associated with the lagged dependent variable (t-ratio on  $\varphi$ ) also does not reject the null. The parsimonious model, obtained under the general-to-specific methodology (removing coefficients not statistically significant at 5% or lower and then appropriate re-estimation of the ECM), yields clear evidence rejecting the null of no long-run relationships.

[Table 2 here]

The ARDL models have remarkable statistical fit as can be shown in Table 3. A large part (about 85%) of the variation of Chinese exports seems to be explained by this dynamic representation under general and parsimonious representations alike. More importantly, no serial correlation is found in the residuals as can be verified by the DW and further Breusch-Pagan LM statistics which do not reject the null of no serial correlation. There seems to be some non-normality in the residuals (by the Jarque-Bera test) together with heteroskedasticity in the residuals (by the White test). The latter, however, should not be that surprising given the differing order of integration among the variables.

In order to confirm the good fit of the model, the plots of the stability test results (CUSUM and CUSUMSQ) of the general ADRL model are provided in Figure 4. Both recursive estimates CUSUM and CUSUMSQ plotted against the critical bound of the 5% significance level show that the model is stable over time. This suggests policy conclusions can be inferred from the model.<sup>10</sup>

[Figure 4 here]

Table 3 presents the coefficients associated with the long-run values, namely those of the  $\Psi$ -vector in (15). The constant ( $c$ ), trend ( $t$ ), seasonals and dummy variable terms were statistically significant in both cases (general and parsimonious models) at the 1% level. The values of  $c$  and  $t$  are not reported for space constraints. Several interesting conclusions follow from inspection of Table 3. First, the effect of the real price of oil on equilibrium exports is estimated to be positive and statistically significant with an elasticity of 0.063 for the general model and 0.068 for the model without GDP. The theoretical discussion in Section 2 provided reasons for why China's export growth is capable of moving up with higher world oil prices.<sup>11</sup>

Second, the effect of  $expy$  - our measure of competitiveness borrowed from Rodrik (2006) - is shown to be positive and strongly significant with values of 4.065 for the general model and 2.479 for the parsimonious model. This is indeed a large impact.

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<sup>10</sup> Figure 4 contains the results for the general model. The parsimonious model also yields a good CUSUM plot overall except for 2002 when Chinese exports surged dramatically. The CUSUMSQ offers a borderline plot in some cases but overall suggests a very good stability fit. Comparing to the general model, however, the recursive fit of the parsimonious model over time is worse.

<sup>11</sup> When Chinese TFP increases, the subsequent increase in output brings about an increase in international oil prices. Given the elastic labor supply in China, the increase in oil prices increases production costs by less than those of its competitors. Hence, exports grow as the relative impact of the oil price increase is smaller for China. This brings about the observed positive correlation between these two variables. This is not to say, however, that oil price increases have a positive impact on Chinese costs and competitiveness, but that the simultaneous increase in both variables is brought about by TFP growth and an elastic labor supply.

Taken together with the effect of the oil price, we can see that the basic hypothesis of this paper finds empirical support. Oil prices do not appear to harm Chinese exports that, in turn, enjoy a large expansion in world markets due to their exceptional competitiveness vis-à-vis the rest of the world.

[Table 3 here]

The effect of productivity ( $\Psi_3$ -coefficient) does not vary in magnitude across models but is not statistically significant. In theory, an increase in labor productivity brings about an increase in the supply of exports and then of exports in equilibrium. The other two  $\Psi$ -coefficients reported in Table 3 also match our theoretical priors: an increase in the real exchange rate index (an appreciation of the yuan vis-à-vis other currencies) leads to lower exports; a fall leads to higher manufactured exports. The estimated coefficients vary from -0.328 for the general model to -0.251 for the no-productivity model. The effects of foreign industrial production are estimated positive but not statistically significant.

For robustness purposes, we need to conduct alternative estimations of (15), reducing the order of the vector  $z_t$ . One important modification is to remove from the  $z_t$  vector the productivity measure. We had seen in Figure 2 that GDP per capita and *expy* both display a similar trended pattern. In fact, this possibility had been acknowledged by Rodrik (1996) after his calculation of the Chinese competitiveness measure: “As would be expected, *expy* is strongly correlated with per-capita income: rich countries export goods that other rich countries export” Rodrik (1996, p. 7). In Rodrik’s sample, the correlation coefficient between *expy* and per-capita GDP for 1992 was 0.83 in his cross-section of countries. In our case for China only it is 0.99. We thus removed GDP per

capita from the  $z_t$  vector. As it turns out, the cointegration results become stronger in what we call the “no-productivity model” in Table 2, with rejection of the null of no long-run relationship. There is no downside in the model stability since the CUSUM and CUSUMSQ tests reveal stability as shown in Figure 5. In this modified model the stability tests are unchanged across general and parsimonious representations.

