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Asymmetry of Processing Trade in China : Theory and Empirics

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Asymmetry of Processing Trade in China: Theory and Empirics

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Abstract

THIS paper studies decision of whether outsourcing or localization in China. Both strategies can enjoy low wage advantage. But outsourcing induces processing trade, while localization, which has additional localization cost can turn processing trade of some goods to ordinary trade. The asymmetric effect lies on that once localized, it is hard to return to outsourcing due to competition or fixed expenditures involved. If wage difference larger, it is more preferable to localized. Therefore, we can expect asymmetric effect of processing trade due to movement of relative wage difference, which was proved by econometrics on recent data by cointegrating analysis within a VECM model.

keywords: **Processing Trade, REER, Outsourcing, Cointegration**

To my grandfather

Acknowledgement

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Declaration

I hereby plege that this thesis was my independent academic work under the instruction of my supervisor. So far as I know, this thesis does not have any contents that may impair others' copyright except those cited in the text. I have given clear indication of contribution offered by other individuals and/or teams.

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Table of Contents

Abstract **I**

Acknowledgement and Declaration **II**

Table of Contents **III**

List of Tables **V**

List of Figures **VI**

List of Symbols **VII**

1 Introduction **1**

2 Literature Review **5**

3 Processing Trade in China **8**

3.1 Setup 8

3.2 Firm Behavior 10

3.2.1 Localization in China 10

3.2.2 Outsourcing in China 10

3.3 Equilibrium Choice 11

3.3.1 Fixed k 11

3.3.2 Alterable k 13

3.4 Import and Export 14

4 Empirical Evidences **15**

4.1 Data 15

4.2 Econometric Model 18

4.3 VECM Representation 20

4.4 ADF Test 21

4.5 Cointegration Analysis 21

4.6 Further on Asymmetry 26

5 Concluding Remark **27**

A Data Plot **29**

B Mathematics **35**

Bibliography **37**

List of Tables

4.1 Variables 16

4.2 Granger Causality Test for *ex* and *im* 16

4.3 ADF Unit Root Tests 22

4.4 Johansen's Test for Cointegrating Vectors 23

4.5 Additional Over-identified Restrictions Test 24

4.6 Lag Length Selection 24

4.7 Restricted Cointegrating Vectors of Processing Trade Model 24

List of Figures

3.1 Choice of Localization vs Outsourcing 12

4.1 Ratio of Processing Import to export and Real Effective Exchange Rate 18

A.1 Total Export 30
A.2 Ordinary Export 30
A.3 Processing Export 31
A.4 Total Import 31
A.5 Ordinary Import 32
A.6 Processing Import 32
A.7 Foreign Demand 33
A.8 Domestic Demand 33
A.9 Real Effective Exchange Rate 34

B.1 Phase Diagram 36

List of Symbols

ex	Total processing export
im	Total processing import
fd	Foreign demand
dd	Domestic demand
reer	Real Effective Exchange Rate
open	Proxy of integration, valued by export plus import being divided by GDP.

Chapter 1

Introduction

As a matter of fact, foreign trade is playing a key role as the growth engine in China now[1], which lets Chinese economy have the property of out-oriented. Among all types of trade, processing trade makes use of international resources and markets, importing intermediate inputs and exporting final goods, and contributes a big part of economic growth. However, what determines the amount of imported inputs in final goods? How does it vary from time to time? Economists do not pay much attention to these questions yet.

We have the following formal definitions of trade type[2].

Definition 1. *Ordinary trade or General trade refers to the import or export of goods by enterprises in China with import-export rights.*

[1]According to National Statistics of China, Total Value of Foreign Trade has increased from 20.6 billion US$ in 1978 to 1422.1 billion US$ in 2005. Yearly average increasing rate is 26.5%, much higher than GDP growth rate.

[2]Definitions come from China Custom Statistics

Definition 2. *Processing trade refers to the business activity of importing all or part of the raw and auxiliary materials, parts and components, accessories, and packaging materials from abroad in bond, and re-exporting the finished products after processing or assembly by enterprises within the mainland. It includes processing with supplied materials and processing with imported materials.*

From definitions above, we can see that processing trade is arisen by outsourcing of foreign companies. It is influenced by the relative difference in labor cost. As an economy with abundant labor, more and more firms in China are now taking part into processing trade. They receive orders abroad, importing intermediate inputs, and exporting finished products. This type of trade is booming in Southeast China by making use of the comparative advantages in labor. The main force of processing trade are those foreign invested enterprises. These firms are branches of or contracted with multinational companies. They assembly in China, with R&D or production of some high-tech inputs accomplished abroad.

However, with more and more educated engineers available now in China, the part of high-tech inputs can also be finished inside China. Some cities of Southern China can produce all the required components of computers, handphones, home appliances, etc. In these cities, cluster production have even attracted top companies like NEC, Philips, Panasonic to build R&D centers there. For example, NEC has moved all its handphone affairs, from R&D to production, to China. Microsoft build the only research institute outside U.S. in Beijing in 2001. All these facts show that except of outsourcing, more and more companies can localize in China now.

Although companies with high-tech plant in China can enjoy low wage advantage, they also suffer from the necessary training fees and operating cost occurred with unskilled engineers and workers, which we call localization cost. Therefore, they face with the trade off of whether localization or simply outsourcing. A notable effect of localization is that once they are localized, it is hard to return to outsourcing, because of competition or fixed expenditures. Therefore, even the low wage advantage disappear in some day, localization can keep their production in China.

To decide whether outsourcing or localization, one of facts worthy of consideration is the proportion of high-tech inputs and low-tech inputs. Obviously, If production involves more low-tech inputs, companies are prone to localize so that they can save more costs.

Therefore, the following story may be true. When the relative wage difference becomes larger, more goods are localized and the number of goods for outsourcing will fall. Since the remaining goods for outsourcing involve more high-tech inputs, we can expect the rise of ratio of these high-tech inputs that need import to total amount of output. After localization, if the relative wage difference becomes lower, it is hard for this ratio to decrease because of the already sunk fixed localization costs.

In mathematics, we can write

$$Processing\ import = a \times processing\ export \tag{1-1}$$

where a is the ratio of processing import to processing export. From analysis above, we know that a increases when relative wage difference becomes larger. Contrarily, a can not decrease too much.

We can summarize the direction of im, a, ex as below,

$$\begin{array}{rcccc} & \dot{im} = & \dot{a} & + & \dot{ex} \\ \text{Wage Difference smaller} & - & \underset{\text{(small)}}{-} & & - \\ \text{Wage Difference larger} & + & \underset{\text{(large)}}{+} & & + \end{array}$$

(1-2), (1-3)

This paper is divided into 5 parts. After introduction, Chapter 2 reviews related literatures. Chapter 3 builds a model to explain facts that influence processing trade in China. In chapter 4, I provide empirical evidences based on cointegrating analysis. Chapter 5 is the concluding remark of this paper.

