Globalisation and China's Iron and Steel Industry
Modelling China's Demand for Steel Importation

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Introduction

China is now the world's biggest steel producer with an annual steel output exceeding 100 million tons, a position held since 1996. In 2003 its crude steel production was 219. 3 million tons and was increased to 272.8 million tons in 2004 (IISI, 2004). However, over the past 10 years, the growth of steel demand in China has been averaging 10% annually on a compound basis, roughly in line with the expansion of the economy. Within a very short time period, China has become the largest steel consumer in the world. In 2003, China's annual steel consumption reached 215 million tons (IISI, 2003). As a large proportion of this consumption consist of high quality steel and the domestic producers have great difficulty to meet the requirement, the shortfall had to be met from imports. While China has significantly reduced its steel imports since 1990s, its size in world markets still makes it of key importance. Therefore, the determination of the demand, price and substitution elasticises in the Chinese market can provide exporters with a partial base for developing marketing strategies.

In this study, the effect of trade liberalisation and the impact of China's economic activities and the real change rate of Renminbi (RMB), the Chinese currency, on China's demand for steel import will be examined.

II. The impact of trade liberalisation on China's steel industry

It is widely accepted that China's steel industry is characterised as fragmented, inefficient and over-employed comparing to its Western counterparts (Brizendine and Oliver, 2001, Chinese Academy of Social Science, 2005).

Since the early 1990s, in response to the development of trade liberalisation, China steel sector has gone through a series of reform and transformation aiming to improve

the sector's competitiveness in international market. The two major steps of these reform were:

1. Corporatisation of steel enterprises and establishment of multiple ownership structure

Given steel's strategic importance in China's national economy China's steel sector has been long controlled by state owned enterprises (SOEs). These SOEs were divided into two categories: 'key' and 'local'. The former were directly supervised by the central government and the latter by the provincial government (Wu 2001). They both controlled a bulk share of steel production. In order to reduce the responsibility of the state and to allow SOEs to have a greater autonomy, a series of reform had been undertaken, such as the introduction of the contracting system, the share-holding system and the asset responsibility (Huang & Kalirajan, 1998). In the meantime, other types of ownerships production were also encouraged by the government. While some SOEs of steel had been reformed into share-holding companies or international joint ventures, some collectively-owned steel enterprises were also established (Wu, 2001, Liu & Otsuka, 2004).

2. Consolidation of the sector

China's membership of the WTO has posed a tremendous challenge for China's steel sector. It was claimed that as China's steel sector is far behind the world steel powers in terms of technology and equipment, product variety and quality, and labour productivity, China's entry into the WTO will place its steel sector at a disadvantage in international competition (Chinese Academy of Social Science, 2005).

The forces of the unprecedented programme of trade liberalisation and the eager desire to become a member of the WTO were the driving force for the consolidation of China's steel sector.

It was noted that despite that the current tariff rates of China's steel products have already met the WTO's requirement, the pressure on its steel sector brought by the over-haul elimination of no-tariff barriers on steel imports will be enormous. In fact,

as early as 1992, China has abolished the license and quota controls over its steel imports. The elimination non-tariff barriers on steel imports is expected to take place by the end of 2005 (www. tdcrade.com). Once the non-tariff barriers are removed, the role the governmental protection will become very limited. Within this context, how to compete against the global giants has become an urgent itinerary on the agenda of enhancing competitiveness of Chinese enterprises.

It was decided that one way to face the challenge was to merge and acquisition of the existing steel enterprises in order to benefit from the economies of scale and mitigate problems of repetitive production and inefficient uses of resource. Examples of these mergers and acquisitions included the taking over of China National Non-ferrous Metal Corporation and Beijing Heavy Machinery Factory; the merger between Baosteel and all other steel enterprises in Shanghai; Wugang with some enterprises along the Yangzi River. Moreover, two leading steel enterprises from North Eastern China, Anshan Steel and Benxi Steel are also planning to merge. It was agued, however, since most these mergers have been driven by administrative action, rather than by the enterprises acting in their own commercial interest and many enterprises being taken over were loss-making, the ability of these enlarged giants to compete in the international market was under doubt (Wu, 2000, Woetzel, 2001, Nolan, 2001).