The last two columns in Table 3 report the sensitivity results: the  $\Psi_2$ -coefficient becomes larger, varying from 6.523 to 6.332 across specifications. On the real exchange rate effect, the  $\Psi_4$ -coefficient is reduced slightly, varying from -0.251 to -0.265. The parameter for the oil price is very similar to that of the previous model, although it becomes not significant in the parsimonious specification.

The oil price effect on exports therefore does not vary much with whether the labor productivity variable is included or not. This would suggest that the labor productivity channel does not have a key role in explaining Chinese exports as put forward in the theoretical model above. Rather, the competitiveness measure of exports has a clear and positive effect when labor productivity is omitted in columns (3) and (4) at 6.523 and 6.332, respectively. While the abundant supply of labor does not seem to be supporting the paradox of simultaneously high exports and high oil prices, the role of China vis-à-vis its major competitors can not be overlooked in the recent run-up of oil prices. The possibility remains, of course, that there are still omitted variables correlated with the price of oil or that the proxies for productivity and foreign competition are inadequate. The fact, however, that our results take into account the competitiveness role of China relative to its partners *along with* productivity changes, makes the modeling strategy particularly enriching.

[Figure 5 here]

## 5. Concluding Remarks

The recent increase in oil prices has been usually associated with the increase in demand stemming from the spectacular expansion of the Chinese economy. However, as China is a net importer of oil, this increase in oil prices should affect negatively Chinese export supply. What we observe in equilibrium, however, is a positive correlation between Chinese exports and the oil price. In this paper we advance an explanation for this phenomenon, namely, that given its large labor surplus, the Chinese economy suffers from the increase in energy costs less than its competitors. In other words, China is more able than its competitors to replace oil with labor in its production function and as a result an increase in China's relative labor productivity will lead to an increase in its exports (partially at the cost of its competitor's exports) and will also lead to an increase in oil prices due to increased demand. The main driving factor behind the rapid expansion of Chinese exports is therefore its exceptional competitiveness. As stated by Rodrik (2006) " [China's] export bundle is that of a country with an income-per-capita level **three times** higher than China's. China has somehow managed to latch on to advanced, high-productivity products that one would not normally expect a poor, labor abundant country like China to produce, let alone export" (Rodrik, 2006, p. 4).

We have presented a stylized open economy macro model in which an exogenous shock to Chinese TFP can explain the positive correlation between exports and the oil price that is in line with our working hypothesis. We then estimated a reduced form equation for Chinese exports for the monthly sample running from 1992 to 2005. The

export function contains productivity, oil prices, the real exchange rate, world output, and Rodrik's (2006) measure of competitiveness.

We find a very strong and significant long-run effect of the competitiveness measure on Chinese manufactured exports. The estimated elasticity of competitiveness on exports seems too high, however, varying from 6.332 to 6.523 in our preferred specification. The coefficient on the price of oil is positive but small in the general models: either 0.063 or 0.068. The basic intuition of this paper finds empirical support as long as the increase in costs brought about the rise in the price of oil are more than compensated by the competitive gains of Chinese exports. While the coefficient on foreign income is not statistically significant, the coefficient of real exchange rate on exports is fairly stable (-0.328 to -0.251). The latter supports the thesis that Chinese exports fall with a stronger Yuan.

