EXPORT PENETRATION COSTS AND INTERNATIONAL BUSINESS CYCLES

DISSERTATION

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By

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The international co-movements of macroeconomic variables have been one of the major topics studied in the international macroeconomics literature. The current generation of international macroeconomic models cannot explain many features of the dynamic behavior of time series. The international business cycle literature begins with Backus, Kehoe, and Kydland (1992). They develop a one-good, two-country dynamic general equilibrium model and find anomalies in their model. Their model predicts negative cross-country correlations in output, investment, and employment, whereas the data statistics are positive. The model also predicts higher cross-country consumption correlation than the output correlation, whereas the opposite is true in data. This divergence between the model prediction and the stylized facts is called the consumption correlation puzzle.

In the literature, economists have attempted to find out what are the major factors that drive these international co-movements by introducing additional features (e.g., international trade costs or asset market imperfections) in two-country general equilibrium models. They find that these additional features improve the performance of two-country general equilibrium models in explaining international co-movements, but yet insufficient to fully explain the data. Especially, the fact that the cross-country consumption correlation is lower than the output correlation still remains as a major puzzle in international macroeconomics.
This dissertation investigates the importance of the firm-level dynamics driven by the export penetration costs in resolving the consumption correlation puzzle. Using firm-level data, empirical research finds interesting features that have not been modeled in two-country general equilibrium framework. Existing research finds that firms that engage in export have several notable characteristics. They tend to have higher productivity, have higher levels of output, use higher levels of capital and labor inputs, and are efficient enough to overcome higher costs of doing international business. These costs include higher foreign marketing and distribution costs, additional bureaucratic procedures, and required changes in product characteristics to match up to the tastes of foreign consumers and government regulations. Moreover, firm-level data show that collection of firms that engage in international trade evolves dynamically across time. A significant percentage of firms that were exporters in one period cease to export in the next period, and vice versa. This transition of export status is positively correlated across countries. That is, the ratio of exporting to non-exporting firms in a country changes over time and this ratio is positively correlated across countries.

In this dissertation, these special features of the export sector are embedded in a two-country dynamic general equilibrium model. In the model, firms that export to the foreign country face two sets of international trading costs. There is a (relatively) high initial entry cost that must be borne to gain entry into the export market. In subsequent periods, a lower but nonzero cost must be borne to continue exporting to the foreign country. Firms experience productivity shocks that are comprised of a firm-specific component and a country-wide component. Due to international trading costs, the export status of a firm depends not only on current market conditions but
also on expected future conditions and productivity levels. Firms with high productivity enter the export market whereas firms with low productivity do not. Because exporters have access to larger markets than non-exporters, in equilibrium exporters have relatively higher levels of capital accumulation, employment, and output levels than non-exporters, which matches up with the empirical evidence.

The model resolves the consumption correlation puzzle in the following way. A positive country-specific productivity shock at home reduces production costs for home firms and increases the domestic demand for foreign goods. The measure of exporters that transition to non-exporting declines at home and abroad. The measure of non-exporters that transition to exporting also increases at home and abroad. These result in a greater variety of traded goods, and an increased volume of international trade. Output, investment, and employment increase both at home and abroad. For several periods following the shock, a large fraction of output is devoted to investment in both countries. Since all of the home intermediate goods that are produced with high productivity are available at home country whereas only some of them are available at foreign country, the consumption at home increase from the initial period of the shock whereas the consumption at foreign decreases initially for higher future consumption. These result in the cross-country consumption correlation which lies below the output correlation. Hence, the model successfully generates cross-country correlations in international macroeconomic variables with correct signs and magnitudes. A key result of the model is that relatively high costs associated with export penetration generate the cross-country consumption correlation which lies below the output correlation thus providing a resolution to the international consumption correlation puzzle.
Dedicated to my parents
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CHAPTER 1

INTRODUCTION

This dissertation investigates the importance of firm-level dynamics driven by export penetration costs in explaining the international transmission of business cycles. This research conducts a quantitative evaluation of a two-country dynamic general equilibrium model. In particular I examine implied cross-country correlations in output, consumption, investment, and employment.

