International Business Cycles with Nontradable Goods

by

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This is to certify that I have examined this copy of a master's thesis by

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and have found that it is complete and satisfactory in all respects,
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To my parents

ABSTRACT

This paper examines the international transmission of business cycles in a two-country model with nontradable goods. The model is parameterized, calibrated, and simulated to explore its ability to rationalize characteristics of observed business cycles. The predictions of this model are compared to those of others under different financial structures. The findings are interpreted as evidence that the structure of international trade of goods and assets are interdependent, and therefore an endogenous approach in both dimensions is necessary when analyzing the transmission of macroeconomic fluctuations and financial integration.

Keywords: International business cycles, Transmission of macroeconomics fluctuations, Incomplete markets

ÖZET

Bu makale konjonktürel dalgalanmaların uluslar arası geçişini, uluslar arası ticarete konu olmayan malları da içerecek şekilde 2 ülkeli bir modelle açıklamaya çalışmaktadır. Bu modelin konjonktürel dalgaların mantığını rasyonalize etmedeki başarısını görmek amacıyla, verilerden elde edilen parametreler aracılığıyla model simüle edilmektedir. Sonuçlar, uluslar arası mal ve aktif ticareti yapısının birbirine bağımlı olduğuna işaret olarak yorumlanmıştır. Buna göre, finansal bütünleşmeyi ve makroekonomik dalgalanmaların geçişini analiz ederken, gerek mal gerekse aktiflerin uluslararası ticaretindeki yapıyı içselleştiren bir yaklaşımın gerekliliği vurgulanmaktadır.

Anahtar Kelimeler: Uluslar arası konjonktürel dalgalanmalar, makroekonomik dalgalanmaların geçişi, eksik piyasalar.

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Chapter 1

INTRODUCTION

The very basic idea of closed-economy business cycle literature was to understand economic fluctuations by imitating the real world. To do so, theoretical models have been constructed and their simulated results are compared with the data properties derived from real world. This literature has accounted for many of the features of observed business cycles. In their pioneering work, Backus, Kehoe and Kydland (henceforth BKK)[2] applied the same methodology to open economies. The main question was whether their two-country model could account for both the comovements studied in closed-economy models and international comovements, including correlations of macroeconomic aggregates across countries and movements in the balance of trade. Unlike closed-economy models, now the second country's technology process, international trade and the ability to borrow and lend internationally were important factors. Moreover, each was both a possible source of fluctuation and a new tool for international risk sharing. With this inspiring step, a brand new literature emerged, international real business cycles.

Since BKK[2] many have attempted to adopt the two-country version of dynamic general equilibrium models to explain the properties of international real business cycles(IRBC). Though some stylized facts could be produced by this line of research, some properties of IRBC have been difficult to generate in models. In another paper, BKK[3] name two of these properties as the "quantity anomaly" and the "price anomaly." The price anomaly refers to very high volatility of the terms of trade in the data compared to the predictions of the model. In BKK[3], they calculate cross-correlations between US aggregates and their counterparts in nine other developed countries. They point that the cross-country correlations of output are generally higher than the correlations of productivity measured by the Solow residual and the cross-correlations of productivity are higher than that of consumption.

$\rho_{y,y^*} > \rho_{z,z^*} > \rho_{c,c^*}$

They also find that the cross-correlations of output, investment and employment are generally positive. However, the model they developed suggested the reverse ordering;

$\rho_{y,y^*} \leq \rho_{z,z^*} \leq \rho_{c,c^*}$

and negative cross-correlations of investment and employment. They called these features as the "quantity anomaly."

Ambler et al.[1] extend the BKK[3] sample to twenty industrialized country with a more recent data. They calculate all pairwise cross-country correlations. Concerning the order of correlations, their findings confirm the quantity anomaly though with lower magnitudes. They also find that cross-country correlations of investment, output and employment are positive rather than negative as suggested in the baseline model. Their predictions of the frictionless baseline model with complete markets are not surprising because its structure creates incentive to invest in the more productive country which leads to negative cross-country correlations of output, investment and employment. Risk sharing agents, on the other hand, give rise to high cross-country consumption correlation.

Not observing that much consumption correlation in the data, many scholars attribute it to the limited risk sharing capability of agents. In line with these, Kollmann[11] and Baxter and Crucini[4] build models with incomplete asset markets which limit risk sharing. These authors find that incomplete markets help to reduce cross-country correlation of consumption, but the cross-country correlation of output, investment, and hours worked remain countercyclically negative.

With a similiar motivation, Devereux et al.[8] develop a model with a particular type of nonseparability between consumption and leisure. They succeed in lowering the cross-country correlation of consumption predicted by the BKK[2] model.

Though with stringent assumptions, there are models yielding plausibe ordering of correlations. In particular, Ricketts and McCurdy[12] build a two-country model with money and different rates of trend productivity growth rates across countries. In the version of their model in which there is no international trade in investment goods, they obtain a relative ordering of the cross-country correlations that is compatible with the data used by BKK[3].

Stockman and Tesar[13] introduce nontraded goods sector in each country, and succeed in lowering the cross-country correlation of consumption while raising the cross-country correlation of output. Also the quantity anomaly remains for the traded goods sector.

Another exemption from trade is introduced by Canova and Ubide[6]. They develop a two-country model with home production. Their model can generate cross-country correlation of output similar to those of consumption and positive cross-country correlation of investment and employment.

Baxter and Farr[5] build a two-country international business cycles model with variable factor utilization which lets producers to vary the utilization rate of capital. The model succeeds in producing the positive correlation in cross-country wages, hours, and investment. Further, variable capital utilization reduces the required size of productivity shock which is necessary to replicate the output relativity in the data.

Until Heathcote and Perri[9], most of the papers in the IRBC literature has had an assumption about the trade structure(i.e. each country's export and import goods are given) and about the international financial structure(i.e. there is single bond market or markets are complete). For spill-over effect of technology shocks, usually there is a transition matrix estimated from the data, and this estimation depends on the structure of the model. Then simulation results are compared with the data. However, we can never learn the contribution of the trade structure and the contribution of the financial structure seperately in the success of the model yielding similar results with some data properties.

Heathcote and Perri, on the other hand, compares their model with data under different financial markets. Therefore they are able to acknowledge, under the given trade structure, which financial structure is to closest to the real world. Their main finding is that the financial autarky model is closest to the data along most dimensions.

In their seminal paper, Heathcote and Perri provide us both a motivation and a question. The motivation would be to compare the implications of different financial structures. The question would be whether their findings result from ignoring the tradable and nontradable composition of agents' consumption bundle. In their model, there is an internationally traded intermediate good and a nontradable consumption good. Therefore, there is no trade for consumption goods and there is a clear distinction between consumption good and intermediate good.

However, we choose to adapt Stockman and Tesar[13]'s structure where there are tradable and nontradable sectors, and two sectors' products are both consumption and investment goods. Our choice emanates from that Stockman and Tesar's 2-sector model has a considerable recognition in the literature and we believe that the interdependence between tradable and nontradable good consumption is important in terms of cross country correlations and volatility of terms of trade.

We owe our approach to Heathcote and Perri[9] and our structure to Stockman and Tesar[13]. Stockman and Tesar solve their model under the assumption of complete markets. Our aim is to fill the gap in the literature by solving a model with nontradable goods under the financial autarky and under bond economy. We compare our results with those of Stockman and Tesar's with reference to Heathcote and Perri's conclusions.

The remainder of this thesis is organized as follows. In chapter 2, some empirical findings are stated. In chapter 3, "the model economies" are described. Chapter 4 is dedicated to the discussion of the calibration method and parametrization. In chapter 5, the results are presented and lastly chapter 6 has the concluding remarks.

Chapter 2

EMPIRICAL REGULARITIES

There have been several papers which have attempted to clarify the empirical regularities both among countries and within countries. BKK[3] and Ambler et al.[1] are the two major ones. However we will rely on Stockman and Tesar[13] since theirs is the only one that distinguishes between tradable and nontradable sectors. We will also refer to Heathcote and Perri[9]'s results while comparing the models across different financial structures. Table 2.1 compares the reports of Ambler et al.[1] and BKK[3]. Note that the time periods of the third and the forth columns are almost the same albeit huge discrepancy in quantities. On the other hand we still observe the 'quantity anomaly'. We should also admit that the findings of different papers are not comparable in one-to-one manner. This is not due to the different time periods but it is because different models have different approaches.

Average cross-correlations					
	Averages from 190 cross-correlations[1]			from BKK[3]	
Variable	1960-2004	1973-2000	1973-1990	1970-1990	Baseline model
Output	0.22	0.28	0.30	0.66	-0.21
Consumption	0.14	0.15	0.14	0.51	0.88
Investment	0.18	0.22	0.22	0.53	-0.31

Table 2.1: Average cross-correlations

BKK[3] compares the US and the European Union for calibration and parameter values. Heathcote and Perri criticize this on the grounds that the bilateral trade between the US and the European Union is very small as a fraction of US GDP. Due to this small fraction, trade balance and international relative prices do not have strong effects on the macroeconomic dynamics. Therefore they choose to compare the US to the rest of the world. They keep the functional forms and parameter values of BKK[3].

Ambler et al. and Stockman and Tesar rather look at the pairwise cross-country correlations of the countries in their samples, then focus on the averages of those correlations. Ambler et al. extend the BKK sample to consider twenty industrialized countries and consider all pairwise cross-country correlations. With 190 cross-country correlations, they search for common features of international business cycle comovements.