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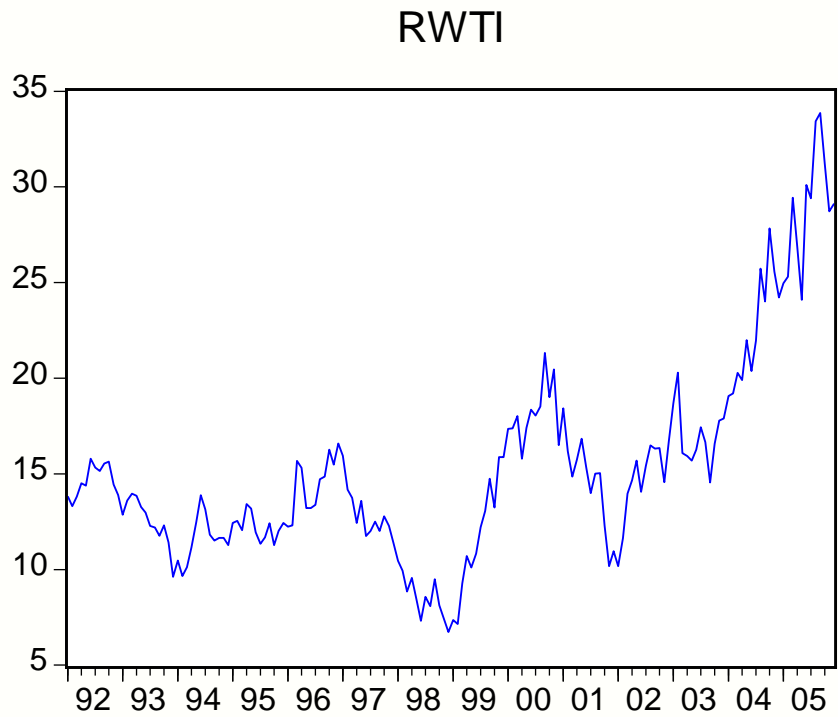
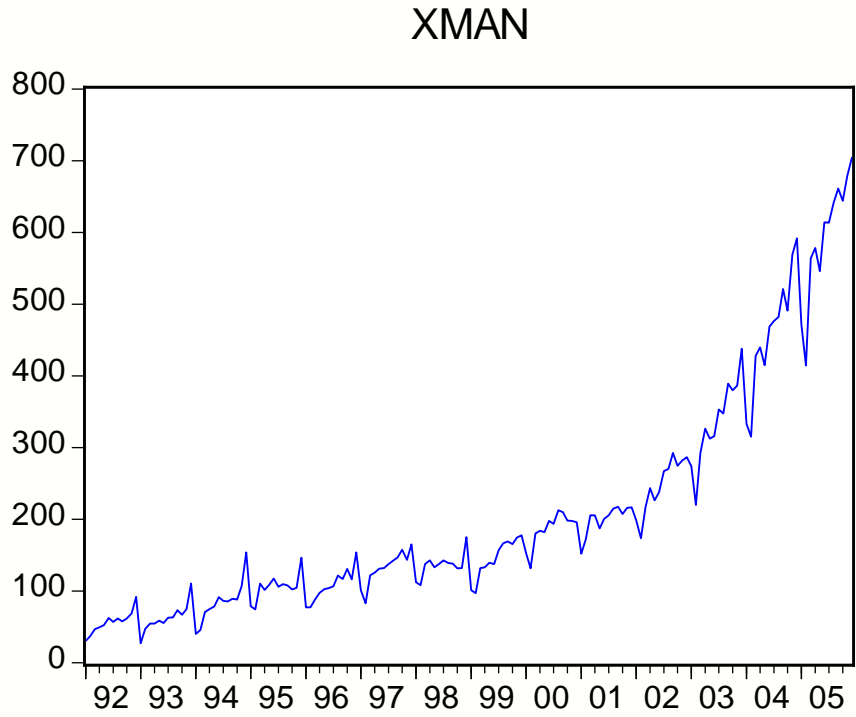
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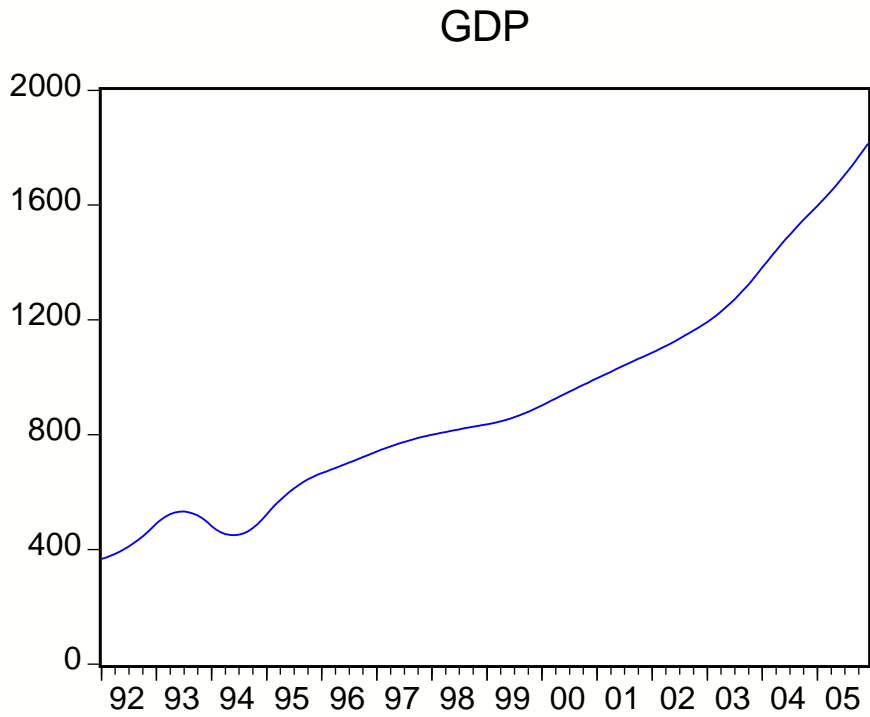
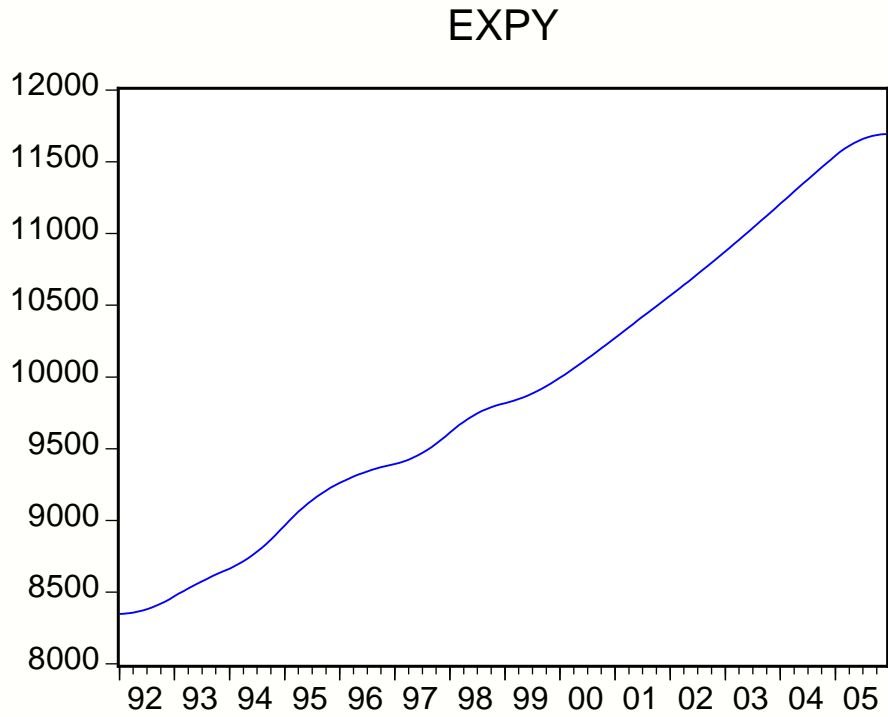