Chapter 2

Literature Review

LITERATURES related to this paper can be divided into three classes. 1. On trade theory of outsoucing and vertical FDI; 2. On analysis of China foreign trade; 3. On Johansen's cointegrating frame. Each topic can involve thousands of works. Due to text limitation, I will give some clear directions to review them instead.

On outsourcing and vertical FDI modeling. Traditional trade models focus on 1. Constant return to scale(CRTS) technology; 2. Final goods. beyond traditional models, new models break through these two limitations. **?**, **?** developed models of trade arisen by increasing return to scale(IRTS) [1]. Papers on vertical integration and inner-industry trade can be traced to **?**. **?** gives us detailed analysis on it. Antras

[1] In **?**, new goods are produced in the industrialized North and exchanged for old goods produced in the South, with technological transfer, new goods becoming old goods, at an exogenous rate. **?** endogenized it in the frame of New Growth Theory.

[2004], following **?**, presents a model of vertical FDI vs. outsourcing, in which the incomplete nature of contracts governing international transactions limits the extent of integration across borders. Model developed in my paper is mainly based on Antras [2004] with a little variation.

On analysis of China's foreign trade. Edmonds et al. [2006] gives us a very clear overview on China's policy path and long trend statistics on the evolution of foreign trade. As to the relationship between growth and trade, Lin and Li [2002] has pointed out that the traditional methods[2] have underestimated the contribution of foreign trade in China because of an significant fact: import, especially the processing import, can arise domestic consumption, investment and export because most of processing import are intermediate inputs to industrial production. Considering this fact, Lin and Li [2002] concludes that foreign trade has an elasticity of 0.1 to economic growth each year, i. e., 10 percent increase in foreign trade leads to 1 percent growth in GDP.

However, economists have not pay much attentions to these analysis. Another related paper is DEES [2001], which estimates empirical factors that influence trade according to different trade types[3].

[2]Traditional methods, based on an accounting identity of gross domestic product,

$$Y = C + I + G + X - M$$

where Y, C, G, X and M are GDP, Consumption, Government Purchase Export and Import, calculate the contribution of foreign trade as

$$\frac{dX - dM}{dY}$$

.

[3]It deems that firms exporting products that are imported beforehand are less sensitive to relative

Most of papers on foreign trade of China focus on the relationships between trade and real effective exchange rate. Two main papers are popularly cited in this field.Zhang [1996] provides some recent econometric techniques designed to assess the relationship between exchange rate of the Chinese Renminbi (RMB) and China's trade balance[4]. Chou [2000] estimates the impact of exchange rate variability on total exports[5] But all these papers ignore that the asymmetry effect discussed in Chapter 1, which induces their estimate not perfect. Usually, papers on trade and exchange rate of China are "partially" correct: they get satisfied results in export analysis but unexpected results in import analysis or contrarily. I believe that the key lies on the asymmetric property of elasticities.

On Johansen's cointegrating frame. Johansen [1995] is the summary of it. Johansen [1992a,b, 1997, 2000a,b, 2005] provide us assistant understanding of this frame. My paper will run cointegrating analysis under it.

price changes than firms exporting goods produced with national inputs. He looked carefully at the different types of trade and to investigate separately their behaviors. Once depreciation, the processing firms should benefit from cheaper imports of foreign goods and relatively cheap labor costs in China. This type of trade should remain competitive at a worldwide level

[4]They find bidirectional causal relationship between the real exchange rate and trade but unequally. My ideas above may serve as a complement to their findings.

[5]In this paper, he studied exports of China by SITC category and made use of ARCH model to detect REER volatility. Estimation results show that exchange rate variability has a long-run negative effect on total exports, exports of manufactured goods, and exports of mineral fuels.

Chapter 3

Processing Trade in China

3.1 Setup

I follow Antras [2004] and release the production limitation of high-tech inputs in the South. Suppose that the world has two countries, China and America. Wage rate are denoted by w^{CN} and w^{US} respectively. Consumer preference can be simplified to producer of good y facing isoelastic demand function,

$$y = \lambda p^{\frac{-1}{1-\alpha}}, \quad 0 < \alpha < 1 \tag{3-1}$$

where p is the price of the good and λ is a parameter.

Production of good y requires two kinds of inputs: high-tech inputs x_h and low-tech inputs x_l,

$$y = \zeta_z x_h^{1-z} x_l^z, \quad 0 \leq z \leq 1 \tag{3-2}$$

where $\zeta_z = z^{-z}(1-z)^{-(1-z)}$.

The production of high and low-tech inputs in both countries requires one unit of labor. High-tech inputs are the key components produced by high-tech plant and low-tech inputs are labor inputs to assemble these components to final product. Suppose both countries can produce these two types of inputs. Limited to capital scarcity, China has difficulty to setup high-tech plants independently. Therefore, American will determine where to produce these two type of inputs.

If they only setup assembly line in China, no additional expenditures required. These two partners transaction by contract. Under a frame of cooperative game, they share revenues through Nash negotiation. It is outsourcing.

However, If they build R&D center in China, there will be k times marginal cost to produce one unit inputs due to unskilled workers and researchers in China. The headquarter in U.S. and plant in China share revenues according to property rights theory of **?**. It is localization.

3.2 Firm Behavior

3.2.1 Localization in China

Total revenue is

$$R = \lambda^{1-\alpha}\zeta_z^{\alpha} x_h^{\alpha(1-z)} x_l^{\alpha z} \tag{3-3}$$

The problem is

$$\max_{x_h, x_l} \pi^L = R - \lambda w^{CN} x_h - \lambda w^{CN} x_l \tag{3-4}$$

Optimal value

$$\pi^L(z) = (1-\alpha)\lambda \left(\frac{kw^{CN}}{\alpha}\right)^{\frac{-\alpha}{(1-\alpha)}} \tag{3-5}$$

3.2.2 Outsourcing in China

Suppose the R&D center and Assembly line have the same negotiation power. So each has half of the total revenue.