I draw upon empirical research that uses plant or firm-level data in several countries. This research finds three notable features in characteristics of exporters and firms’ exporting decisions that have been overlooked in conventional international business cycle literature. First, the empirical evidence suggests that producers that engage in export have several notable differences compared to non-exporters. Exporters tend to have higher productivity, have higher levels of output, and use higher levels of capital and labor inputs, and must be more efficient than non-exporters in order to overcome higher costs of doing international business. These costs include higher foreign marketing and distribution costs, additional bureaucratic procedures, and required changes in product characteristics to match up to the tastes of foreign consumers and government regulations. Using the U.S. Census Bureau’s Annual Survey of Manufacturers (ASM) 1987, Bernard and Jensen (1995) find that compared to
non-exporters, exporters have 47.8% higher capital per workers. Bernard and Jensen (1999a) find that exporters have 13% - 16% higher total factor productivity and 20% - 45% larger employment level using ASM 1984 - 1992.

Second, the data show that a significant percentage of firms that were exporters in one period stop exporting in the next period and vice versa. ASM 1986 - 1992 balanced panel data screened by Bernard and Jensen (2001) show that the ratio of non-exporters that transition to exporter status to the number of last period non-exporters (henceforth starter ratio) is about 14.4%, and the ratio of exporters that transition to non-exporter status to the number of last period exporters (henceforth stopper ratio) is about 12.2% on average. The dynamics of export status result in the changes in the ratio of exporters among all firms over time. Since the starter ratio is slightly higher than stopper ratio, the ratio of exporter to the number of all firms (henceforth exporter ratio) is slightly higher than 50%. The exporter ratio is about 51.8% on average.¹

German and Colombian manufactures data also show significant turnover ratios in export status. Using annual manufacturing plant-level data 1978 - 1992 in Lower Saxony, Germany, Bernard and Wagner (1998) find that on average, starter and stopper ratios are about 4.14% and 5.51%, respectively. Due to the lower starter ratio than the stopper ratio, the exporter ratio is less than 50%. The exporter ratio is about 41.2% on average. Roberts and Tybout (1997) use annual data of Colombian manufacturing Census 1981 - 1989 to find that on average, the starter and stopper

¹Since the starter and stopper ratios can be considered as the transition probabilities in export status, higher starter ratio than stopper ratio does not necessarily mean that the exporter ratio is increasing all the time. If the starter and stopper ratios are n₀ and n₁ all the time, the exporter ratio converges to \( \frac{n₀}{n₀ + n₁} \).
ratios are about 3.3% and 11.5%, respectively. Since the starter ratio is significantly lower than stopper ratio, the exporter ratio is very low in Colombia. The exporter ratio is about 11.8% on average.

More interestingly, it is found that these turnover ratios in export status are positively correlated across countries. The positive cross-country correlations in the turnover ratios suggest that there exist strong interactions among countries that affect exporting decisions of producers.\(^2\)

Third, empirical research finds evidence that entry costs in international trade are significant, and that these costs play a major role in the exporting decisions of producers.\(^3\) These costs encompass higher foreign marketing and distribution costs, additional bureaucratic procedures, and required changes in product characteristics to match up to the tastes of foreign consumers and government regulations.

Using annual data of Colombian chemical producers 1982 - 1991, Das, Roberts, and Tybout (2001) estimate that continuing exporters pay 0.48 million pesos as maintenance costs to continue exporting to foreign countries, whereas newly exporting firms pay 107.99 to 242.17 million pesos as entry costs on average in 1986 pesos. Average firm-level exports in 1986 was 587.50 million pesos. So, a newly exporting firm pays about 18.4% - 41.2% of exports as entry costs on average, whereas a continuing

\(^2\)Using start-up costs in partial equilibrium models, Baldwin (1988), Baldwin and Krugman (1989), and Dixit (1989a,b) explain the export hysteresis. However, to explain the co-movements of the turnover ratios across countries, we need to develop 2 or multiple-country models.

\(^3\)Roberts and Tybout (1997), Bernard and Wagner (1998), Aw, Chung, and Roberts (1998), Bernard and Jensen (1999b), and Das, Roberts, and Tybout (2001) use Colombian, German, Taiwan, and Korean plant or firm-level manufacturing data, respectively. They commonly find the existence of entry costs in export.
exporter pays less than 1% of exports as maintenance costs to remain in foreign markets on average. Hence, the entry costs are great burden for potential exporters, and current exporters that considering to exit from the foreign markets.

The objective of this dissertation is to improve an understanding of international co-movements of macroeconomic variables. The literature begins with Backus, Kehoe, and Kydland (1992). They develop a one-good, two-country dynamic general equilibrium model under Arrow-Debreu security, and find anomalies in their model. Their model predicts negative cross-country correlations in output, investment, and employment, whereas the data statistics are positive. The model also predicts higher cross-country consumption correlation than the output correlation, whereas the opposite is true in data. This divergence between the model prediction and the stylized facts is called the consumption correlation puzzle.