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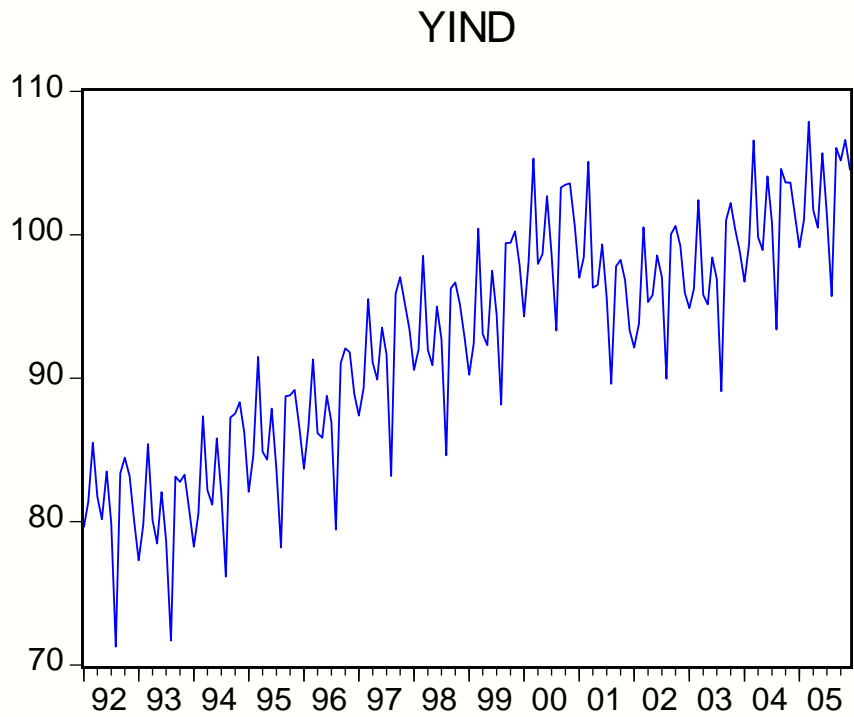
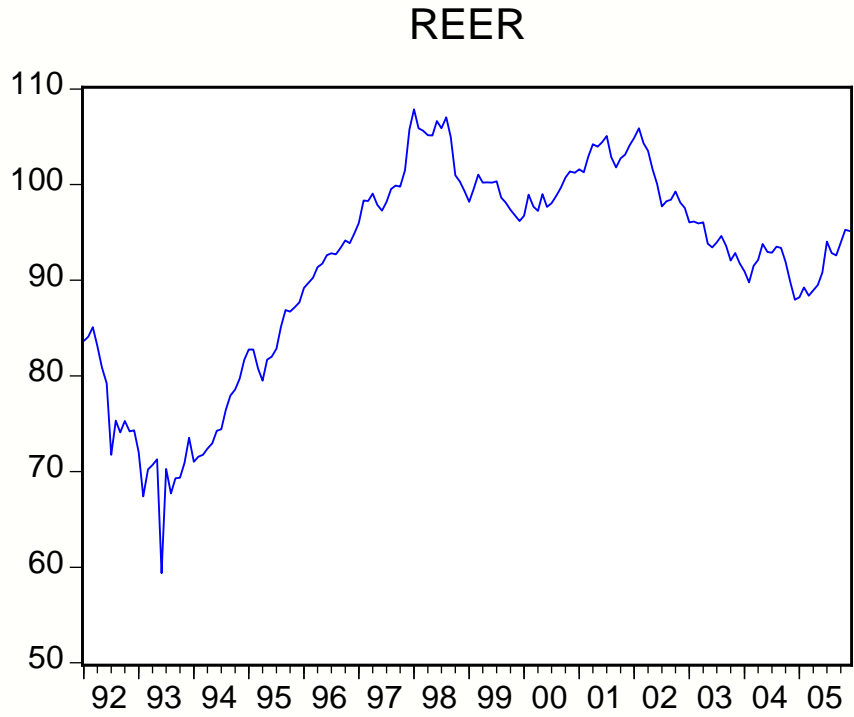
**Figure 1. Chinese manufactured exports (xman) in USD billion and the real price of oil (rwti) in USD.**