Problem of R&D center,

$$\max_{x_h} = \frac{1}{2}R - w^{US} x_h \tag{3-6}$$

First order condition:

$$w^{US} x_h = \frac{1}{2}\alpha(1-z)R \tag{3-7}$$

Problem of assembly line,

$$\max_{x_l} \pi^O = \frac{1}{2}R - w^{US}x_l \tag{3-8}$$

First order condition:

$$w^{CN}x_h = \frac{1}{2}\alpha z R \tag{3-9}$$

Optimal Profit:

$$\pi^O(z) = \left(1 - \frac{1}{2}\alpha\right)\lambda\left(\frac{2(w^{US})^{1-z}(w^{CN})^z}{\alpha}\right)^{\frac{-\alpha}{(1-\alpha)}} \tag{3-10}$$

3.3 Equilibrium Choice

3.3.1 Fixed k

Compare 3-5 and 3-10, we know that outsourcing dominates localization if and only if

$$A(k,z) = \left(\frac{1-\alpha}{1-\frac{1}{2}\alpha}\right)^{\frac{1-\alpha}{(1-z)\alpha}}\left(\frac{2}{k}\right)^{\frac{1}{1-z}} \leq \omega = \frac{w^{CN}}{w^{US}} \tag{3-11}$$

Given value of k, we know that $\lim_{z\to 0} A(z) =$ positive constant, $\lim_{z\to 1} A(z) = +\infty$ and $A'(z) > 0$.

Under the assumption of $0 < \omega = \frac{w^{CN}}{w^{US}} < 1$, we have the necessary condition for outsourcing to exist, $A(0) < 1$. It means that

$$k > 2\left(\frac{1-\alpha}{1-\frac{1}{2}\alpha}\right)^{\frac{1-\alpha}{(1-z)\alpha}} \tag{3-12}$$

i.e. the additional localization costs are high enough.

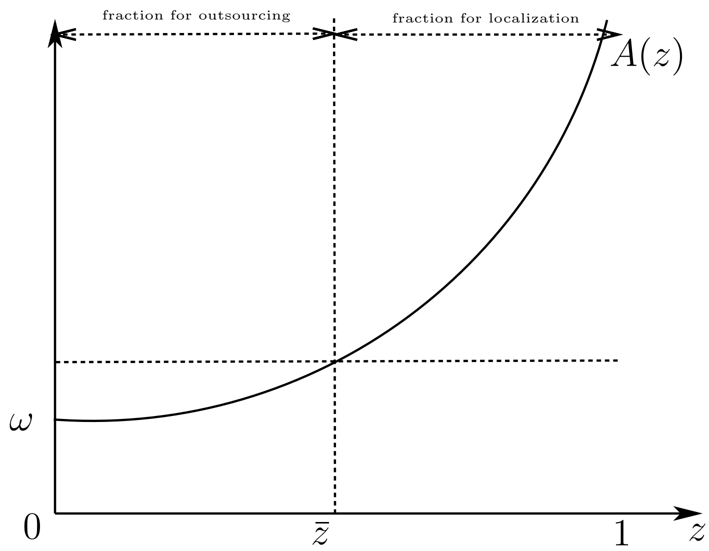

Figure 3.1: Choice of Localization vs Outsourcing

Figure 3.1 shows equilibrium choice of whether localization or not. $\bar{z}$ is the threshold z so that producer of goods involving more low-tech inputs, i.e. $z > \bar{z}$, will localize in China.

we can also see that $\bar{z}$ decreases with lower ω, the relative unit labor cost of China to America. So more producers choose localization other than outsourcing.

But suppose that localization requires fixed cost F, which should be spent in each period. When the relative wage ω increases, some producers will not return to outsourcing, because the relative gains are less than F. This is the key of asymmetry in processing trade.

3.3.2 Alterable k

It is natural to assume that k is a function of z, $k'(z) < 0$ and $\lim_{z \leftarrow 0} k(z) = constant > \lim_{z \leftarrow 1} k(z) = 1$, which means that goods involving more high-tech inputs require higher additional localization costs. So now,

$$A(z) = \left(\frac{1-\alpha}{1-\frac{1}{2}\alpha} \right)^{\frac{1-\alpha}{(1-z)\alpha}} \left(\frac{2}{k(z)} \right)^{\frac{1}{1-z}} \leq \omega = \frac{w^{CN}}{w^{US}} \tag{3-13}$$

We still have $\lim_{z \to 0} A(z) =$ positive constant, $\lim_{z \to 1} A(z) = +\infty$. As to $A'(z)$, we still have

$$A'(z) > 0 \tag{3-14}$$

Proof of Equation 3-14 is presented in Appendix B.

But now we have a flatter curve compared to that with fixed k, which means that outsourcing may not be substituted by localization when ω goes down if additional localization costs are sensitive to industrial structure. It can partly offset this effect.

3.4 Import and Export

The import/export value are given by

$$\begin{aligned} im &= \int_0^{\bar{z}} w^{US} x_h dz = \int_0^{\bar{z}} \frac{1}{2}\alpha(1-z)Rdz \\ ex &= \int_0^{\bar{z}} Rdz \end{aligned} \tag{3-15}$$

So we have

$$\begin{aligned} a &= \frac{im}{ex} \\ &= \frac{\int_0^{\bar{z}} \frac{1}{2}\alpha(1-z)Rdz}{\int_0^{\bar{z}} Rdz} \end{aligned} \tag{3-16}$$

Differentiate it to $\bar{z}$,

$$\frac{da}{d\bar{z}} = \frac{R(\bar{z}) \int_0^{\bar{z}} (z-\bar{z})R(z)dz}{(\int_0^{\bar{z}} Rdz)^2} < 0 \tag{3-17}$$

We have already know that $\frac{d\bar{z}}{d\omega} > 0$, So we have

$$\frac{da}{d\omega} < 0 \tag{3-18}$$

Considering the fixed extra cost of localization, we know that when ω goes down, a goes up. But when ω goes up, a may not go down at the same amount. This is the asymmetry in processing trade. Next chapter, I will provide some empirical evidences.

Chapter 4

Empirical Evidences

4.1 Data

FIGURES A.1-A.9 are time series plots of related variables.

1. Both processing export and import increase greatly, especially after 2001.

2. Notice that REER here is an index. It increase when appreciation and decrease when depreciation.

Reasons for I put *ex* as the domestic demand for *im* lie on the definition of processing import. Also Granger Causality Test can tell us that *ex* does Granger Cause *im*, as is shown in Table 4.2.

IFS provides the real effective exchange rate based on normalized unit labor cost, which is the best proxy of ω. But unfortunately, code line of this variable is blank. It is also hard to get monthly wage of China.

Table 4.1: Variables

Export(PT)	*ex*	source: China Custom Statistics monthly report. 1997.01-2005.10
Import(PT)	*im*	source: China Custom Statistics monthly report. 1997.01-2005.10
Foreign demand	fd	weighted foreign GDP of Hongkong, Japan, Korea, Italy, UK, German, Canada, US, Austrilia. the weight is its import from China divided by total export of China. interpolated into monthly data by quadratic sum to average.
Domestic demand	*dd*	source:Industrial Statistics of China. it is the added value of industrial production of China.
REER	*reer*	source: International Financial Statistics. code: 924..RECZF.... period average index number.
OPEN	$open$	export plus import divided by GDP.