3. Estimation of China's steel import

3.1. Model specification and estimation

This section investigates the determinants of China's import demand for steel products by applying the traditional price-income model. Two hypotheses will be tested. First, a real depreciation in exchange rate is associated with increased domestic competitiveness; and second, an increase in industrial output is associated with a greater degree of "openness" of the Chinese economy reflected by the size of its import. To test these two hypotheses, this article uses the integration and co-integration tests to analyse the joint effect of the Chinese economic activities and the RMB's value on steel import of China. A co-integration relationship is to be established between China's steel imports on the one hand, the value added of

industrial production and real exchange rate on the other. [1] Then, the effects of changes in the growth rate of the Chinese economic activities, the RMB's real value on the growth rate of the Chinese steel import are examined. The short-run and long-run dynamics of this relationship are analysed by estimating the error correction model.

There was a large amount of literature on the import demand modelling in general. Most researchers have used either a linear or log-linear functional form. It has been noted that the choice of the functional form is not important because it was principally made in accordance with statistical convenience (King, 1993). We thus decide to use the traditional price-income model for our analysis. In this model, the quantity of steel import demand from China is assumed to depend on the relative prices of the steel, i.e., the ratio of import price and domestic price of the commodities expressed in the same currency and the economic activities of China. The general functional form of estimating China's steel imports is given as follows:

$$M_t = f(Y_t, ER_t) \qquad (1)$$

where M_t is the quantity of China's imports in time period t, Y_t is China's real value added of industrial output, ER_t is the relative price of steel import prices relative to its domestic prices measured in RMB, i.e. real exchange rate in terms of RMB per US dollar unity. An increase of ER means a real depreciation of RMB. Consequently, China's steel import from the world is more expensive.

The calculation formula of ER_t is the following:

$$ER_t = EN_t * \frac{P_t^f}{P_t^d}$$

Where EN is nominal exchange rate of RMB per unity of U.S. dollar, P_t^f is China's import price of steel, P_t^d is the steel price in Chinese domestic market. Thus, the calculated ER is the real exchange rate in the steel sector.

Following Boylan and Cuddy (1987) and Tabmi (1998), elasticity coefficients are obtained by estimating a log-linear form of equation (1) as follows:

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[1] Due to the difficulty of obtaining monthly data on China's GDP, the industrial production is used as the proxy of China's economic activity in this study.

$$\ln(M)_t = \beta_0 + \beta_1 \ln(Y)_t + \beta_2 \ln(ER)_t + \mu_t \qquad (2)$$

where β_0 is the intercept, β_1 is the elasticity of demand for import steel and β_2 is real exchange rate elasticity for import steel, and μ_t is a stochastic disturbance term.

It is expected that the increase of industrial production will stimulate China's imports of steel from the world, thus, β_1 is expected to be positive and it is referred to as income effect. The sign of the real exchange rate elasticity of demand is expected to be positive, i.e., $\beta_2 < 0$. This is because a real depreciation of RMB against US dollar would mean more expensive steel imports, the import of demand for steel would therefore decline.

3.2. Estimation method

To estimate the above equation, we should know firstly whether there exists a stable long-run relationship between the level of the Chinese steel imports, the Chinese economic activities and the exchange rate between Chinese RMB and the US dollar. If this stable long-run relationship could be established, it may be possible to make quantitative inferences about the anticipation of future steel imports from the observation of changes in economic activities and real exchange rate of RMB. Co-integration test is used to test this long-run relationship is this paper. The necessary condition for using this co-integration technique is that the Chinese steel imports, economic activities and real exchange rate may not be stationary at an absolute level, but could be stationary at the same differenced level. They should have the same inter temporal characteristics in order to build their long-run equilibrium relationship to avoid the problem of spurious regression. Consequently, we test firstly the stationarity of the steel imports, economic activities, and real exchange rate, then analyse if it exists long run and short run relationships between them.

3.2.1. Integration tests

The dynamic characteristic of these series can be expressed by how many times they need to be differenced to achieve time-invariant linear properties and to provide a stationary process. These variables are defined as first difference if they need to be differenced one time to become stationary, or of order zero if not

differencing is needed. The order of their integration can be obtained by Augmented Dickey-Fuller test (ADF).