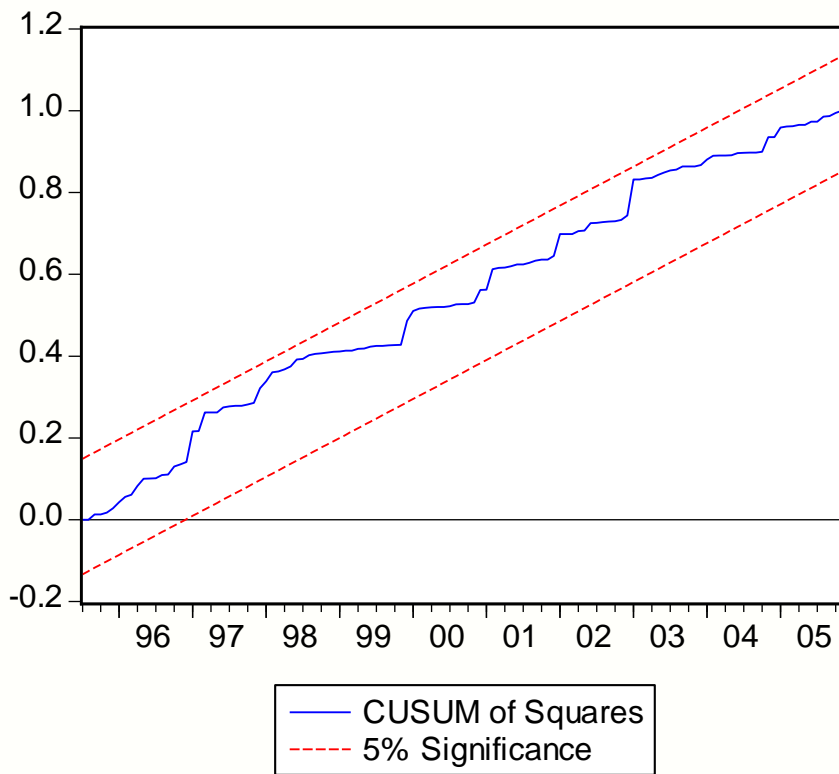
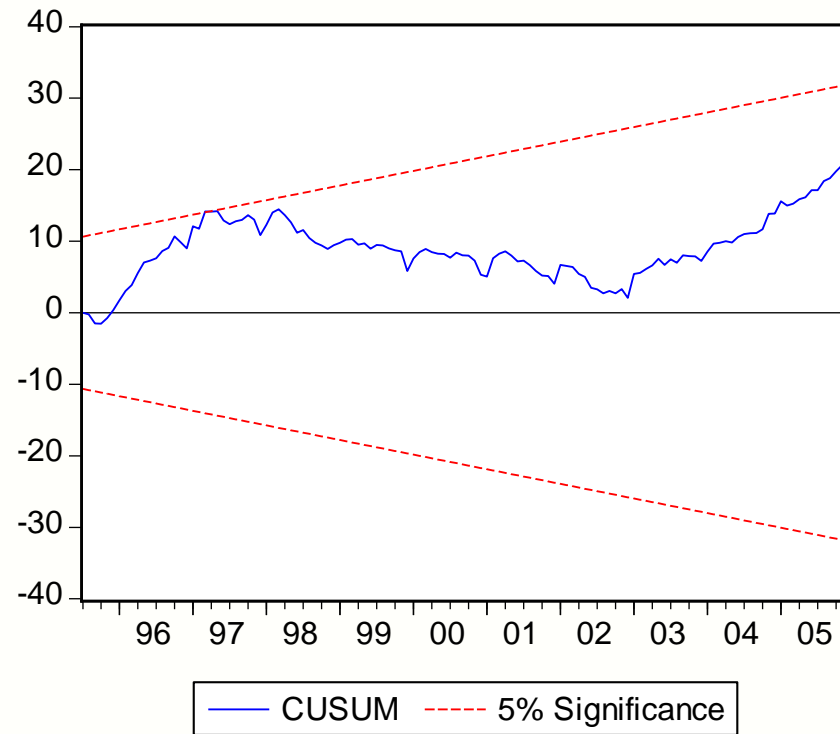
**Figure 2. Rodrik's competitiveness measure (expy) calculated for China and GDP per capita (gdppc) in USD.**