Table 4.2: Granger Causality Test for *ex* and *im*

Null Hypothesis:	Obs	F-Statistic	Probability
im does not Granger Cause *ex*	105	0.11372	0.73664
ex does not Granger Cause *im*		20.7043	0.00002

One way to solve this problem is to assume neoclassical type of labor market and labor markets of China and Foreign move together to keep the ratio of real wage constant. So we have

$$\begin{aligned}\omega =&\frac{w^{CN}}{w^{US}}\\ =&\frac{\hat{w}^{CN}p^{CN}}{\hat{w}^{US}p^{US}}\\ =&Const.\frac{p^{CN}}{p^{US}}\end{aligned} \tag{4-1}$$

where $\hat{w}$ is real wage. Notice that the upper script US stands for the world now.

Therefore, the relative difference in labor cost can be approximately measured by the real effective exchange rate based on CPI. Figure 4.1 show that the ratio of processing import to export variates inversely to real exchange rate.

The exchange rate of RMB has suffered great pressure of appreciation because the foreign trade was booming and foreign capital flowed quickly into China in early 2000s. Theoretically, real exchange appreciation of RMB will increase prices of the export goods, while decrease that of import ones, then the volume of export will decline but that of import will ascend. However, this analysis has the assumption that all tradable goods are final consumption goods,ignoring the impact of trade types.

There are still other variables that should be controlled in the model.

Firstly, the demand effect. So we add foreign demand and domestic demand data.

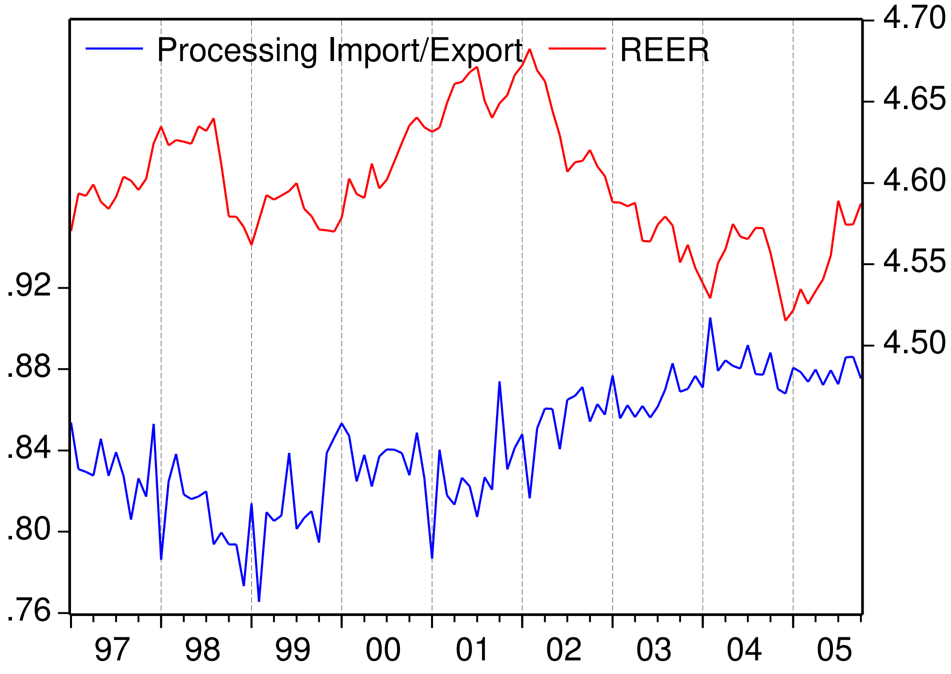

Figure 4.1: Ratio of Processing Import to export and Real Effective Exchange Rate

Secondly, we must take into account of the integration effect. In the last ten years, more and more Chinese firms involved into processing trade, which will lead to bias if we do not control it. Thus I use *open* as the proxy of integration.

4.2 Econometric Model

For processing trade, firstly, we expect that there is asymmetric effect on the elasticity of REER. So I add a dummy variable *d* into the equations, where d equals to 1 if depreciation and 0 if appreciation. *d* can stand for different elasticities. Regression equations are

$$ex_t = \gamma_{11} + (\gamma_{12} + \gamma_{13}d)reer_t + \gamma_{14}dd_t + \gamma_{15}open_t \tag{4-2a}$$

$$im_t = \gamma_{21} + (\gamma_{22} + \gamma_{23}d)reer_t + \gamma_{24}ex_t + \gamma_{25}open_t \tag{4-2b}$$

Equation (4-2) describe the processing trade systems of China. Once all the coefficients are estimated, we can subtract *im* by *ex* to get the function of *a*, the ratio of processing import to export.

As we have mentioned, *a* is decreasing in *reer* and decrease fast when depreciation of *reer*. As to the demand effect, we know that more foreign demand, market size of certain good is bigger to alleviate competition. Therefore, when ω lower, *a* will not increase as much as usual. Regarding to the integration effect, more firms involved, more competition, which will drive companies to the production of more capital intensive goods. So *a* rise.

In sum, we have the following hypotheses.

Hypothesis I: *a* decreases in *reer*.

Hypothesis II: *a* decreases more when depreciation.

Hypothesis III: *a* decreases in fd.

Hypothesis IV: *a* increases in $open$.

4.3 VECM Representation

It is more reliable to capture long-run relationship of the model by cointegrating analysis.

Let z as the vector variables to describe processing trade systems. i.e.

$$z = (ex, im, reer, dreer, fd, open)'$$

The vector autoregression for z can be written in vector error correction model format as

$$\Delta z_t = \alpha\beta' z_{t-1} + \Sigma_{j=1}^{p-1} \Gamma_j \Delta z_{t-j} + \Gamma_0 + \varepsilon_t \qquad (4\text{-}3)$$

where $\beta' z_{t-1}$ consists of $r(< n)$ cointegrating relationships.

We can impose three types of restrictions on the columns of β' to test our hypotheses stated above.

1. Just-identification restrictions to normalize coefficients.
2. Over-identification restrictions to specify demand effects of each equation respectively.
3. Additional over-identification restrictions to detect whether the dummy variable d make sense or not.

4.4 ADF Test

Since cointegration test requires a certain stochastic structure of the time series involved, the first step in the estimation procedure is to determine if the variables should be non-stationary in levels (should contain a unit root). To be able to know the order of integration of the series that make up vector z, the Augmented Dickey-Fuller test (ADF) has been used.

Table 4.3 show that all variables except *dreer* are $I(1)$ process. So we can use Johansen's framework to conduct VECM estimate.