Stockman and Tesar's work is the only one that distinguishes between tradable and nontradable sectors. They use the annual data for seven large industrial countries: Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States, and like Ambler et al. they concentrate on the means of correlations. Their distinction between traded and nontraded sector is crucial. With that aim, they include agriculture, manufacturing, mining, retail, and transportation in the traded-good sector while they include electricity, gas, and water, construction, finance, insurance and real estate, and private and government services in the nontraded-good sector. Their data set spans the years between 1970-1986. For more recent findings we will be referring to aforementioned papers whenever convenient.

Table 2.2 summarizes the empirical findings of above mentioned papers for the 'quantity anomaly'. In the table we observe the presence of the 'quantity anomaly' across different papers. In each column of the table, cross-country correlation of output is higher than that of consumption. Therefore we believe that we have well established facts in regards with the cross-country correlations of output and consumption.

Table 2.3 presents the observed terms of trade volatilities from different papers. In the last column, the prediction of baseline model from BKK[3] is presented. The 'price anomaly' is appearant, and the model yields much less volatile terms of trade.

Cross-correlations from different papers				
	BKK[3]	Ambler et al.[1]	H & P[9]	S&T[13]
Variable	1970-1990	1960-2004	1973-2004	1970-1986
Output	0.66	0.22	0.58	0.64
Consumption	0.51	0.14	0.36	0.53
Investment	0.53	0.18	0.30	-

Table 2.2: Empirics for *Quantity Anomaly*

Terms of trade volatilities					
	BKK[3]	Ambler et al.[1]	H & P[9]	S&T[13]	
Variable	1970-1990	1960-2004	1973-2004	1970-1986	Baseline model
TOT	3.68	-	2.99	5.66	0.48

Table 2.3: Empirics for *Price Anomaly*

Chapter 3

A TWO-SECTOR, TWO-COUNTRY MODEL

The world is composed of two countries, country 1 as home country and country 2 as foreign country. Each country is populated by the identical infinitely lived households. Each country has two production sectors, tradable good sector and nontradable good sector. Capital is mobile.

For notational convenience, we will use asterisk ($*$) to denote foreign country interchangebly with the superscript *2*(i.e. both y_1^* and y_1^2 represent the output of the first sector in foreign country).

3.1 Sector One : Tradable Good Sector

The tradable good sector is assumed to be perfectly competitive and each country specializes in the production of one tradable good. Home country, as country 1, produces the first tradable good while the foreign country producing the second tradable good. Households own the entire stock of capital. They also run the firm and own the whole output. There exist spot markets for these tradable goods, where households purchase the goods at a price P_t^i from the i^{th} country. Households keep some of the output for their own consumption and sell some to the other country. They also decide how much to invest.

Each sector in both countries use *its own output* as investment good. Therefore households cannot import investment good, they can only import for consumption.

Production function for the tradable good sector is in the form of Cobb-Douglas, given by:

$$F^i(\theta_{1t}^i, K_{1t}^i) = \theta_{1t}^i (K_{1t}^i)^\alpha, \quad \text{for i=1,2}$$

where i denotes the country, K_{1t}^i is the stock of the first capital of the i^{th} country.

The law of motion for the first capital is given by:

$$K^i_{1t+1} = (1-\delta)K^i_{1t} + I^i_{1t},$$

and the resource constraint arising from the tradable good sector is:

$$\text{for home country,} \quad c_{1t} + c^*_{1t} + I_{1t} = F(\theta^1_{1t}, K^1_{1t})$$

$$\text{for foreign country,} \; c^*_{2t} + c_{2t} + I^*_{1t} + = F^*(\theta^2_{1t}, K^2_{1t})$$

where c_{1t} denotes the domestic consumption of the first tradable good which is produced in the home country and c^*_{1t} denotes the consumption of first tradable good by the foreign country, in other words it denotes the export to foreign country. I_{1t} denotes the amount of home tradable good investment into the home tradable good sector. Similarly, c^*_{2t} denotes the foreign country's consumption of second tradable good which is produced by the foreign country, and thus c_{2t} referes to export of second tradable good to home country.

Table 3.1 summarizes the production and consumption structure of tradable good sector. Each cell is uniquely identified by the producing country and consuming country.

		Consumption	
		Home	Foreign
Production	Home	c_1	c^*_1
	Foreign	c_2	c^*_2

Table 3.1: Structure of Tradable Good Sector

3.2 Sector Two : Nontradable Good Sector

In the second sector, a nontradable consumption good is produced, which is purchased by households in the spot market at a price of S^i_t. However, this good is also used as an investment good. Therefore the output of the nontradable good sector must be used domestically, either as a consumption good or as an investment good.

The production function of the second sector is given by:

$$G^i(\theta^i_{2t}, K^i_{2t}) = \theta^i_{2t}(K^i_{2t})^\gamma \quad \text{for i=1,2}$$

where i denotes the country, K^i_{2t} is the stock of the capital in the non-tradable sector of the i^{th} country, θ^i_{2t} is an exogenous technology shock to that sector in the i^{th} country.

The law of motion for the capital is given by:

$$K^i_{2t+1} = (1-\delta)K^i_{2t} + I^i_{2t} \tag{3.1}$$

The disturbances to technology are assumed to follow an AR(1) process:

$$\theta_{t+1} = \Omega\theta_t + \varepsilon_t \tag{3.2}$$

where θ_t is the vector $[\theta^1_{1t}, \theta^2_{1t}, \theta^1_{2t}, \theta^2_{2t}]$ and Ω is a 4x4 matrix describing the autoregressive part of the disturbance. The innovation to θ_t is $[\varepsilon^1_{1t}, \varepsilon^2_{1t}, \varepsilon^1_{2t}, \varepsilon^2_{2t}]$. The covariances between the elements of ε reflect the extent to which the shocks are common to industries or countries or are global in nature.

3.3 Households under Different Economies

In this section, we analyze the behavior of households when financial markets have different characteristics. Under all different types of economies, households maximize expected lifetime utility derived from consumption of domestically produced tradable good(c_1), imported tradable consumption good (c_2) and domestic nontradable good:

$$\max E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(c^i_{1t}, c^i_{2t}, x^i_t) \right\}, \quad 0 < \beta < 1, \tag{3.3}$$

and the utility function is :

$$U(c_{1t}, c_{2t}, x_t, l_t) = \frac{1}{1-\sigma}\left\{ \left[(c^\theta_{1t} c^{1-\theta}_{2t})^{-\mu} + x_t^{-\mu} \right]^{-\frac{1}{\mu}} \right\}^{1-\sigma}$$

where c_{1t} and c_{2t} denote the consumption of tradable goods 1 and 2 respectively, and x_t is the consumption of nontradable good. $\frac{1}{1+\mu}$ is the elasticity of substitution between traded and nontraded goods, $\frac{1}{\sigma}$ is the intertemporal elasticity of substitution.

Households choose a sequence of $\{c^i_{1t}, c^i_{2t}, x^i_t, K^i_{1t+1}, K^i_{2t+1}\}$ under financial autarky, $\{c^i_{1t}, c^i_{2t}, x^i_t, K^i_{1t+1}, K^i_{2t+1}, b^i_{t+1}\}$ under bond economy, $\{c^i_{1t}, c^i_{2t}, x^i_t, K^i_{1t+1}, K^i_{2t+1}, b^i_{t+1}(\theta_{t+1})\}$ under complete markets, where c_{1t} and c_{2t} denote the consumption of tradable goods, respectively, x_t is the consumption of domestic non-tradable good, b_{t+1} are holdings of risk-free bond during the period $t+1$. $b^i_{t+1}(\theta_{t+1})$ denotes holdings of internationally traded state-contingent bond during the period $t+1$. Notice that the maximization problem of households differs only in their budget constraints that they maximize the same objective function in all cases. For simplicity, we assume P^1_t=1.

Households under Financial Autarky

Analysis begins with the simplest possible kind of economy, namely financial autarky, where there are no international financial assets to be traded. Under the assumption that there are no *international* financial markets, the representative household's budget constraint is given by:

$$c^i_{1t} + P^2_t c^i_{2t} + S^i_t x^i_t + K^i_{1t+1} + S_t K^i_{2t+1} \leq \theta^i_{1t} K^{\alpha}_{1t} + S_t \theta^i_{2t} K^{\gamma}_{2t} + (1-\delta)(K^i_{1t} + S_t K^i_{2t}) \quad (3.4)$$

Households under Bond Economy

In this economy, a non-contingent (or risk-free) bond is traded in international financial markets, to which both of the countries have access. Let b^i_t denote the quantity of bonds held by households in the i^{th} country and p^b_t, the price of bonds purchased at time t. The bond pays one sure unit of tradable good 1 (of the home country) irrespective of the state in $t+1$. [1] Remember that we had fixed the price of that good to 1. The budget constraint for the representative household is given by:

$$\text{for i=1,} \quad c^1_{1t} + P^2_t c^i_{2t} + S^1_t x^1_t + K^1_{1t+1} + S^1_t K^1_{2t+1} + p^b_t b^2_{t+1} \leq$$
$$\theta^1_{1t} K^{\alpha}_{1t} + S_t \theta^1_{2t} K^{\gamma}_{2t} + (1-\delta)(K^1_{1t} + S_t K^1_{2t}) + b^1_t$$