In the literature, economists have attempted to resolve these anomalies by introducing additional features in two-country general equilibrium models. There are two main approaches in explaining the anomalies. The first approach is introducing asset market imperfection in two-country general equilibrium models. Among others, Baxter and Crucini (1995) use non-state contingent bonds for the asset market environment, instead of Arrow-Debreu security. Kehoe and Perri (2002) assume that countries in the model have limited enforceability of financial contract. The other approach is introducing trade costs in two-country general equilibrium models. Backus, Kehoe, and Kydland (1992) introduce a quadratic costs to trade volumes in their model. Stockman and Tesar (1995) assume that each country has 2 sectors, traded and non-traded goods sectors. They also use preference shocks in their model. Obstfeld and Rogoff (2000) suggest ‘iceberg’ costs that are international trade costs
proportional to trade volumes. This research finds improvements in the predictions of two-country general equilibrium models for co-movements of international macroeconomic variables. However, they are not enough to resolve all the anomalies found by Backus, Kehoe, and Kydland (1992). Especially, the fact that the cross-country consumption correlation is lower than the output correlation still remains as a major puzzle in international macroeconomics.

As a resolution to the anomalies, this dissertation introduces export penetration costs in a two-country general equilibrium model so that firm-level dynamics in the export sector are embedded in the model. In the model, firms that export to the foreign country face two sets of international trading costs. First, there is a (relatively) high initial entry cost that must be borne to gain entry into the export market. In subsequent periods, a lower but nonzero cost must be borne to continue exporting to the foreign country. Productivity shocks are comprised of a firm-specific component and a country-wide component. Due to international trading costs, firms with high productivity choose to enter the export market whereas firms with low productivity choose not to. Because exporters have access to larger markets than non-exporters, in equilibrium exporters have relatively higher levels of capital, employment, and output levels than non-exporters. This prediction matches up with the empirical evidence.

The main result from the model is that relatively high costs associated with export penetration generate the consumption correlation that lies below the output correlation, thus providing a resolution to the international consumption correlation puzzle. In the model, a positive home country-specific productivity shock reduces production costs for home firms and increases the domestic demand for foreign goods. The measure of exporters that transition to non-exporting declines, and the measure of
non-exporters that transition to exporting increases both at home and foreign countries. These result in a greater variety of traded goods, and an increased volume of international trade. Since exporters tend to have higher capital and labor inputs, increases in exporter ratios both home and foreign result in higher capital, labor, and output in both countries. So, positive co-movements in the turnover ratios of export status contribute additional positive co-movements in investment, employment, and output across countries. For several periods following the shock, a large fraction of output is devoted to investment, so relatively small fraction of output are available for consumption. Due to international trade costs, only some of home intermediate goods produced with high productivity are available at foreign country. However, all the variety of home intermediate goods are available at home country. Hence, consumption at home increases from the initial period of the shock, whereas consumption at foreign decreases initially for higher future consumption. These result in low cross-country consumption correlation that lies below the output correlation. Hence, the model successfully generates cross-country correlations in international macroeconomic variables with correct signs and magnitudes.

The rest of the dissertation is organized as follows. Chapter 2 discusses the background of research on international business cycles. Chapter 3 discusses characteristics of exporters found from firm-level data. In Chapter 4, a two-country dynamic general equilibrium model with export penetration costs is developed, an equilibrium of the model is defined, and parameter values for simulation exercises are determined. Chapter 5 discusses the results of simulation exercises. Chapter 6 concludes.
CHAPTER 2

INTERNATIONAL BUSINESS CYCLE FACTS AND ANOMALIES IN TWO-COUNTRY GENERAL EQUILIBRIUM MODELS

This chapter discusses international business cycle facts and the open economy macroeconomics literature explaining the facts under two-country general equilibrium framework.