4.5 Cointegration Analysis

We use the maximum likelihood estimation procedure explained by Johansen [1995], using the full system unrestricted vector autoregressive model. We follow a testing strategy that initially allows for the impact of a constant and deterministic trend in the restricted cointegration space. The selection of our final model is based on one lag (selected by SIC).

The test results reported in Table 4.4 suggest there may be as many as 2 cointegrating vectors on the basis of maximum likelihood and max-eigenvalue tests, although trace test suggests there are four vectors in the model. *A priori*, we expect there to be 2 cointegrating relations among all variables one for each of the endogenous variables, export and import. I will use r=2, so that cointegrating rank equals

Table 4.3: ADF Unit Root Tests

Variable[a]	Lags[b]	t-statistic	5% Critical value
		Level	
ex	2	-0.977	-3.454
im	2	-1.465	-3.454
fd	0	-1.893	-3.548
dd	2	-1.341	-3.454
reer	0	-2.082	-3.453
dreer	0	-8.623	-2.889
open	3	-0.451	-3.454
		1st difference	
ex	1	-11.55	-2.890
im	1	-11.61	-2.890
fd	0	-5.707	-2.954
dd	0	-15.42	-2.889
reer	0	-8.658	-2.889
open	0	-18.18	-2.889

[a] All variables except REER are specified with intercept and linear trend as exogenous when test in level, only intercept as exogenous when test in 1st difference. REER is specified with intercept as exogenous when test in level, none as exogenous when test in 1st difference.
[b] selected by SIC.

Table 4.4: Johansen's Test for Cointegrating Vectors

H_0	H_1	Trace	Critical Value	Max Eigenvalue	Critical Value
Processing Trade			$ex, im, reer, dreer, fd, open$		
$r=0$	$r>0$	160.7**	103.8	67.01**	40.96
$r\leq 1$	$r>1$	93.68**	76.97	35.18**	34.86
$r\leq 2$	$r>2$	58.50**	54.08	23.13	28.59
$r\leq 3$	$r>3$	35.38**	35.19	21.05	22.30
$r\leq 4$	$r>4$	14.33	20.26	9.023	15.89
$r\leq 5$	$r>5$	5.304	9.165	5.304	9.165

[a] All tests are specified as intercept (no trend) in CE and VAR with 1 lag, selected by SIC.
[b] ** indicate 95% significant level.

to the number of endogenous variables.

Now we can impose restrictions on β matrix according to the discussion above. The long-run equations of the model are over-identified using the following restrictions:

$$\begin{bmatrix} \beta_{11}=1* & \beta_{12}=0* & \\ & \beta_{22}=1* & \beta_{25}=0 \end{bmatrix}$$

The just-identified restrictions are indicated by *.

First of all, we should test additional over-identified restrictions, as is shown in Table 4.5.

Therefore, we accept the additional over-identified restriction of $\beta_{24}=0$. i.e.

Table 4.5: Additional Over-identified Restrictions Test

none	restriction not binding	
$\beta_{14} = 0$	$\chi^2(1) = 5.970$	$p - value = 0.015$
$\beta_{24} = 0$	$\chi^2(1) = 0.324$	$p - value = 0.569$
$\beta_{14} = 0, \beta_{24} = 0$	$\chi^2(2) = 40.77$	$p - value = 0.000$

given that processing import is normal, asymmetry is more likely to happen in processing export.

Secondly, we need to set the lag length by SIC. Table 4.6 suggests 1 period lag.

Table 4.6: Lag Length Selection

Lag	0	1	2	3
SIC	-20.04	-20.04	-18.90	-17.98

Results of cointegrating relationships are reported in Table 4.7.

Table 4.7: Restricted Cointegrating Vectors of Processing Trade Model

	ex	im	$reer$	$dreer$	fd	$open$	$Constant$
Normalized β vectors							
CointEq1	1.000	0.000	1.891	0.224	-0.073	-2.819	-9.955
			(1.038)	(0.026)	(0.078)	(0.269)	
			[1.822]	[8.749]	[-0.939]	[-10.48]	
CointEq2	0.885	1.000	2.009	0.302	0.000	-5.695	-11.69
	(0.143)		(1.461)	(0.036)		(0.617)	
	[6.207]		[1.375]	[8.418]		[-9.238]	

[a] $\log L = 1185$, SIC=-20.04.
[b] standard errors in the parentheses and t-statistics in the brackets.

The first comment from Table 4.7 confirms the main intuition and Hypotheses I and II.

1. Real exchange rate movements have negative influences on both export(elasticity equal to 1.89) and import(elasticity equal to 2.01).

2. The impact of world demand is not significant, albeit the correct direction. As a control variable, I will keep it left here.

3. The effect of integration is significantly positive. Moreover, integration has a double times effect on import than on export. This may be caused by the competition among firms. If more and more firms enter market, competition will drive some of them to do outsourcing of goods with more high-tech inputs, to avoid competition. Thus integration will cause more import of high-tech inputs.

Secondly, there is significant effect of asymmetry in both export and import: coefficient on dummy variable is about 0.22 and 0.30. So depreciation can have additional influence than appreciation. It can stimulate processing trade in China greatly.

4.6 Further on Asymmetry

Cointegration analysis implies the following relationships.

$$ex = -(1.89 + 0.22d)reer + 0.07fd + 2.82open + 9.96 \tag{4-4a}$$

$$im = -(2.01 + 0.30d)reer + 0.88ex + 5.70open + 11.69 \tag{4-4b}$$

Therefore, solve from equations (4-4a) and (4-4b), we have

$$\log a = im - ex = -(1.78 + 0.27d)reer - 0.008fd + 5.36open + 10.49 \tag{4-5}$$

as claimed before, a is the ratio of processing import to export. Equation (4-5) confirms our Hypotheses III and IV.

Now we have proved equation (3-18) by empirical work.

Chapter 5

Concluding Remark

THIS paper studies one of the important features in processing trade in China. I build a model to illustrate the relationship between the ratio of processing import to export and relative wage difference. Empirical work by cointegrating analysis provide us evidences and confirm what I state in Chapter1.

The main conclusion of this paper is that the ratio of processing import to export is influenced by relative wage difference-the industry effect and competition effect. The results of the present study claim to look carefully at processing trade, where China is now in the transition from low add-value industries to high add-value industries. The paper also gives some elements to understand why multinational companies take localization strategy in China. Finally, according to predictions concerning the change in the Chinese competitiveness resulting from the entry into WTO, we can expect processing trade will boom continuously because it faces up with much larger markets and more resources. The processing firms should benefit from cheaper imports of foreign goods and relatively cheap labor costs in China. This type of trade should remain competitive at a worldwide level.

Appendix A

Data Plot

Data plots in this appendix have the same unit:

vertical axis: Billion US$.

horizontal axis: Year 1997-2005.