[1] The price and payment of the bond are denominated in units of country 1's tradable good. Equilibrium allocations would not change if they were assumed to be denominated in country 2's tradable good.

$$\text{for i=2,} \quad c_{1t}^2 + P_t^2 c_{2t}^2 + S_t^2 x_t^2 + P_t^2 K_{1t+1}^2 + S_t^2 K_{2t+1}^2 + p_t^b b_{t+1}^2 \leq$$
$$\theta_{1t}^2 K_{1t}^\alpha + S_t \theta_{2t}^2 K_{2t}^\gamma + (1-\delta)(K_{1t}^2 + S_t K_{2t}^2) + b_t^2$$

Households under Complete Markets

One way of achieving complete markets is to assume that there exists a complete set of Arrow securities. Here we assume existence of a set of state-contingent bonds, denominated in units of the tradable good produced by home country, again. A bond contingent on state θ_{t+1} pays 1 sure unit of good 1 (of country 1) if the state θ_{t+1} is realized at time $t+1$. Let $p_t(\theta_{t+1})$ denote price of that bond at time t and $b_t^i(\theta_{t+1})$ amount of bond held by residents of the i^{th} country. The budget constraint of the representative household is given by:

$$\text{for i=1,} \quad c_{1t}^1 + P_t^2 c_{2t}^1 + K_{1t+1}^1 + S_t^1 K_{2t+1}^1 + \sum_{\theta_{t+1}} p_t(\theta_{t+1}) b_{t+1}^1(\theta_{t+1}) \leq$$
$$\theta_{1t}^1 K_{1t}^\alpha + S_t \theta_{2t}^1 K_{2t}^\gamma + (1-\delta)(K_{1t}^1 + S_t K_{2t}^1) + b_t^1(\theta_t)$$

$$\text{for i=2,} \quad c_{1t}^2 + P_t^2 c_{2t}^2 + P_t^2 K_{1t+1}^2 + S_t^2 K_{2t+1}^2 + \sum_{\theta_{t+1}} p_t(\theta_{t+1}) b_{t+1}^2(\theta_{t+1}) \leq$$
$$\theta_{1t}^2 K_{1t}^\alpha + S_t \theta_{2t}^2 K_{2t}^\gamma + (1-\delta)(K_{1t}^2 + S_t K_{2t}^2) + +b_t^2(\theta_t)$$

Markets Clear

In equilibrium, all of the markets in the economy clear. Let us give those conditions for each market separately.

Tradable Good:

$$\text{for home country,} \quad c_{1t} + c_{1t}^* + I_{1t} = F(\theta_{1t}^1, K_{1t}^1)$$

$$\text{for foreign country,} \quad c_{2t}^* + c_{2t} + I_{1t}^* = F^*(\theta_{1t}^2, K_{1t}^2)$$

where c_{1t} denotes the domestic consumption of the first tradable good which is produced in the home country and c_{1t}^* denotes the consumption of the first tradable good by the foreign country, in other words it denotes the export to the foreign country. I_{1t} denotes the amount of home tradable good investment into the home tradable good sector. Similarly, c_{2t}^*

denotes the foreign country's consumption of the second tradable good which is produced by the foreign country, and thus c_{2t} referes to the export of the second tradable good to the home country.

Nontradable Good:

$$\text{for home country,} \quad x_t^1 + I_{2t}^1 = G^1(\theta_{2t}^1, K_{2t}^1)$$

$$\text{for foreign country,} \quad x_t^2 + I_{2t}^2 = G^2(\theta_{2t}^2, K_{2t}^2)$$

Bond Market: Riskless non-contingent bond is assumed to be in zero net supply in all periods:

$$b_{t+1}^1 + b_{t+1}^2 = 0, \qquad \text{for all } t$$

Complete Markets: State-contingent bonds in complete markets set up is assumed to be in zero net supply in all periods contingent on each state:

$$b_{t+1}^1(\theta_{t+1}) + b_{t+1}^2(\theta_{t+1}) = 0, \qquad \text{for all } t \text{ and } \theta_t$$

Chapter 4

CALIBRATION OF THE MODEL

One of our aims is to compare our results under financial autarky to Stockman and Tesar[13]'s sice they solve under the complete markets assumption. Therefore we choose consistent parameters with Stockman and Tesar for the sake of comparability. They estimate the parameters for an 'average' industrialized country.

Table 4.1 summarizes the parameter values. The production parameter in the tradable good sector α is set to the average capital share in seven countries. For the nontradable sector's production parameter we equate the steady state output values of two sectors so that traded goods constitute half of the output.

Parameter	Definition
Technology :	
$\delta = 0.10$	Depreciation rate
$\alpha = 0.39$	Capital share in traded-good industry
$\gamma = 0.39$	Capital share in nontraded-good industry
Preferences :	
$\beta = 0.96$	Rate of time preference
$1/\sigma = 0.5$	Intertemporal Elasticity of Substitution
$1/(1+\mu) = 0.44$	Elasticity of substitution between traded and nontraded goods
$\theta = 0.5$	Share of domestically produced goods in consumer's bundle of traded goods

Table 4.1: Parameter Values

We set the rate of time discount (β) equal to 0.96 and the intertemporal elasticity of substitution ($1/\sigma$) to 0.5. We take Stockman and Tesar's estimation for the elasticity of substitution $[1/(1+\mu)]$ between traded and nontraded goods and set it to 0.44. We also set θ equal to 0.5 which implies equal share of domestic and foreign tradable goods in the consumption bundle.

According to their estimation, the technology shocks to two sectors show a limited persistence when calculated from Hodrick-Prescott filtered data. The estimated transition matrix for the vector of shocks $[\theta_1, \theta_1^*, \theta_2, \theta_2^*]$ is

$$\Omega = \begin{bmatrix} 0.154 & -0.199 & 0.040 & 0.262 \\ -0.199 & 0.154 & 0.262 & 0.040 \\ -0.150 & -0.110 & 0.632 & 0.125 \\ -0.110 & -0.015 & 0.125 & 0.632 \end{bmatrix} \tag{4.1}$$

The degree of autocorrelation is low, especially in the traded-good industry. The estimated variance-covariance matrix of the shocks is

$$V[\epsilon] = \begin{bmatrix} 3.62 & 1.21 & 1.23 & 0.51 \\ 1.21 & 3.62 & 0.51 & 1.23 \\ 1.23 & 0.51 & 1.99 & 0.27 \\ 0.51 & 1.23 & 0.27 & 1.99 \end{bmatrix} \tag{4.2}$$

The variance of the productivity shocks is nearly twice as high in the traded-good industry as in the nontraded-good industry.

4.1 Solution Method :

We solve the models linearizing the equations characterizing equilibrium around the steady state and solving the resulting system of linear difference equations. In the bond economy the law of motion for bonds is not stationary, as it is in Heathcote and Perri[9]. However, unlike Heathcote and Perri, we could not make it stationary by imposing a small quadratic cost on bond holdings.

Nevertheless, it is not bad as it seems, because both Baxter and Crucini[4] and Heathcote and Perri[9] only discuss the complete markets and the financial autarky models due to little difference between the complete markets and the bond economy.

We use the methods from Uhlig[14] to solve the system of linear difference equations. Steady state derivaions are available in appendix.

Chapter 5

RESULTS

Table 5.1 compares some results of the model with the data and with some other models' results. On the left, the results of Heathcote and Perri[9] are shown. On the right side, we have our results together with Stockman and Tesar[13]'s. On the first row, there are the standard deviations of variables obtained from the data. Heathcote and Perri's derivations differ from Stockman and Tesar's. This is not only because they use quarterly data while Stockman and Tesar use yearly data, but they also have a different economic structure. Though they have only one consumption good, there is also an intermediate good which is an input for firms. Therefore their grouping of national accounts differ from Stockman and Tesar's, so do their findings.

The numbers in the 'data' row refer to the U.S. data for the Heathcote and Perri's part while they refer to five-country averages from Stockman and Tesar's. For complete markets models, it is clear that the nontradable good model of Stockman and Tesar does better than Heathcote and Perri's. Both nontradable good models, Stockman and Tesar's and ours, produces standard deviation of aggregate output pretty close to the data. However, concerning consumption and investment volatilities, complete markets model seem to be closer to the data. Each model produces a less volatile terms of trade compared to the data, so we have 'price anomaly' for each and every model. We will be speculating about this subject in the last chapter.

In table 5.3, we have cross country correlations of consumption and output. On the first row, findings form the data are presented and on the other rows we have the correlations of simulated series under different structures. The nontradable good model under complete markets assumption replicates exactly the correlation of 0.64 between home and foreign output. However it overpredicts the consumption correlations, therefore we still observe the 'quanity anomaly', especially for the traded good sector. The financial autarky model, on the other hand, reproduces the consumption correlation across countries but it underpredicts the output correlation. This should arise from that we do not allow for any investment good trade or trade for any intermediate good. In Heathcote and Perri, the financial autarky model produces closer results to the data compared with the complete markets model. This is due to the existence of a trade mechanism that allows for more resources for investment. In their model, a country can increase its future outputs by importing more intermediate good. However, our model does not allow any mechanism that can lead to higher future output levels by a foreign resource. Countries can only increase their consumption level by foreign oriented goods.

The main reason for the 'quantity anomaly' is clearly the high consumption correlation. The intuition for the high correlation between consumption of traded goods in the two countries is straightforward. The model under complete markets assumption would imply perfect correlation between traded-good consumption across countries except for two nonseparabilities in utility.