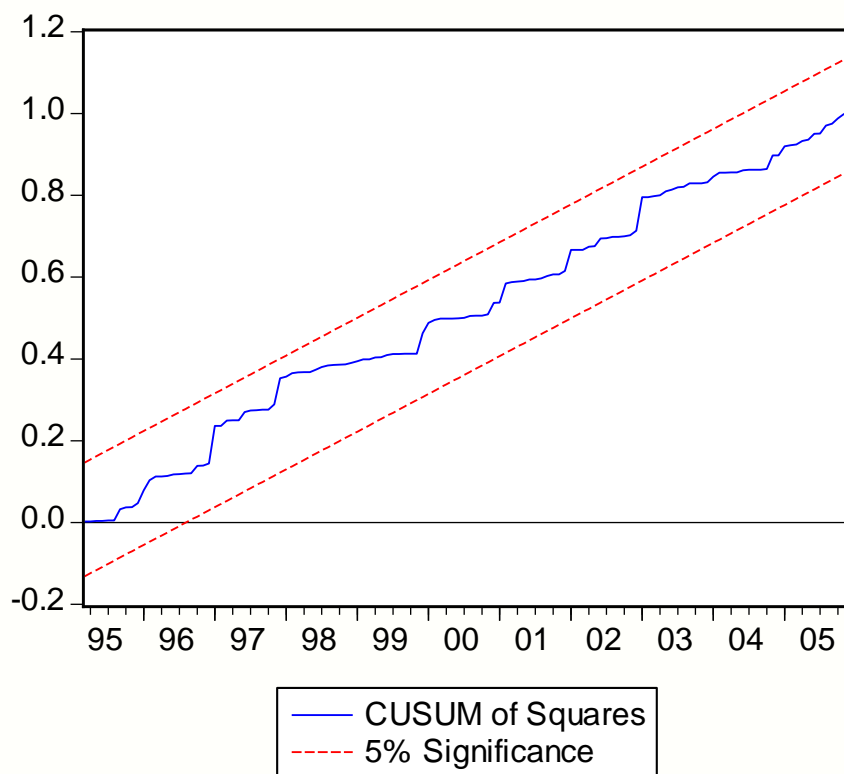
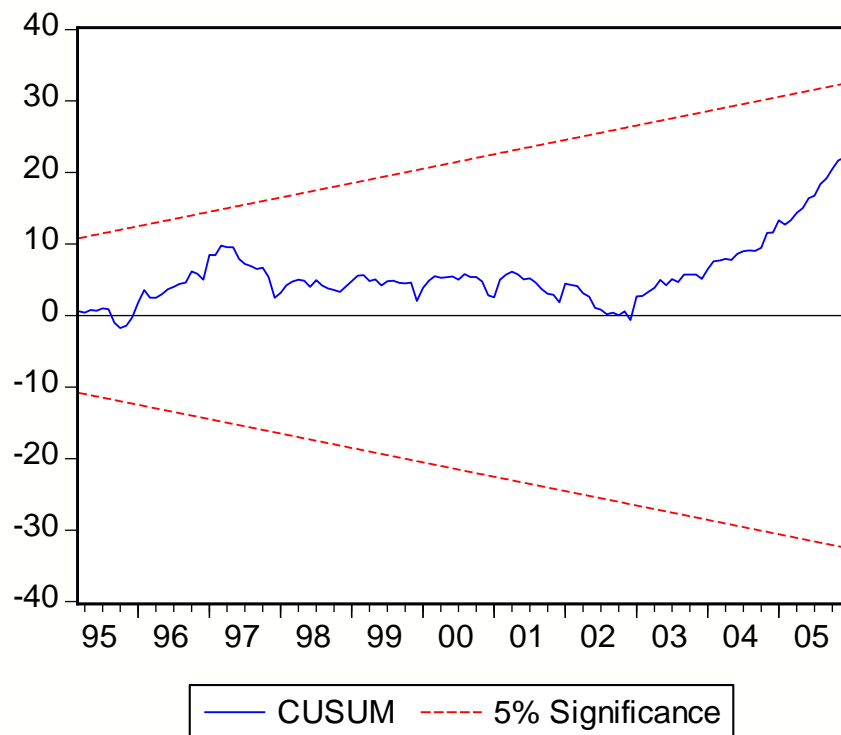
**Figure 3. Indexes of real effective exchange rate (reer), and industrial production of industrialized countries (yind).**