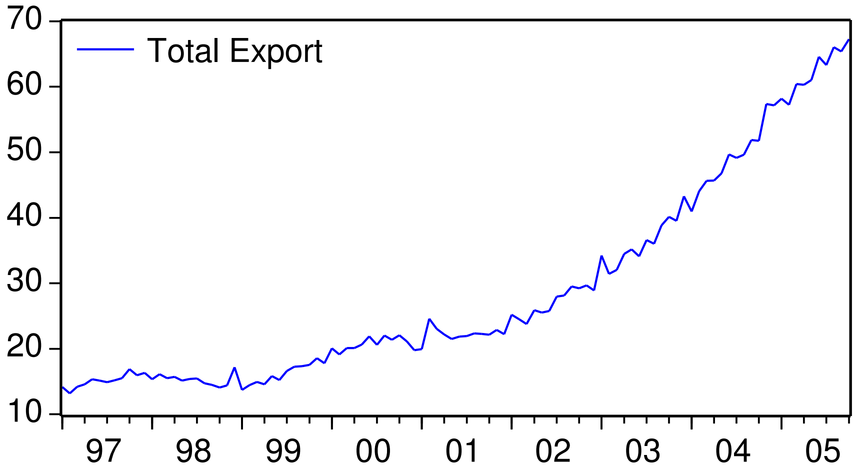

Figure A.1: Total Export

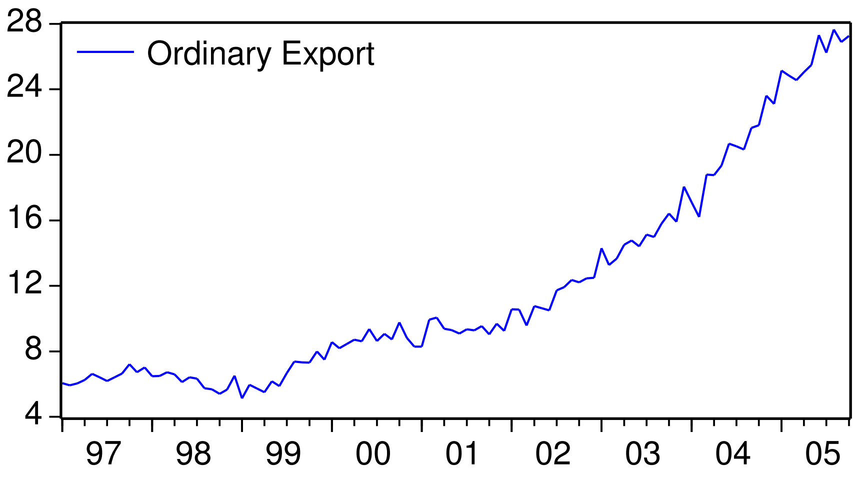

Figure A.2: Ordinary Export

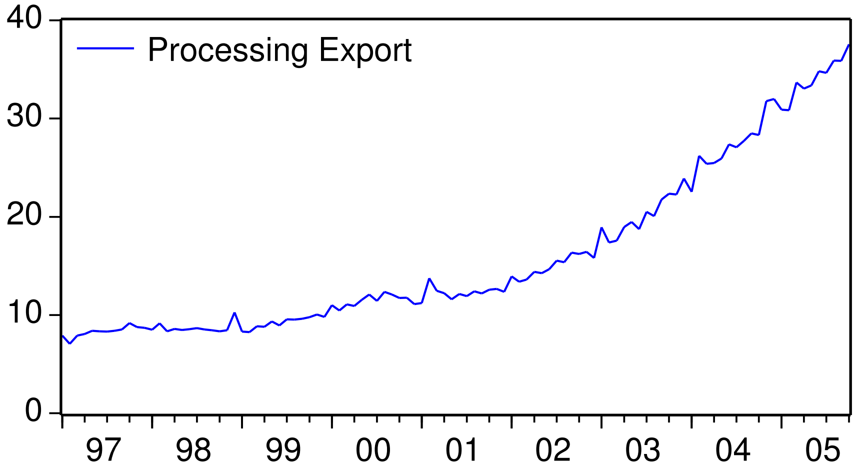

Figure A.3: Processing Export

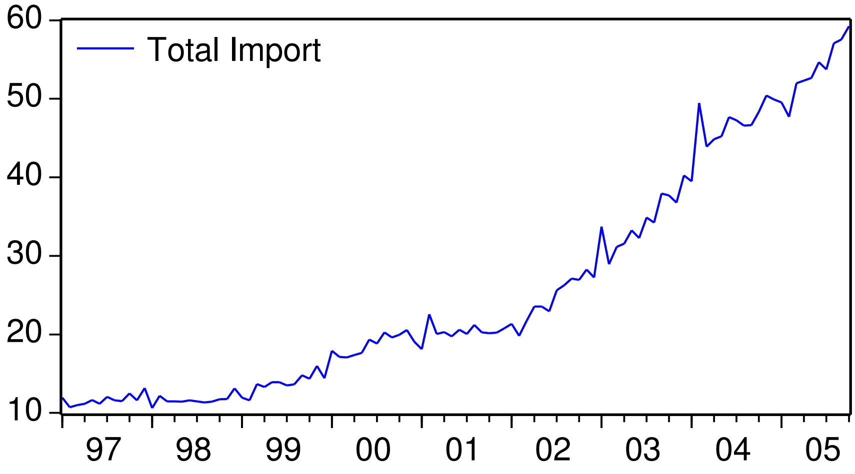

Figure A.4: Total Import

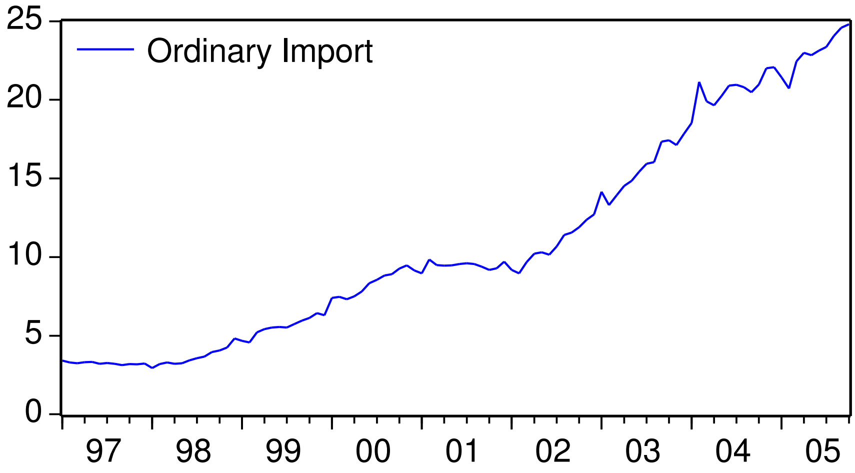

Figure A.5: Ordinary Import

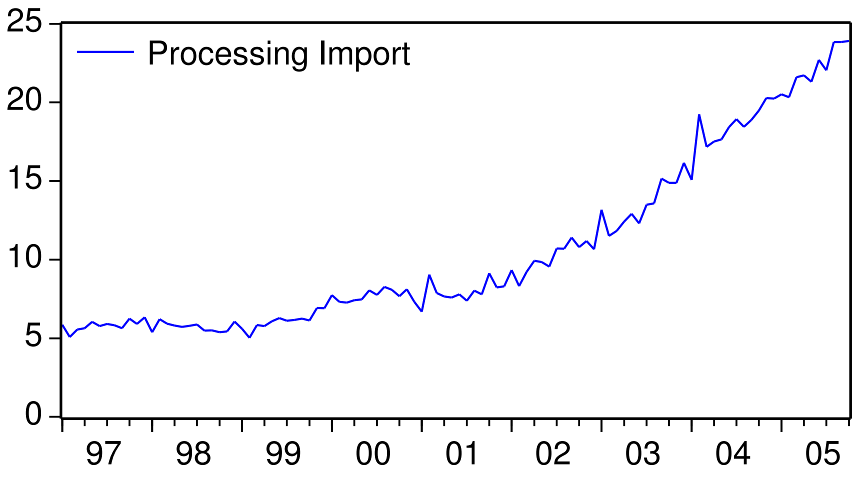

Figure A.6: Processing Import

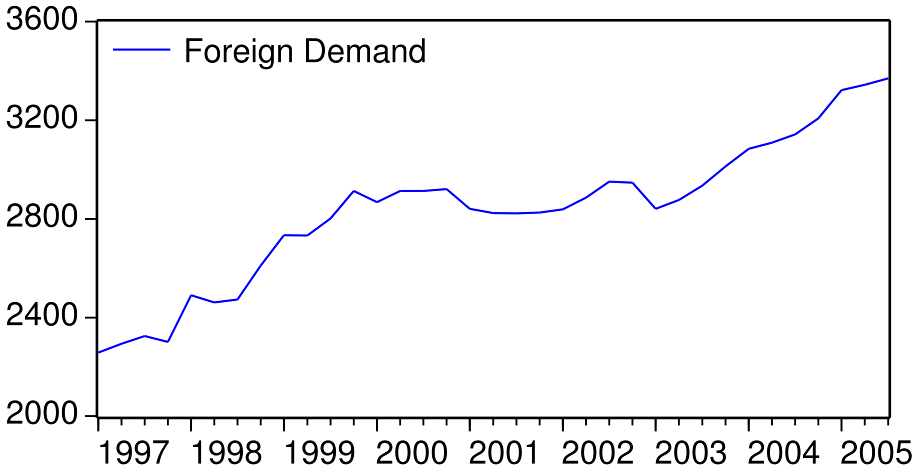

Figure A.7: Foreign Demand

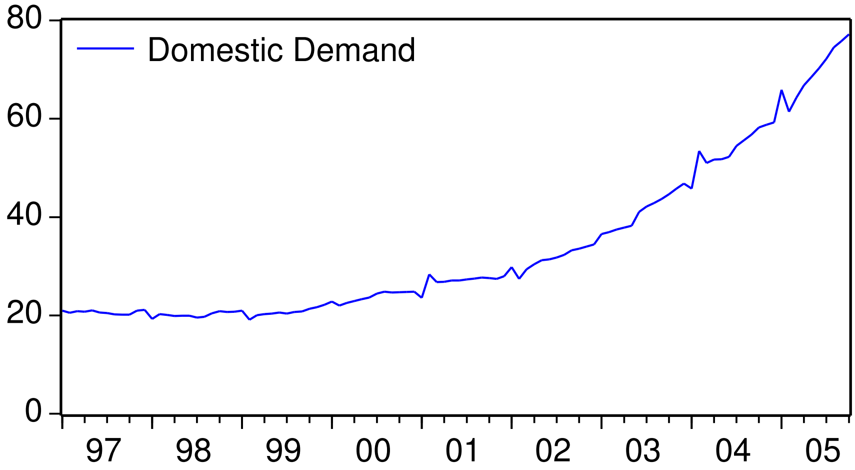

Figure A.8: Domestic Demand

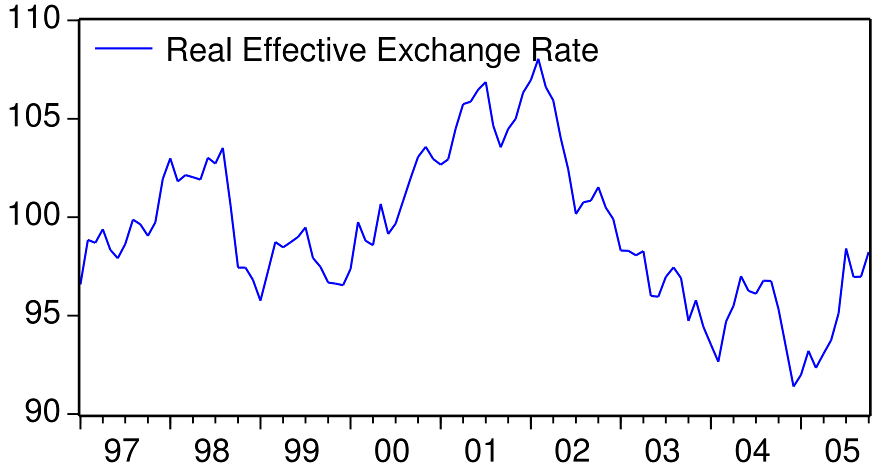

Figure A.9: Real Effective Exchange Rate

Appendix B

Mathematics

Theorem 3. $A'(z) > 0$

Proof. On $A'(z)$, firstly, we take the logarithm of $A(z)$.

$$\log A(z) = \frac{1-\alpha}{\alpha(1-z)} \log \frac{1-\alpha}{1-\frac{1}{2}\alpha} - \frac{1}{1-z} log \frac{k(z)}{2} \tag{2-1}$$

Differentiate both side on z, $\Rightarrow$

$$\frac{\partial \log A(z)}{\partial z} = -(1-z)^{-2} \left((1-z) \frac{\partial \log k}{\partial z} + \log k - \frac{1-\alpha}{\alpha} \log \frac{1-\alpha}{1-\frac{1}{2}\alpha} \right) \tag{2-2}$$

So we still have $A'(z) > 0$ if and only if

$$(1-z) \frac{\partial \log k}{\partial z} + \log k - \frac{1-\alpha}{\alpha} \log \frac{1-\alpha}{1-\frac{1}{2}\alpha} > 0 \tag{2-3}$$