Firstly, traded and nontraded goods do not enter utility in an additively separable way, so variations in consumption of nontraded goods, brought about by productivity shocks in the nontraded sector, affect the marginal utility of traded goods. The cross-country correlation of nontraded-sector technology shocks implied by the variance-covariance matrix in equation (4.2) is only 0.14, so the near-independence of these shocks creates cross-country differences in nontraded-good consumption, and complementarity between consumption of traded and nontraded goods creates cross-country differences in traded-good.

Secondly, the marginal utility of consumption of traded goods is not independent of leisure, so variations in labor effort that differ across countries (in response to technology shocks that cause international differences in the marginal product of labor) lead to cross country differences in consumption of traded goods.

However, the model under financial autarky is constrained more severely because of trade balance. Tradable good consumption of each country is related to each other in a one-to-one manner since each country's imports should equate its exports. Therefore we observe a perfect correlation between consumption of traded goods.

We also observe that the ratio of consumption correlation relative to output correlation is higher under the financial autarky compared to the complete markets model. This is true for both nontraded good model and Heathcote and Perri's model. We believe that this is due to the additional constraint introduced by the financial autarky. Since countries cannot run current account deficits under financial autarky, the export of home country is in the same amount of foreign country's import. This leads to higher consumption correlation compared to model with complete markets where countries may run current account deficits.

To summarize, the two largest discrepancies between the data and the predictions of the model are:

The model significantly underpredicts the cross-country correlation of output. This problem is not unique to our model; it is a fairly general feature of the previous works (e.g., BKK[2]).

Both the complete markets model and the financial autarky model grossly understate the standard deviation of the terms of trade.

The fact that all trade in the financial autarky economy has to be an equal exchange in monetary terms also means that following the shock it is impossible to consume more domestically produced tradable consumption good in country 1, since the share of that good in the bundle of tradable good consumption is constant. Consequently, we observe a fall in the import ratio and a decrease in the terms of trade (home country's imports and exports are c_2 and c_1^* relatively, and their responses can be seen in figure C.2, the response of terms of trade is illustrated in figure C.7). Thus, under financial autarky, a positive productivity shock to tradable sector in home country reduces the relative value of home country's tradable good.

The fact that productivity shocks imply less volatile terms of trade is related to our finding that cross-country correlations of tradable good consumption are larger under financial autarky than in the other economies. Following a positive shock, not only the households in home country increase their consumption and investment but also the households in foreign country. These movements are illustrated in figures C.2 and C.6. Since the large movements occur in tradable good consumption levels, the terms of trade is less volatile relative to other economies. In figure C.6 we should note that households in foreign country increase their investment to tradable good sector, even though their country is now the less productive country. This is because they want to take advantage of the terms of trade movement in their favor.

Volatilities								
	Heathcote & Perri				Nontradable Good Model			
Economy	y	c	I	p	y	c	I	p
Data	1.67	1.35	4.74	2.99	2.53	1.60	5.53	5.66
Complete markets	1.21	0.64	3.31	0.78	2.58	1.54	5.84	2.05
Bond economy	1.21	0.62	3.30	0.84	?	?	?	?
Financial autarky	1.18	0.60	2.40	1.68	2.59	2.28	3.38	1.99

Table 5.1: Standard Deviations of Output, Consumption, Investment and Terms of Trade

Domestic Correlations with Output				
	Heathcote & Perri		Nontradable Good Model	
Economy	c,y	I,y	c,y	I,y
Data	0.86	0.95	0.88	0.87
Complete markets	0.96	0.96	0.92	0.95
Bond economy	0.95	0.96	?	?
Financial autarky	0.92	0.99	0.48	0.27

Table 5.2: Consumption and Investment Correlations with Output

Cross Country Correlations						
	Heathcote & Perri			Nontradable Good Model		
Economy	$y, y*$	$c, c*$	c^T, c^{T^*}	$y, y*$	$c, c*$	c^T, c^{T^*}
Data	0.58	0.36	-	0.64	0.53	0.47
Complete markets	0.18	0.65	-	0.64	0.78	0.94
Bond economy	0.17	0.68	-	?	?	?
Financial autarky	0.24	0.85	-	0.24	0.58	1

Table 5.3: Cross Country Correlations

Chapter 6

CONCLUDING REMARKS

We have examined the international transmission of business cycles in a two-country model with nontradable goods. We have questioned Heathcote and Perri[9]'s results by solving a different model under financial autarky, which is known to yield close results to the data under the complete markets assumption.

We thought that Heathcote and Perri's conclusion stems from ignoring the evidence that about half of output consists of nontraded goods. Nevertheless, we know from Stockman and Tesar[13] that incorporating nontraded goods does not resolve all the difficulties in replicating the data.

This line of research may have implications in regards with the discussions around the global liquidity and problems related with liquidity. The IMF recently published a report[10] regarding the experiences that countries across the world have had with capital controls. The report was basically referring to the costs associated with capital controls regardless of whether capital controls are effective.

A successful analysis should include both the cost and the benefit of these capital controls. However, disentangling the impact of the controls from that of the accompanying policies, which included the strengthening of prudential regulations, greater exchange rate flexibility and adjustment in monetary policy is uneasy. Therefore, we believe that this line of research that we tried to implement might be fruitful for it is able to comprehend both the costs and the benefits of the international capital flows in a simple model.

This line of research may also be beneficial since it enables a welfare analysis of capital control related policies. With these types of models that we used, we can examine the volatility of variables of interest. Hence, it is possible to have a welfare analysis by writing a value function implicitly representing the costs and the benefits. This value function, in general could be for levels and volatilities. For our model in particular, it might be useful to write a value function in terms of volatilities since we have detrended variables. We can answer the cost of exchange rate volatility caused by capital flows and the effects of capital controls within our framework.

Together with technological spill-overs, international trade of goods and assets are the two major means of transmissions of business cycles. In IRBC literature, the trade patterns of goods are taken as given and the effects of financial markets, international trade of assets are examined. However, if the evolution of trade patterns of goods and assets are interdependent, taking trade structure of goods as given will be misleading.

Future research should focus on the interdependence between international trade of goods and assets. Cunat and Maffezzoli[7]'s work could be an example in this line of research. They introduce comparative advantage elements into an IRBC framework and this approach may help to understand the effects of international trades of goods in transmissions of business cycles. This work may help to analyze separate effects of good and asset trade in cross country correlations. Specialization patterns may help in understanding the transmission of business cycles and cross country correlations.

To conclude, this paper suggests that the structure of international trade of goods and assets may be interdependent, and therefore an endogenous approach in both dimensions is necessary when analyzing the transmission of macroeconomic fluctuations and financial integration.

Appendix A

HOUSEHOLD PROBLEM UNDER FINANCIAL AUTARKY

Under financial autarky each household chooses a sequence of $\{c_{1t}^i, c_{2t}^i, x_t^i, K_{1t+1}^i, K_{2t+1}^i\}$. We will seek a competitive equilibrium such that the prices $\{P_t^2, S_t^1, S_t^2\}$ given $P_t^1 = 1$ and allocations $\{c_{1t}^1, c_{1t}^2, c_{2t}^1, c_{2t}^2, x_t^1, x_t^2, K_{2t}^1, K_{2t}^2, K_{1t}^1, K_{1t}^2,\}$ will maximize the discounted utility stream of agents and resource constraints will hold.

Household will maximize the following utility function,

$$U(c_{1t}, c_{2t}, x_t, l_t) = \frac{1}{1-\sigma}\left\{\left[(c_{1t}^{\theta} c_{2t}^{1-\theta})^{-\mu} + x_t^{-\mu}\right]^{-\frac{1}{\mu}}\right\}^{1-\sigma} \tag{A.1}$$

given the budget constraint

$$0 \leq \theta_{1t}^i K_{1t}^{\alpha} + S_t \theta_{2t}^i K_{2t}^{\gamma} + (1-\delta)(K_{1t}^i + S_t K_{2t}^i) - c_{1t}^i - P_t^2 c_{2t}^i - S_t^i x_t^i - K_{1t+1}^i - S_t K_{2t+1}^i \tag{A.2}$$

and resource constraints,

$$c_{1t} + c_{1t}^* + I_{1t} = F(\theta_{1t}^1, K_{1t}^1) = \theta_{1t}^1 (K_{1t}^1)^{\alpha} \tag{A.3}$$

$$c_{2t}^* + c_{2t} + I_{1t}^* = F^*(\theta_{1t}^2, K_{1t}^2) = \theta_{1t}^2 (K_{1t}^2)^{\alpha} \tag{A.4}$$

$$x_t^1 + I_{2t}^1 = G^1(\theta_{2t}^1, K_{2t}^1) \tag{A.5}$$

$$x_t^2 + I_{2t}^2 = G^2(\theta_{2t}^2, K_{2t}^2) \tag{A.6}$$

The first-order conditions are as follows;

$$A_t(c_{1t}^{\theta}c_{2t}^{1-\theta})^{-\mu}\frac{\theta}{c_{1t}} = \lambda_t \tag{A.7}$$

$$A_t(c_{1t}^{\theta}c_{2t}^{1-\theta})^{-\mu}\frac{1-\theta}{c_{2t}} = \lambda_t P_t^2 \tag{A.8}$$

$$A_t x_t^{-\mu-1} = \lambda_t S_t \tag{A.9}$$

$$\lambda_t = \beta\lambda_{t+1}[\alpha\theta_{1t+1}K_{1t+1}^{\alpha-1} + 1 - \delta] \tag{A.10}$$

$$\lambda_t S_t = \beta\lambda_{t+1}[S_{t+1}\gamma\theta_{2t+1}K_{2t+1}^{\gamma-1} + S_{t+1}(1-\delta)] \tag{A.11}$$

where $A_t = \left\{\left[(c_{1t}^{\theta}c_{2t}^{1-\theta})^{-\mu} + x_t^{-\mu}\right]^{-\frac{1}{\mu}}\right\}^{-\sigma}(-\frac{1}{\mu})\left[(c_{1t}^{\theta}c_{2t}^{1-\theta})^{-\mu} + x_t^{-\mu}\right]^{-\frac{1}{\mu}-1}(-\mu)$
By rearranging the first-order conditions, we get the folowing conditions;

from equation (B.7) and (B.8)

$$\frac{c_{1t}}{c_{2t}} = \frac{\theta}{1-\theta}P_t^2 \tag{A.12}$$

from (B.7) and (B.9)

$$x_t^{-\mu-1} = (c_{1t}^{\theta}c_{2t}^{1-\theta})^{-\mu}\frac{\theta}{c_{1t}}S_t \tag{A.13}$$