**Figure 4. CUSUM and CUSUM of Squares (CUSUMQ) of the Full Model: General Specification.**



**Figure 5. CUSUM and CUSUM of Squares (CUSUMQ) of the “No Productivity” Model: General Specification.**



**Table 1. Economic Growth Rates.**

<b>Region</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>
World	4.6	11.5	-3.1	7.5	11.0	2.5	-0.5
Developing countries	4.0	36.2	-16.7	11.1	14.4	9.4	4.5
Latin America and Caribbean	5.2	9.3	8.6	14.5	6.4	8.7	9.2
Asia	4.8	57.2	-27.9	11.4	19.5	10.2	2.3
<b>China</b>	<b>6.2</b>	<b>11.0</b>	<b>3.3</b>	<b>25.7</b>	<b>29.1</b>	<b>16.6</b>	<b>10.0</b>
	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	
<b>Region</b>							
World	-0.8	3.7	2.7	-1.0	3.7	12.0	
Developing countries	-6.2	1.1	8.6	-1.4	0.5	10.4	
Latin America and Caribbean	0.3	-11.7	11.2	-2.9	-12.9	4.1	
Asia	-10.1	8.6	8.0	-0.5	7.1	11.7	
<b>China</b>	<b>5.3</b>	<b>4.8</b>	<b>9.0</b>	<b>8.8</b>	<b>7.7</b>	<b>11.4</b>	

*Source:* WEO and IFS, GDP original data in US\$ Millions.