The classic statistic tests of ordinary least square regression are not valid here, because the statistical limited distributions are not standard if the variables are not stationary. We will use the critical values calculated by MacKinnon (1991) for ADF test. Indeed, MacKinnon has implemented a much larger set of replications to permit the calculation of Dickey-Fuller critical values for any sample size.

3.2.2. Co-integration tests

If the Chinese steel imports, its economic activities and real exchange rate are separately integrated of first difference, the cointegration, first proposed by Granger (1981), Engle-Granger (1987) and extended by Johansen (1988), can therefore be applied in order to see if there exists one special long-run relationship between them and to specify the dynamic of an error correction model.

The Chinese steel imports are defined to be co-integrated with its economic activities and real exchange rate if these temporal series have the conjoint movements so that they verify approximately one long-run relationship. There exists therefore one linear combination between them in levels so that the residual (unexplained error) of regression of the Chinese steel import on its economic activities and real exchange rate is integrated of order zero. This is a rather special condition, because it implies that there exist some extremely important long-run components between them. However, in forming their residual these long run components cancel out. The cointegration of the Chinese economic imports with its economic activities and real exchange rate translates therefore the fact that their linear combination does not move away much long time to their average despite that they have tendancial movements.

The ADF cointegration test are inefficient when there are more than two variables under consideration, as in our case. In fact, these tests are sensitive to the specific choice of the endogenous variable on the left-hand side of the equation (Dickey et al., 1991). They also ignore the possibility of more than one cointegration vector when more than two variables are included in the analysis. Finally, they impose an implicit common factor restriction. If the latter is invalid, then the tests lose power

(Kremers et al. 1992; Banerjee et al., 1993). Taking into account these shortcomings, we decide to test the cointegration hypothesis by the more powerful Johansen approach (Johansen & Juselius, 1992).

The Johansen procedure is based on maximum likelihood estimation of a vector autoregressive (VAR) system. Given a 3×1 vector of variables $X_t = ($ $lnRM_t$, lnY_t , $lnER_t)$ —— the logs of the Chinese steel imports in quantity, real economic activities, real exchange rate of Renminbi, and considering a VAR model of order 3, with Gaussian errors, we obtain :

$$Xt = C + \pi_{t-1}X_{t-1} + \pi_{t-2}X_{t-2} + \pi_{t-3}X_{t-3} + \mu_t$$

Where:

C is an 3×1 vector of constants or drift terms

μ_t are white noise errors with covariance matrix >0

t=1...T.

Be re-parameterizing, the VAR can be rewritten as a reduced-form error-correction model (Johansen , 1988 ; Banerjee et al. 1993) as

$$\Delta X_t = C + \sum \Gamma_i \pi_i \Delta X_{t-i} - \pi X_{t-i} + \mu_t$$

where $\Gamma_i = -(\pi_1 + \pi_2)$

$$\pi = (\pi_1 + \pi_2 + \pi_3) - I$$

The vectors Γ_i consist of short-run parameters which capture the disequilibrium features of the data and the matrix π contains the information on the long-run relationships corresponding directly to the equilibrium relationships. Therefore, the cointegration analysis can separate long-run equilibrium features of the data from their short-run dynamics.

The cointegration test involves determining the rank of the matrix π, which corresponds to its number of nonzero eigenvalues. In the situation where the components are non-stationary and integrated of order 1, the rank of the matrix π determines the cointegration properties of X_t, that is the number of cointegrating vectors in the system. Three different cases of the rank (r) of the matrix π can result and are of particular importance. (1) if r = 3, that is the matrix π has full rank, this implies that all the variables in X are stationary; (2) if r = 0, that is the matrix π is a

null matrix, this implies that no cointegration vectors exists because all linear combination of X are I(1); if $0 < r < 3$, that is, the matrix π has a reduced rank, then there are (n-r) linear combinations of X that act as a common stochastic trend, and r cointegrated linear combinations.