Now we will look for steady states. Bar denotes the steady state value of any variable. define $\rho = \frac{1}{\beta} - 1$

$$\bar{K}_1 = \left[\frac{\rho+\delta}{\alpha\theta_1^1}\right]^{\frac{1}{\alpha-1}} \tag{A.14}$$

$$\bar{K}_1^* = \left[\frac{\rho+\delta}{\alpha\theta_1^2}\right]^{\frac{1}{\alpha-1}} \tag{A.15}$$

$$\bar{K}_2 = \left[\frac{\rho+\delta}{\gamma\theta_2^1}\right]^{\frac{1}{\gamma-1}} \tag{A.16}$$

$$\bar{K}_2^* = \left[\frac{\rho+\delta}{\gamma\theta_2^2}\right]^{\frac{1}{\gamma-1}} \tag{A.17}$$

from equations (B.13) and first resource constraint we get,

$(c_2 + c_2^*)\frac{\theta}{1-\theta}\bar{P}^2 + \delta\bar{K}_1 = \theta_1^1\bar{K}_1^\alpha$

and dividing the previous equation by the second resource constraint at the steady state we get,

$$\frac{\theta}{1-\theta}P_t^2 = \frac{\theta_1^1\bar{K}_1^\alpha - \delta\bar{K}_1}{\theta_1^2\bar{K}_1^{*\alpha} - \delta\bar{K}_1^*} \tag{A.18}$$

Combining (B.15), (B.16) and (B.19) allows us to find $\bar{P}$.

Now we are to find $\bar{c_1}, \bar{c_2}, \bar{c_1^*}, \bar{c_2^*}, \bar{S}, \bar{S}, \bar{S}^*$

From (B.13), we know that at the steady state

$$\bar{c_1} = \frac{\theta}{1-\theta}\bar{P}\bar{c_2} \tag{A.19}$$

Since we are in financial autarky, trade balance should always be zero, i.e. $\bar{c_1^*} = \bar{P}\bar{c_2}$

Together with (B.20) this implies that $\bar{c_1} = \frac{\theta}{1-\theta}\bar{c_1^*}$. Plugging this into the first resource constraint we get,

$$\bar{c_1} + \bar{c_1^*} = \bar{\theta_1}\bar{K_1^\alpha} - \delta\bar{K_1} \tag{A.20}$$

$$\frac{\bar{c_1^*}}{1-\theta} = \bar{\theta_1}\bar{K_1^\alpha} - \delta\bar{K_1} \tag{A.21}$$

Since we know $\bar{K_1}$, we can find $\bar{c_1^*}$ and $\bar{c_1}$

Using (B.7) and (B.9) at the steady state

$$\bar{S} = [\theta_2\bar{K_2}^\alpha]^{-\mu-1}\frac{\bar{c_1}}{\theta(\bar{c_1^*}^\theta\bar{c_2^*}^{1-\theta})^{-\mu}} \tag{A.22}$$

Since we know $\bar{K_2}$, we can find $\bar{S}$ and similarly $\bar{S}^*$

Appendix B

HOUSEHOLD PROBLEM UNDER BOND ECONOMY:

Under a non-contingent bond economy each household chooses a sequence of $\{c^i_{1t}, c^i_{2t}, x^i_t, K^i_{1t+1}, K^i_{2t+1}$
We will seek a competitive equilibrium such that the prices $\{P^2_t, S^1_t, S^2_t, r^1_t, r^2_t, p^b_t\}$ given $P^1_t = 1$ and allocations
$\{c^1_{1t}, c^2_{1t}, c^1_{2t}, c^2_{2t}, x^1_t, x^2_t, K^1_{2t}, K^2_{2t}, K^1_{1t}, K^2_{1t}, b^1_t, b^2_t\}$ will maximize the discounted utility stream of agents, firms will maximize their profit, and resource constraints will hold.

Household will maximize the following utility function,

$$U(c_{1t}, c_{2t}, x_t, l_t) = \frac{1}{1-\sigma}\left\{\left[(c^{\theta}_{1t}c^{1-\theta}_{2t})^{-\mu} + x_t^{-\mu}\right]^{-\frac{1}{\mu}}\right\}^{1-\sigma} l^a_t \tag{B.1}$$

given the budget constraint

$$0 \leq \theta^i_{1t}K^{\alpha}_{1t} + S_t\theta^i_{2t}K^{\gamma}_{2t} + (1-\delta)(K^i_{1t} + S_tK^i_{2t}) - c^i_{1t} - P^2_t c^i_{2t} - S^i_t x^i_t - K^i_{1t+1} - S_tK^i_{2t+1} + p^b_t b^i_t - b^i_{t+1} \tag{B.2}$$

and linearized resource constraints,

$$c_{1t} + c^*_{1t} + K_{1t+1} - (1-\delta)K_{1t} \approx \bar{\theta}_1\bar{K}^{\alpha}_1 + (\theta_{1t} - \bar{\theta}_1)\bar{K}^{\alpha}_1 + (K_{1t} - \bar{K}_1)\alpha\bar{\theta}_1\bar{K}^{\alpha}_1 \tag{B.3}$$

$$c^*_{2t} + c_{2t} + K^*_{1t+1} - (1-\delta)K^*_{1t} \approx \bar{\theta}^*_1\bar{K}^{*\alpha}_1 + (\theta^*_{1t} - \bar{\theta}^*_1)\bar{K}^{*\alpha}_1 + (K^*_{1t} - \bar{K}^*_1)\alpha\bar{\theta}^*_1\bar{K}^{*\alpha}_1 \tag{B.4}$$

$$x_{1t} + K_{2t+1} - (1-\delta)K_{2t} \approx \bar{\theta}_2\bar{K}^{\alpha}_2 + (\theta_{2t} - \bar{\theta}_2)\bar{K}^{\gamma}_2 + (K_{2t} - \bar{K}_2)\gamma\bar{\theta}_2 1\bar{K}^{\gamma}_2 \tag{B.5}$$

$$x^*_{1t} + K^*_{2t+1} - (1-\delta)K^*_{2t} \approx \bar{\theta}^*_2\bar{K}^{*\alpha}_2 + (\theta^*_{2t} - \bar{\theta}^*_2)\bar{K}^{*\gamma}_2 + (K^*_{2t} - \bar{K}^*_2)\gamma\bar{\theta}^*_2\bar{K}^{*\gamma}_2 \tag{B.6}$$

The first-order conditions are as follows;

$$A_t(c_{1t}^{\theta}c_{2t}^{1-\theta})^{-\mu}\frac{\theta}{c_{1t}} = \lambda_t \tag{B.7}$$

$$A_t(c_{1t}^{\theta}c_{2t}^{1-\theta})^{-\mu}\frac{1-\theta}{c_{2t}} = \lambda_t P_t^2 \tag{B.8}$$

$$A_t x_t^{-\mu-1} = \lambda_t S_t \tag{B.9}$$

$$\lambda_t = \beta\lambda_{t+1}[\alpha\theta_{1t+1}K_{1t+1}^{\alpha-1} + 1 - \delta] \tag{B.10}$$

$$\lambda_t S_t = \beta\lambda_{t+1}[S_{t+1}\gamma\theta_{2t+1}K_{2t+1}^{\gamma-1} + S_{t+1}(1-\delta)] \tag{B.11}$$

$$\lambda_t p_t^b = \beta\lambda_{t+1} \tag{B.12}$$

where $A_t = \left\{\left[(c_{1t}^{\theta}c_{2t}^{1-\theta})^{-\mu} + x_t^{-\mu}\right]^{-\frac{1}{\mu}}\right\}^{-\sigma}(-\frac{1}{\mu})\left[(c_{1t}^{\theta}c_{2t}^{1-\theta})^{-\mu} + x_t^{-\mu}\right]^{-\frac{1}{\mu}-1}(-\mu)$
By rearranging the first-order conditions, we get the folowing conditions;

from equation (B.7) and (B.8)

$$\frac{c_{1t}}{c_{2t}} = \frac{\theta}{1-\theta}P_t^2 \tag{B.13}$$

from (B.7) and (B.9)