**Table 2. Bounds Test Analysis of Long-Run Relationships.**

$$\Delta x_t = \alpha_0 + \alpha_1 t + \phi_{seasonals} + \gamma_{dum93:1} + \varphi x_{t-1} + \Psi z_{t-1} + \sum_{j=1}^{p-1} \beta_{xj} \Delta x_{t-j} + \sum_{j=1}^{q-1} \beta_{zj} \Delta z_{t-j} + \omega \Delta z_t + \varepsilon_t$$

	<b>Lag-Length</b>		<b>F-IV</b>	<b>F-V</b>	<b>t-V</b>
	<b>Info. Criterion</b>		$\alpha = \varphi = \Psi = 0$	$\varphi = \Psi = 0$	<b>t-ratio on <math>\varphi</math></b>
<b>Full Model</b>					
General:					
$z \rightarrow x$	AIC	5	3.758	4.093	-3.618
	SIC	3			
Parsimonious:					
$z \rightarrow x$	$\Delta x_{t-1}, \Delta x_{t-2}, \Delta gdp_{t-1},$ $\Delta gdp_{t-2},$ $\Delta y^*_{t-1}, \dots, \Delta y^*_{t-3}$		3.798*	4.287**	-3.834
<b>No productivity Model:</b>					
General:					
$z \rightarrow x$	AIC	6	4.562*	5.325**	-3.106
	SIC	3			
Parsimonious:					
$z \rightarrow x$	$\Delta x_{t-1}, \Delta x_{t-2}, \Delta x_{t-3}$ $\Delta expy_{t-1}, \Delta expy_{t-3}$ $\Delta yind_{t-1}, \dots, \Delta yind_{t-3}$		5.007**	5.922**	-2.943

*Notes:* The “no-productivity” model is the original model when we drop GDP per capita from vector  $z_t$ . The table produces F (Wald-type) and t-tests for the existence of long-run relationships. If the values fall outside the critical value bounds, a conclusive inference can be drawn without needing to know the integration or cointegration status of the underlying regressors. \*\* indicates rejection of the null hypothesis at 5%; \* at 10%. The upper bound of the critical value of the F-test for the full model (5 independent variables) is 4.25 (5%) and 3.79 (10%) and, for the t-test, -4.52 (5%) and -4.21 (10%). The upper bound of the critical value of the F-test for the model without GDP is 4.57 (5%) and 4.06 (10%) and for the t-test, -4.36 (5%) and -4.04 (10%). All critical values are taken from the tables in Pesaran et al. (2001).

**Table 3. Long-Run Coefficients and Diagnostics.**

$$\Delta x_t = \alpha_0 + \alpha_1 t + \phi \text{seasonals} + \gamma \text{dum93:1} + \varphi x_{t-1} + \Psi_1 \text{rtwi}_{t-1} + \Psi_2 \text{expy}_{t-1} + \Psi_3 \text{gdp}_{t-1} \\ + \Psi_4 \text{reer}_{t-1} + \Psi_5 \text{yind}_{t-1} + \sum_{j=1}^{p-1} \beta_{xj} \Delta x_{t-j} + \sum_{j=1}^{q-1} \beta_{zj} \Delta z_{t-j} + \omega \Delta z_t + \varepsilon_t$$

	Full Model General	Full Model Parsimonious	No- Productivity Model General	No- Productivity Model Parsimonious
$\Psi_1$	0.063** (0.031)	0.039 (0.033)	0.068** (0.033)	0.052 (0.033)
$\Psi_2$	4.065 (2.607)	2.479 (2.413)	6.523*** (3.164)	6.332* (3.242)
$\Psi_3$	0.357 (0.320)	0.322 (0.235)		
$\Psi_4$	-0.328** (0.133)	-0.339** (0.127)	-0.251* (0.131)	-0.265** (0.105)
$\Psi_5$	0.076 (0.504)	0.022 (0.453)	0.249 (0.588)	0.246 (0.527)
DW	2.031	1.944	1.944	1.846
Adj. R <sup>2</sup>	0.851	0.854	0.846	0.851
LM-test	0.00 [1.00]	0.00 [1.00]	0.00 [1.00]	0.00 [1.00]
JB test	15.31*** [0.001]	23.38*** [0.000]	43.38*** [0.00]	52.55*** [0.00]
White F-test for hetero	2.129*** [0.001]	2.673*** [0.000]	1.582** [0.022]	1.742*** [0.013]

*Notes:* The first two columns in the table report estimated long-run coefficients of, respectively, *rtwi* (real oil price), *expy*, *gdp*, *reer*, and *yind*. The last two columns do the same for the “no-productivity model”, in which per capita GDP is excluded. The coefficients associated with the deterministic terms are omitted. Standard errors in parentheses and p-values in brackets.