So, the hypothesis of the cointegration is formulated as the hypothesis of reduced rank of the coefficients matrix π. The latter can be decomposed as: $\pi = \alpha\beta'$ under the Johansen ML procedure, where β is the $3 \times r$ matrix of cointegrating vectors (each raw is a cointegrating vector) and α is the $3 \times r$ matrix of weighting elements. The stationary relations $\alpha\beta'$ are referred to as the cointegrating relations. The estimate of β' is obtained by solving an eigenvalue problem. As for testing cointegration, the Johansen approach is based on sequential likelihood ratio test of the null hypothesis of at most 3-r unit roots against the alternative of 3-r-1 unit roots. This "equilibrium" relation can be given in its more familiar form as equation 1 (ln denotes logarithm) as: $\ln M_t = a_o + a_1 \ln Y_t + a_2 \ln ER_t$

The second question to be examined is whether there exists an instantaneous adjustment in the changes in the growth rate of the Chinese steel imports to the changes in the growth rate of their precedent levels and economic activities and real exchange rate in the context of their equilibrium solutions. This draws upon the error correction specification which allows the long-run components of the Chinese steel imports to obey equilibrium constraints while their short-run components have a flexible dynamic adjustment. This specification is therefore suitable to explain the observed disequilibrium steel imports in the context of their long-run equilibrium imports. The reduced-form error correction specification can be written as (Δ represents rate of change of variable; ECM denotes residual of co-integration regression as $\ln M_t = a_o + a_1 \ln Y_t + a_2 \ln ER_t$:

$\Delta \ln M_t = b_o + b_1 \Delta \ln RP_{t-k-1} + b_2 \Delta \ln Y_{t-k} + b_3 \Delta \ln ER_{t-k} + b_4 ECM_{t-1} + z$
    with $k = 0 \ldots n$.

The co-integration test gives the "equilibrium" coefficient estimates. The error-correction model not only relates the instantaneous adjustments in the changes of the growth rate of the Chinese steel imports to the short-run changes of the growth

rate in their precedent levels and in its economic activities and real exchange rate (impact effect), but also ties the changes of the steel imports to the residual of the precedent date at untransformed level through a feedback mechanism (long run effect). It permits therefore the combination of long run and short run information of the steel imports in the same model.

3.3. Data sources, econometric tests and economic results

We use monthly data for the period of October 1996 to December. 2004, which allows us to obtain 99 observations for each of the data series for the co-integration analysis. The data are obtained from several sources. Data on China's imports of steel products, the price of imported steel and domestic price of steel are from "**World Trade Atlas**" databank by the UN and **International Statistics of Iron and Steel** by International Institute of Steel. Data on Chinese industrial production index, a proxy variable for income level, are from **China Macroeconomic Monthly Report** published by Information Network Development Research Centre of State Council of China. Foreign exchange rate dada came from **International Financial Statistics** published by IMF and **Finance of China**, also by Information Network Development Research Centre of State Council of China.

3.3.1. Results of integration tests

Table 1 reports the results of integration tests of the Chinese steel imports, its economic activities and real exchange rate based on monthly data from October 1996 to December 2004. The ADF results permit to reject the hypothesis that all the series tested in untransformed data are stationary. On the contrary, they show that the rates of changes of the Chinese steel imports, its economic activities and real exchange rate are respectively stationary at first difference level. These results allow us to test if the Chinese steels are changed together with its economic activities and real exchange rate.

Table 1. The Results of ADF Test

	Absolute level	First difference
Steel import	-2.55	-9.999***
Economic activities	-0.926	-10.532***
Real exchange rate	-2.491	-10.475***

Note. *** indicates 1% level of significance level

3.3.2. Results of co-integration tests

Table 2 reports the results of Johansen-Juselius cointegration test. Using the Max-lambda statistic, we test the null hypothesis that (r) = 0 against the alternative that (r) is at most 1. Our test statistic of 33.61 exceeds the critical value of 20.97 which leads to the rejection of the hypothesis of no cointegrating relationship. The Trace statistic of 38.52 also exceeds its corresponding criticalvalue of 29.68 which is consistent with the result using the Max-lambda statistic.