$$x_t^{-\mu-1} = (c_{1t}^{\theta}c_{2t}^{1-\theta})^{-\mu}\frac{\theta}{c_{1t}}S_t \tag{B.14}$$

define $\rho = \frac{1}{\beta} - 1$

$$\bar{K}_1 = \left[\frac{\rho+\delta}{\alpha\theta_1^1}\right]^{\frac{1}{\alpha-1}} \tag{B.15}$$

$$\bar{K}_1^* = \left[\frac{(\rho+\delta)}{\alpha\theta_1^2}\right]^{\frac{1}{\alpha-1}} \tag{B.16}$$

$$\bar{K}_2 = \left[\frac{(\rho+\delta)}{\gamma\theta_2^1}\right]^{\frac{1}{\gamma-1}} \tag{B.17}$$

$$\bar{K}_2^* = \left[\frac{(\rho+\delta)}{\gamma\theta_2^2}\right]^{\frac{1}{\gamma-1}} \tag{B.18}$$

from equations (B.13) and first resource constraint we get,

$(c_2 + c_2^*)\frac{\theta}{1-\theta}\bar{P}^2 + \delta\bar{K}_1 = \theta_1^1\bar{K}_1^\alpha$

and dividing the previous equation by the second resource constraint at the steady state we get,

$$\frac{\theta}{1-\theta}P_t^2 = \frac{\theta_1^1\bar{K}_1^\alpha - \delta\bar{K}_1}{\theta_1^2\bar{K}_1^{*\alpha} - \delta\bar{K}_1^*} \tag{B.19}$$

Combining (B.15), (B.16) and (B.19) allows us to find $\bar{P}$.

Now we are to find $\bar{c_1}, \bar{c_2}, \bar{c_1^*}, \bar{c_2^*}, \bar{S}, \bar{S}, \bar{S}^*$

From (B.13), we know that at the steady state

$$\bar{c_1} = \frac{\theta}{1-\theta}\bar{P}\bar{c_2} \tag{B.20}$$

Since we are in financial autarky, trade balance should always be zero, i.e. $\bar{c_1^*} = \bar{P}\bar{c_2}$

Together with (B.20) this implies that $\bar{c_1} = \frac{\theta}{1-\theta}\bar{c_1^*}$. Plugging this into the first resource constraint we get,

$$\bar{c_1} + \bar{c_1^*} = \bar{\theta_1}\bar{K_1^\alpha} - \delta\bar{K_1} \tag{B.21}$$

$$\frac{\bar{c_1^*}}{1-\theta} = \bar{\theta_1}\bar{K_1^\alpha} - \delta\bar{K_1} \tag{B.22}$$

Since we know $\bar{K_1}$, we can find $\bar{c_1^*}$ and $\bar{c_1}$

Using (B.7) and (B.9) at the steady state

$$\bar{S} = [\theta_2 \bar{K_2}^{\alpha}]^{-\mu-1} \frac{\bar{c_1}}{\theta(\bar{c_1^*}^{\theta} \bar{c_2^*}^{1-\theta})^{-\mu}} \tag{B.23}$$

Since we know $\bar{K_2}$, we can find $\bar{S}$ and similarly $\bar{S}^*$

Appendix C

RESPONSES TO 1 STD. DEV. PRODUCTIVITY SHOCK IN DOMESTIC TRADABLE SECTOR

In this section, we have the impulse response functions of some important variables to one standard deviation technology shock in domestic tradable sector(i.e. a shock to θ_1).