This is an ordinary differential equation, which has an eigenvalue equal to $-\frac{1}{1-z}$. Given $z \in [0,1]$, the eigenvalue is negative. Therefore, the ODE is globally stable, which has a phase diagram as Figure B.1

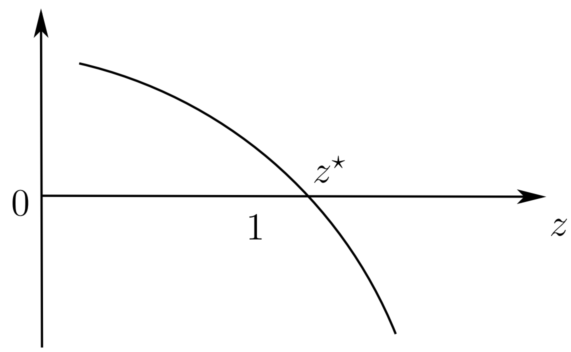

Figure B.1: Phase Diagram

So the only thing we need to do is to prove $z^\star > 1$.

Consider the ODE 2-3 at point $z = 1$. We have the reduced form of ODE as

$$\begin{aligned}
&\log k(1) - \frac{1-\alpha}{\alpha}\log\frac{1-\alpha}{1-\frac{1}{2}\alpha} \\
&= 0 - \frac{1-\alpha}{\alpha}\log\frac{1-\alpha}{1-\frac{1}{2}\alpha} \\
&= -\frac{1-\alpha}{\alpha}\log\frac{1-\alpha}{1-\frac{1}{2}\alpha} \\
&> 0
\end{aligned} \tag{2-4}$$

□

Bibliography

Antras, P. (2004), “Incomplete Contracts and the Product Cycle,” *Econometric Society 2004 North American Summer Meetings 62*, Econometric Society, available at http://ideas.repec.org/p/ecm/nasm04/62.html. 2, 3.1

Chinn, M. D. (2005), “A Primer on Real Effective Exchange Rates: Determinants, Overvaluation, Trade Flows and Competitive Devaluation,” *NBER Working Paper 11521*, National Bureau of Economic Research.

Chou, W. L. (2000), “Exchange Rate Variability and China’s Exports,” *Journal of Comparative Economics*, *28*, 61–79. 2

DEES, S. (2001), “The Real Exchange Rate and Types of Trade: Heterogeneity of Trade Behaviours in China,” *Tech. rep.*, Centre dEtudes Prospectives et dInformations Internationales, Paris. 2

Edmonds, C., S. J. L. Croix, , and Y. Li (2006), “China’s Rise as an International Trading Power,” *East-West Center Working Paper 88*, East-West Center. 2

Engle, R. F. and C. W. J. Granger (1987), "Co-integration and Error Correction: Representation, Estimation, and Testing," *Econometrica*, *55*(2), 251–76, available at http://ideas.repec.org/a/ecm/emetrp/v55y1987i2p251-76.html.

Engle, R. F., D. F. Hendry, and J.-F. Richard (1983), "Exogeneity," *Econometrica*, *51*(2), 277–304, available at http://ideas.repec.org/a/ecm/emetrp/v51y1983i2p277-304.html.

Engle, R. F. and A. J. Patton (2004), "Impacts of trades in an error-correction model of quote prices," *Journal of Financial Markets*, *7*(1), 1–25, available at http://ideas.repec.org/a/eee/finmar/v7y2004i1p1-25.html.

Engsted, T. and S. Johansen (1997), "Granger's Representation Theorem and Multicointegration," *Economics Working Papers eco97/15*, European University Institute, available at http://ideas.repec.org/p/eui/euiwps/eco97-15.html.

Greene, W. H. (1993), *Econometric Analysis*, New Jersey:Prentice-Hall, Inc.

Hamilton, J. D. (1994), *Time Series Analysis*, Princeton University Press.

Johansen, S. (1992a), "Determination of Cointegration Rank in the Presence of a Linear Trend," *Oxford Bulletin of Economics and Statistics*, *54*(3), 383–97, available at http://ideas.repec.org/a/bla/obuest/v54y1992i3p383-97.html. 2

—— (1992b), "Testing weak exogeneity and the order of cointegration in UK money demand data," *Journal of Policy Modeling*, *14*(3), 313–334, available at http://ideas.repec.org/a/eee/jpolmo/v14y1992i3p313-334.html. 2

—— (1995), *Likelihood-based inference in cointegrated vector autoregressive models*, Advanced texts in econometrics, New York : Oxford University Press. 2, 4.5

—— (1997), "Mathematical and Statistical Modelling of Cointegration," *Economics Working Papers eco97/14*, European University Institute, available at http://ideas.repec.org/p/eui/euiwps/eco97-14.html. 2

—— (2000a), "A Bartlett Correction Factor for Tests on the Cointegrating Relations," *Econometric Theory*, *16*(5), 740–78, available at http://ideas.repec.org/a/cup/etheor/v16y2000i5p740-78.html. 2

—— (2000b), "Modelling of cointegration in the vector autoregressive model," *Economic Modelling*, *17*(3), 359–373, available at http://ideas.repec.org/a/eee/ecmode/v17y2000i3p359-373.html. 2

—— (2005), "Interpretation of Cointegrating Coefficients in the Cointegrated Vector Autoregressive Model," *Oxford Bulletin of Economics and Statistics*, *67*(1), 93–104, available at http://ideas.repec.org/a/bla/obuest/v67y2005i1p93-104.html. 2

Johansen, S. and A. R. Swensen (1999), "Testing exact rational expectations in cointegrated vector autoregressive models," *Journal of Econometrics*, *93*(1), 73–91, available at http://ideas.repec.org/a/eee/econom/v93y1999i1p73-91.html.

—— (2004), "More on testing exact rational expectations in cointegrated vector autoregressive models: Restricted constant and linear term," *Econometrics Journal*, *7*(2), 389–397, available at http://ideas.repec.org/a/ect/emjrnl/v7y2004i2p389-397.html.

Lin, J. Y. and Y. Li (2002), "Export and Economic Growth: Demand Approach," *CCER Working Paper No.C2002008*, China Center for Economic Research. 2

Mackinnon, J. G., H. White, and R. Davidson (1983), "Tests for Model Specification in the Presence of Alternative Hypotheses: Some Further Results," *Journal of Econometrics*, *21*(1), 53–70.

Zhang, Z. (1996), "The Exchange Value of the Renminbi and China's Balance of Trade: An Empirical Study," *NBER Working Papers 5771*, National Bureau of Economic Research, Inc, available at http://ideas.repec.org/p/nbr/nberwo/5771.html. 2