We now move on to testing the null hypothesis that the rank is 1. In this instance however, the Max-lambda statistic of 4.91 is smaller than the critical value of 14.07 and we cannot reject the null hypothesis. The Trace test leads to the same conclusion. Therefore, regardless of which statistic is used, we cannot reject the hypothesis that we have 1 cointegrating vector. Their coefficient estimates of "equilibrium" relations are given in table 2. The growth of industrial production is one of the main factors to explain the increase of the Chinese imports. The real depreciation of the RMB leads a decrease of the Chinese imports.

These results are therefore supportive of the hypothesis that the Chinese steel imports are co-integrated with its economic activities and real exchange rate and that there exist long-run co-movements between them. They imply therefore that economic activities and real exchange rate are the good indicators for explaining the movements of the Chinese steel imports.

Table 2. Results of Johansen-Juselius Cointegration Rank Test

H0 :		H1 :	
Eigenvalues (lambda)	Rank<=r	Max-lambda statistics (rank<=(r+1))	Trace statistics (rank<=(p=3))
0.29033725	0	33.610612	38.524126
0.04887663	1	4.9109268	4.9135145
0.0000264	2	0.00258768	0.00258768
"equilibrium" relation : $\ln M_t = 2.21 + 0.84 \ln Y_t - 1.10 \ln ER_t$			
Error correction specification: $\Delta \ln M_t = -0.003 + 0.93 \Delta \ln Y_t - 0.62 \Delta \ln ER_t - 0.16 REC_t$			

3.3.3. Results of error-correction model

The obtained cointegration relations allow us to apply our reduced-form error correction specification to estimate the Chinese steel imports. Our procedure is to regress the changes of the steel imports not only on the unrestricted distributed lags of its own past values in variations, its economic activities and real exchange rate in variations, but also on the residual of their co-integration of the precedent date at absolute level. The resulting over-parameterized equations are then simplified in order to obtain the results which are both in line with theoretical considerations and error correction specification. The econometric results for simplified estimated steel imports are reported in table 2.

The model seems general enough to capture the salient features of the data and is consistent with the main implications of economic theories. The estimated equation explains 49 % of the adjusted variance of the Chinese steel imports. Considering that the equations explain the rate of changes in steel imports, the obtained adjusted R^2 value, although not too high in theory, can be considered in this case as quite good.

All the diagnostic tests display the appropriateness of the specification, suggesting that a satisfactory model for commodity prices is reached. The values of Durbin-Watson test and LM test (up to fourth-order) allow to conclude with certainty as for residual serial correction for the steel imports and allow to not reject the

hypothesis of serial independence of errors. So, we can conclude that there is no evidence of autocorrelation in the equation errors. In order to verify if there does not exist the correlation between residual and explanatory factors, we have applied the homoscedasticity test, Arch and White tests (up to fourth-order). The results appear significant at the level of 5 % for all the equations. So, the distribution of error term is independently and homoscedastically normal. The results of Ramsey's test show that the functional form is not misspecified. Finally, the Chow test has been used for verifying the exogeneity of explanatory variables.

The estimated coefficients of our reduced-form error-correction specification allow for a clear interpretation of dynamic process. The first feature to notice from the simplified estimated dynamic model is that the error correction term of the precedent data (MCE_{t-1}) is statistically significant. This well-defined term indicates a feedback of approximately 16 % of the previous year's disequilibrium from the long-run economic activities and real exchange rate of the Chinese steel imports. The strong significances of the coefficients of MCE_{t-1} support our earlier conclusion that the steel imports are cointegrated with its economic activities and real exchange rate.

The second feature to indicate is that the changes in the growth rate of the steel imports resulting from the changes in the growth rate of its economic activities tend to produce sharp import movements. The t-student test value for the economic activities is very significant at 1% level.

The third feature to explain is that the changes in the growth rate of real exchange rates of RMB have an impact on the changes in the growth rate of steel imports. The econometric analyses confirm the impact of exchange rates on the steel imports. The immediate import pricing reactions may be due to that the importer countries buy immediately commodities in world markets.

References

Bahmani-Oskooee, M. (1986), Determinants of International trade Flows: the Case of Developing Countries, Journal of Development Economics, Vol. 20, Issue 1, pp.107-123.

Bahmani-Oskooee, M. and Pourheydarian, M. (1991), The Australian J-curve: a re-examination, International Economic Journal, Vol. 5, pp.49-58.