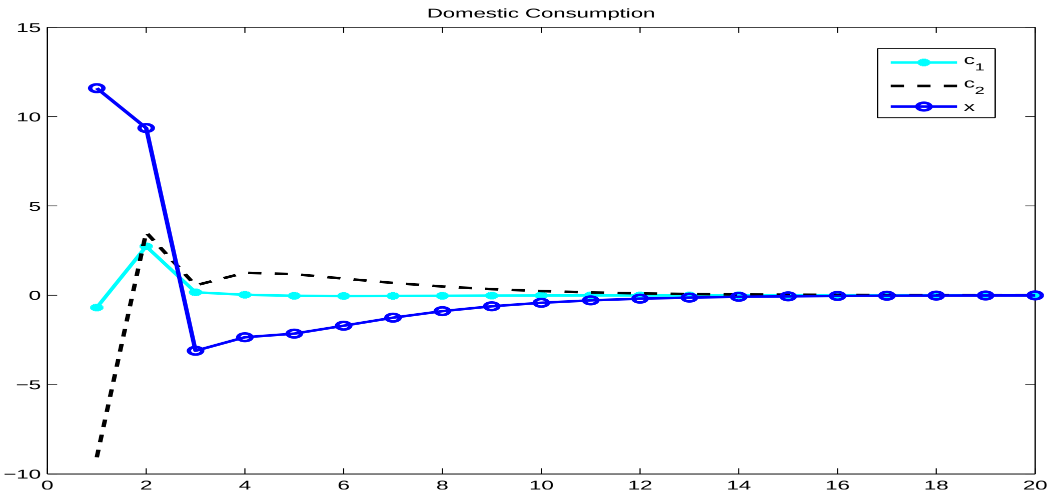

Figure C.1: Responses of Domestic Consumption Variables

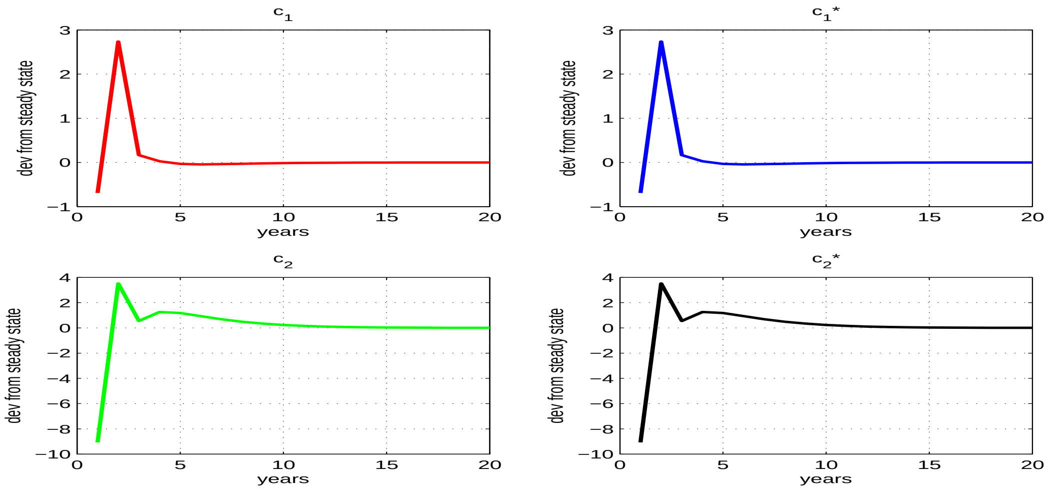

Figure C.2: Responses of Tradable Good Consumption

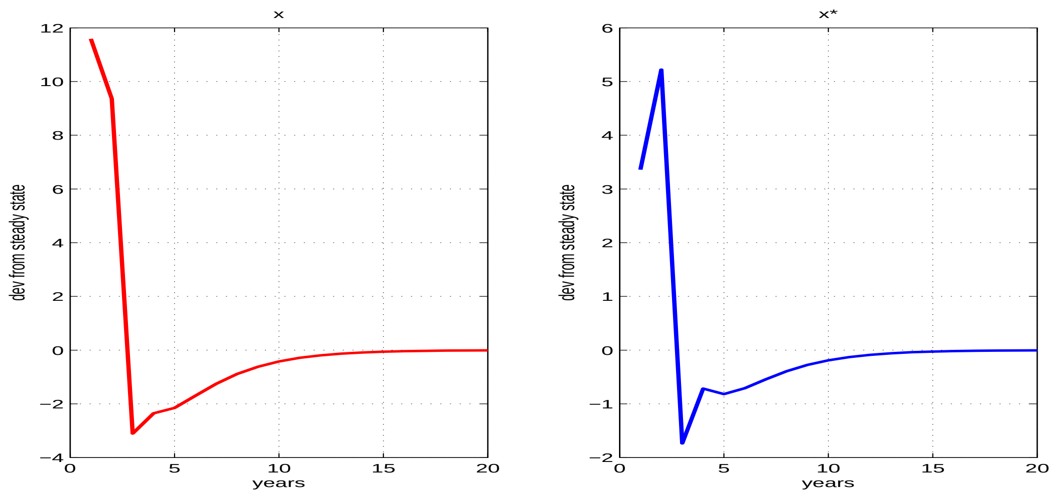

Figure C.3: Responses of Non-tradable Good Consumption

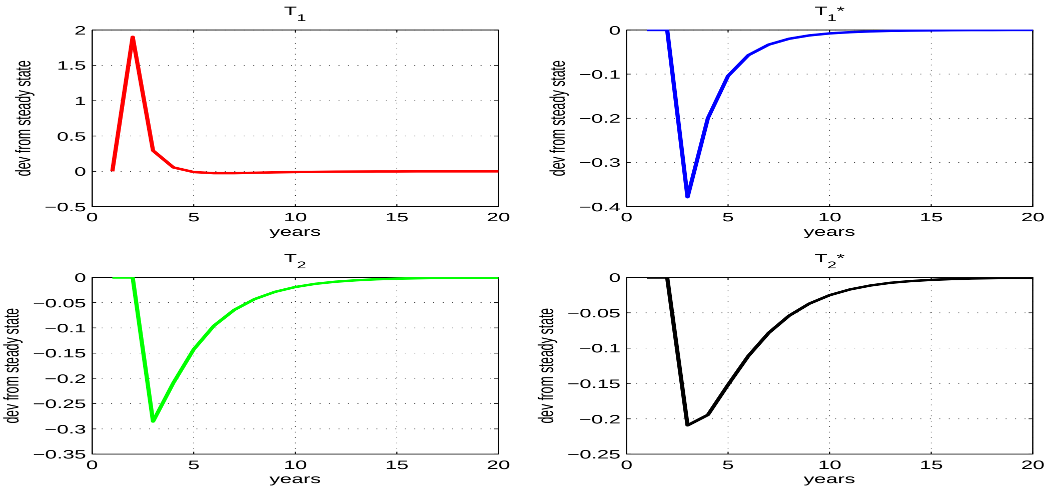

Figure C.4: Responses of Technology Shocks

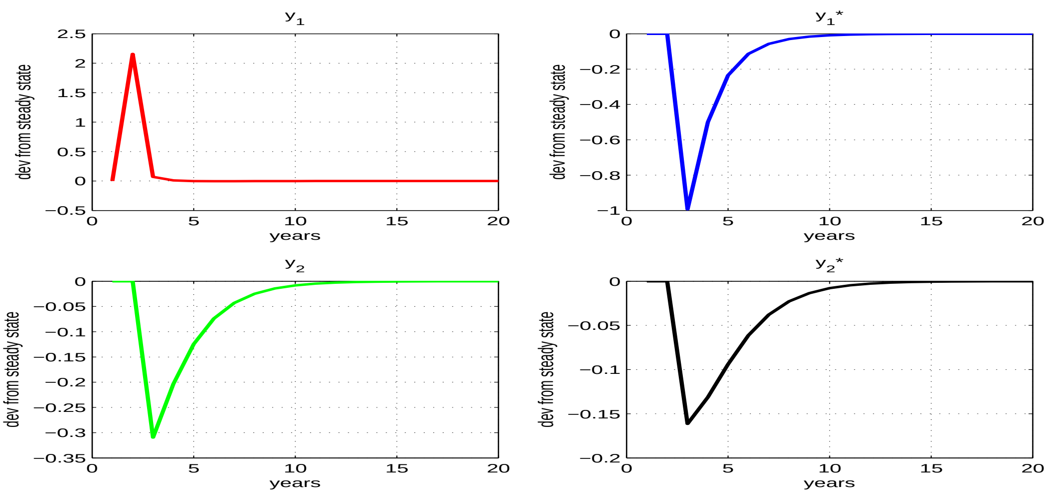

Figure C.5: Responses of Outputs

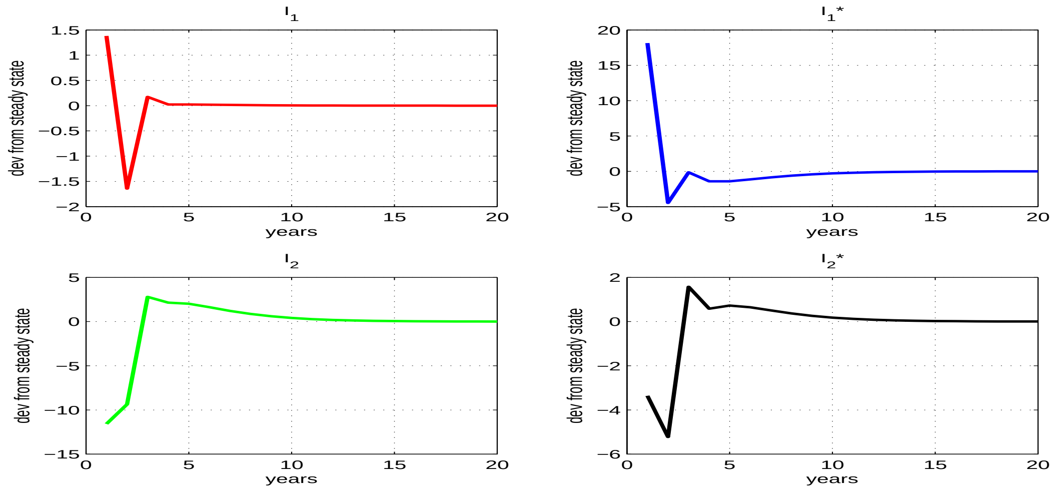

Figure C.6: Responses of Investment

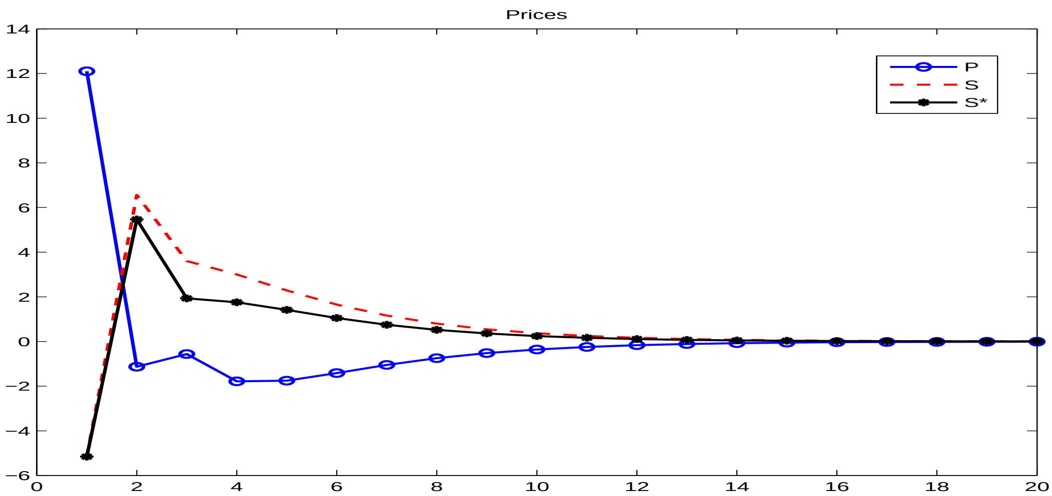

Figure C.7: Responses of Prices

Appendix D

RESPONSES TO 1 STD. DEV. PRODUCTIVITY SHOCK IN DOMESTIC NON-TRADABLE SECTOR

In this section, we have the impulse response functions of some important variables to one standard deviation technology shock in domestic non-tradable sector(i.e. a shock to θ_2).

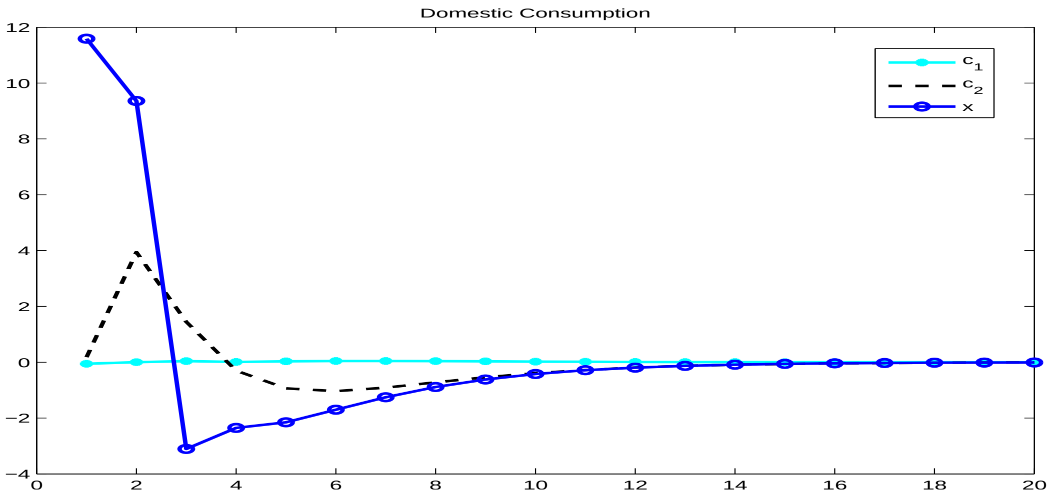

Figure D.1: Responses of Domestic Consumption Variables

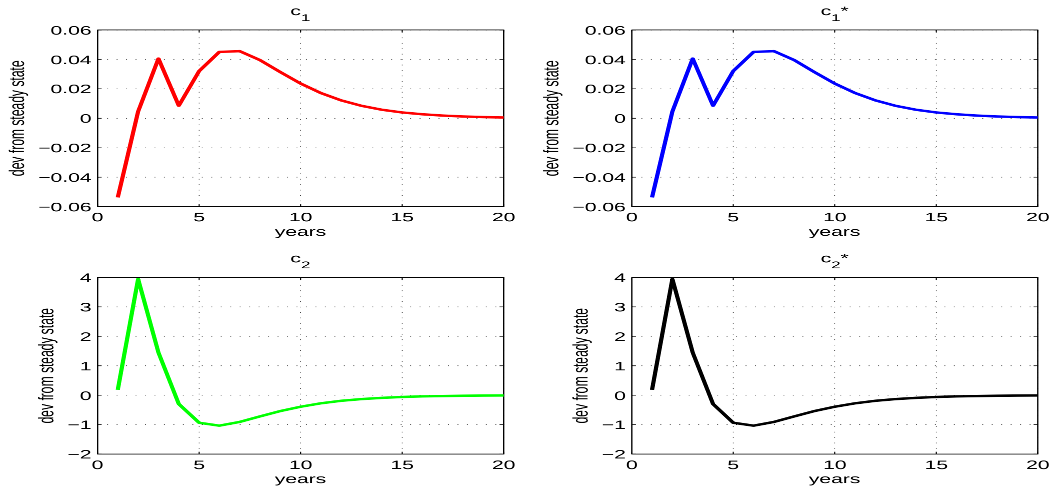

Figure D.2: Responses of Tradable Good Consumption Variables

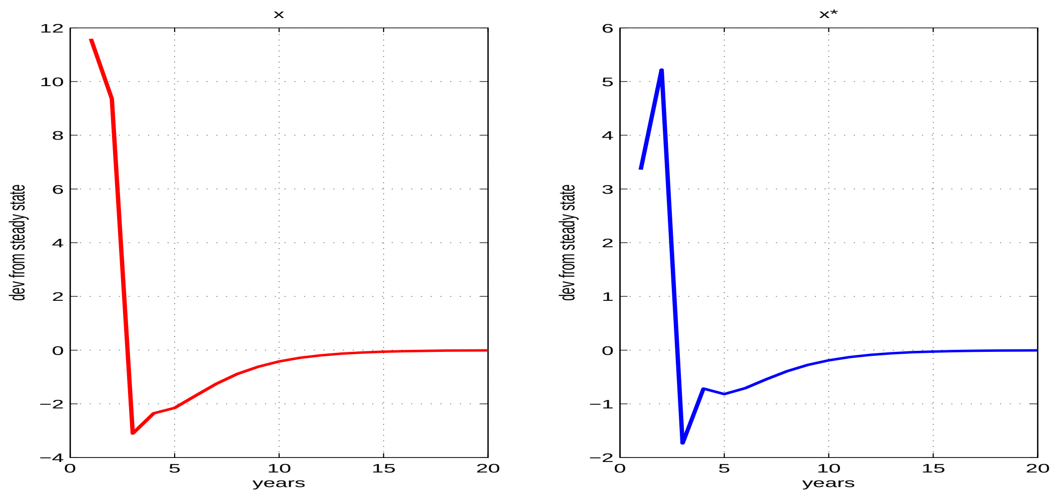

Figure D.3: Responses of Non-tradable Consumption

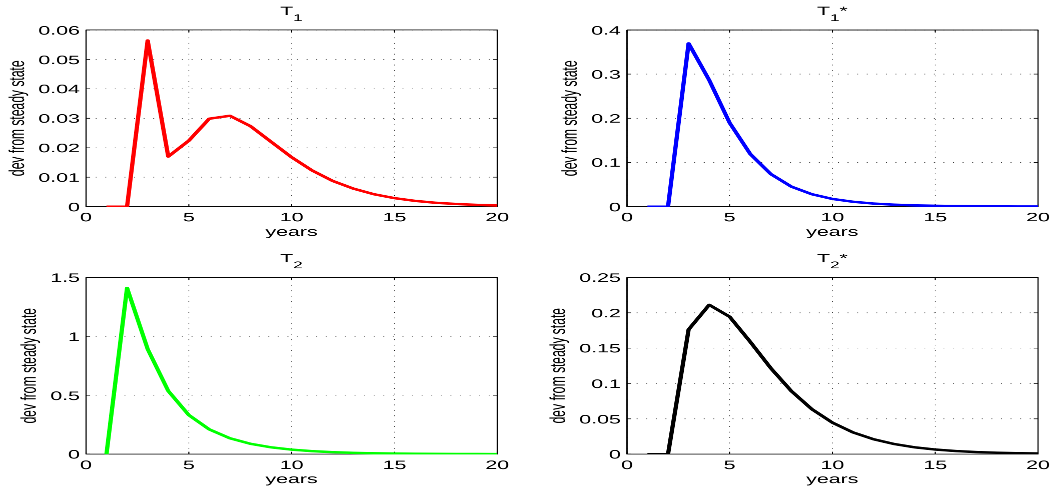

Figure D.4: Responses of Technology Shocks

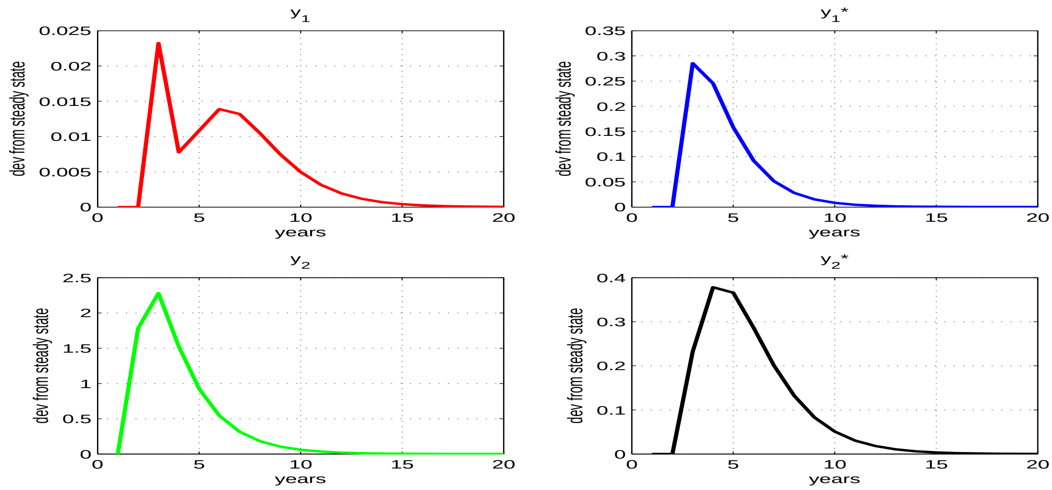

Figure D.5: Responses of Outputs.

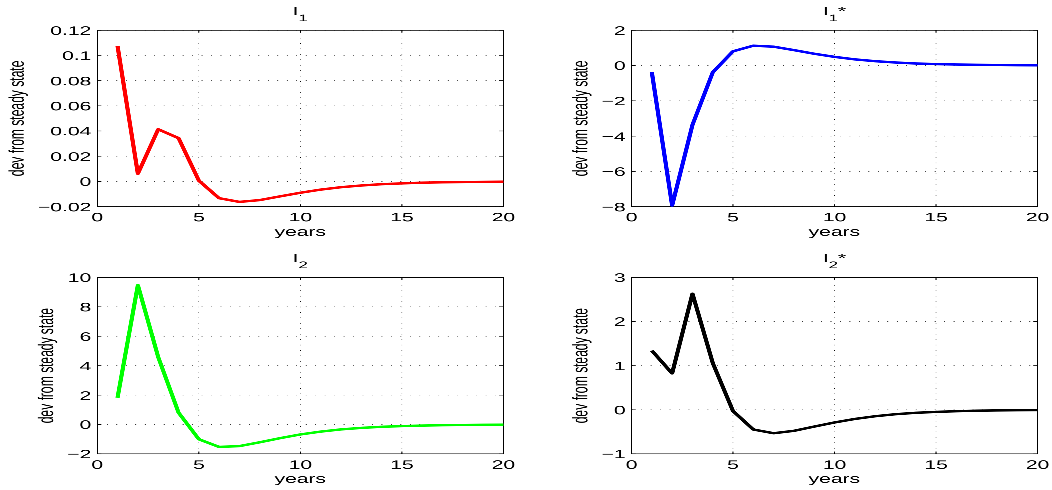

Figure D.6: Responses of Investments

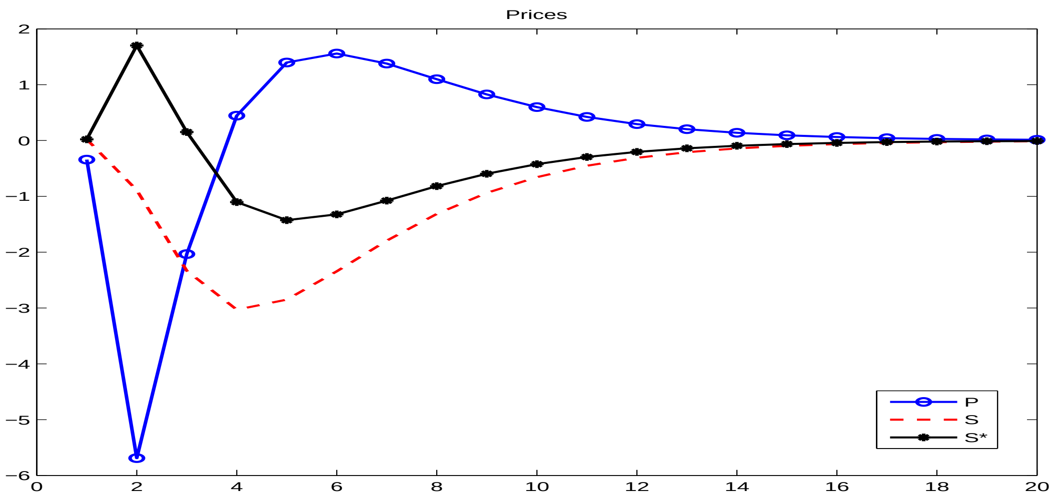

Figure D.7: Responses of Prices

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