Bahmani-Oskooee, M. and Pourheydarian, M. (1992), What are the Long-run Determinants of the U.S Trade Balance, Journal of Post Keynesian Economics, Vol. 15, pp.85-97.

Bahmani-Oskooee, M. and Taggert J. B. (1999), Co-integration Approach to Estimating Bilateral Trade Elasticities between U.S. and Her Trading Partners, International Economic Journal, Vol. 13, No. 4, pp.119-127.

Banerjee, Anindya, Lumsdaine, Robin L., Stock, James H. (1992), Recursive and Sequential Tests of the Unit-Root and Trend-Break Hypotheses: Theory and International Evidence, Journal of Business & Economic Statistics, Vol. 10, Issue 3, pp.271-288.

Brizendine, T. and Oliver, C. (2001), China's Steel Sector in Transition, China Business Review, Vol. 28, Issue, 1. pp. 22-27.

Boylan, T.A., and Cuddy, M.P. (1987), Elasticises of Import Demand and Economic Development –the Irish Experience, Journal of Development Economics, Vol. 26, No. 2, pp. 301-309.

Engle, R.F. and Granger, C.W.J. (1987), Co-integration and Errorr Correction: Representation, Estimation and Testing, Econometrica, Vol. 51, pp.227-304.

Granger, C.W.J. (1981), Some Properties of Time Series Data and Their Use in Econometric Modal Specification, Journal of Econometrics, Vol. 16, Issue 1, pp.121-131.

Holden, D. and Perman, R. (1994), Unit roots and Co-integration for the Economist, in B.B. Rao (Ed.), co-integration for the Applied Economist, New York. St. Martin's Press.

International Iron & Steel Institute (IISI), Iron and Steel Statistics, various issues.

Johansen, Soren (1992), Cointegration in Partial Systems and the Efficiency of Single-Equation Analysis, Journal of Econometrics, Vol. 52 Issue 3, pp. 402.

Johansen Soren and Juselius Katarina (1992), Testing Structural Hypothese in a Multivariate Cointegration Analysis of the PPP and the UIP, Journal of Econometrics, Journal of Econometrics, Vol. 53, Issue 1/2/3, pp.211-244.

King, A. (1993), The Functional Form of Import Demand: The Case of UK Motor Vehicle Imports, 1980-90, Journal of Economic Studies, Vol. 3, No. 3. pp. 36-50.

Kremers, J.J.M., Ericsson, N.R. and Dolado, J.J. (1992), The Power of Cointegration Tests, International Finance Discussion Paper, No. 431, Board of Governors of the Federal Reserve System, Washington, DC.

MacKinnon, J.G. (1991), Critical Values for Cointegration Tests, Chapter 13, in Engle, R. F. and Granger C.W. J (eds), Long-Run Economic Relationship: Readings in Cointegration, Oxford, Oxford University Press.

Nachane, D.M. and Prassd, P.R. (1998), India's Trade Balance in the 1980s – an Econometric Analysis, Applied Economics, Vol. 30, pp.761-774.

Nolan, P. (2001), China and the Global Economy, Basingstoke, Palgrave.

Smith, T. (2002), China's Steel Industry in the WTO Era, Steel Times International, February.

Tambi, N. E. (1998), Trade Liberalisation Effects on Commodity Imports in Cameroon, Journal of Economic Studies, Vol. 25, No. 3, pp. 193-202.

The Impact of WTO Entry on China's Steel Industry, http:www.tdctrade.com/ecoforum/sc/sc000903.htm, visited on May, 15, 2005.

Wei, Weixian (1999), An Empirical Study of the Foreign Trade Balance in China, Applied Economics Letters, Vol, 6, Issue 8.

Woetzel, J. R. (2001), Remaking China's Giant Steel Industry, The McKinsey Quarterly, Vol. 4, pp. 93-102.

Wu, Yanrui. (2000), The Chinese Steel Industry: Recent Development and Prospects, Resources Policy, Vol. 26, Issue 3, pp. 171-178.

Yu Yongding, Zheng Binwen and Song Hongren (2000), New Chinese Academy of Social Science Report: China After WTO, Beijing, Social Sciences Archive Publishing House.