2.1 International Business Cycle Facts

The international co-movements of macroeconomic variables have been one of major topics studied in the open economy macroeconomics literature. Table 2.1 shows cross-country correlations in quarterly major macroeconomic variables between the U.S. and an aggregate of 15 European countries from 1970:1 to 1998:4. All the correlation statistics are calculated from the data that are in logarithm. All the

\[\text{All the data statistics in Table 2.1 are from Kehoe and Perri (2002). 15 European countries are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. The value of the aggregate is calculated as a weighted average of the value of its component currencies from Organisation Economic Co-operation and Development, Main Economic Indicators. Aggregate values are calculated using totals obtained by the addition of constant prices data expressed at 1995 price levels and converted into the U.S. dollars using fixed 1995 Purchasing Power Parities.} \]
data are passed through Hodrick-Prescott filter with the smoothing parameter of 1600 to remove the non-stationarity of the data.\(^5\) The statistics show that the U.S. output is positively correlated with European aggregate output. The cross-country correlation in output is 0.51. Consumption is positively correlated across countries, but less correlated than output. The consumption correlation across countries is 0.32. Investment and employment are positively correlated across countries. The cross-country correlations in investment and employment are 0.29 and 0.43, respectively.

These findings that output, consumption, investment, and employment are positively correlated across countries, and the cross-country consumption correlation is lower than the output correlation, are qualitatively robust across countries and detrending methods. Table 2.2 shows cross-country correlations in quarterly output and consumption between the U.S. and individual 15 foreign countries from 1970:1 to 1990:2. All the correlation statistics are calculated from the data that are in logarithm. Backus, Kehoe, and Kydland (1993) use Hodrick-Prescott filter to detrend the data. Hodrick-Prescott filter works as a approximation to a filter that passes cycles of frequency eight years or less. The results show that the U.S. output is positively correlated with all foreign countries in the sample. The statistics show that high consumption correlation is associated with high output correlation, but the consumption correlation is always lower than the output correlation. Output correlations across countries range from 0.38 to 0.76, and consumption correlations from -0.19 to 0.49.

Baxter (1995) uses a band-pass filter as a detrending method. This band-pass filter passes only cyclical components of the data with periodicity between 6 and 32

\(^5\)For quarterly data, Hodrick-Prescott filter with the smoothing parameter of 1600 works as a approximation to a filter that passes cycles of frequency eight years or less.
quarters. Similarly to Hodrick-Prescott filtered data, high consumption correlation is associated with high output correlation, but the consumption correlation is always lower than the output correlation. Cross-country output correlations range from 0.46 to 0.81, and consumption correlations range from -0.13 to 0.64.

Pakko (1994) uses first differenced data. The first differencing method eliminates stochastic and deterministic trends from the data when a time series is integrated of order 1. Unlike Hodrick-Prescott and band-pass filters, the first differencing method passes most of the cyclical components of the data, including the components with periodicity more than 32 quarters. With one exception, Portugal, all the other countries’ output are positively correlated with the U.S. output. Output correlations across countries range from -0.16 to 0.48, and consumption correlations from -0.28 to 0.35. With exceptions of two countries, Finland and Japan, the statistics show that the consumption correlation is lower than the output correlation across countries.

Table 2.3 shows cross-country correlations in quarterly investment and employment between the U.S. and individual 9 countries from 1970:1 to 1990:2. All the correlation statistics are calculated from the data that are in logarithm. The Hodrick-Prescott filtered data show that U.S. investment is positively correlated with other countries, except Canada. Cross-country investment correlations range from -0.01 to 0.56. Employment levels of seven countries out of nine countries are positively correlated with employment levels of the U.S. Cross-country employment correlations range from -0.18 to 0.69. Band-pass filtered data show similar results. All the investment correlations across countries are positive ranging from 0.00 - 0.66. Eight countries’ employment levels are positively correlated with the U.S. employment levels. Employment correlations across countries range from -0.17 to 0.68.
2.2 Predictions from Two-Country General Equilibrium Models

Closed economy stochastic dynamic general equilibrium models have been successful in explaining co-movements of domestic macroeconomic variables. To introduce the basic framework of the business cycle theory, Cooley and Prescott (1994) use a simple stochastic closed economy general equilibrium model, which is a simplified version of Kydland and Prescott (1982). In the model, consumers maximize their life time expected utility defined over consumption, \( C_t \), and leisure, \( 1 - L_t \), where \( L_t \) is the labor supply, and the total available time of consumers is normalized to be 1.

\[
\max \ E_0 \sum_{t=0}^{\infty} \beta \frac{[C_t^{1-\gamma}(1 - L_t)^{\gamma}]^{1-\sigma} - 1}{1 - \sigma},
\]

where \( E_0 \) is the expectation operator conditional on the information available at period 0, and \( \beta \) is the discount factor. The production technology is a constant returns to scale Cobb-Douglass technology which uses capital and labor inputs. So, the resource constraint of the model is given by

\[
C_t + K_{t+1} - (1 - \delta)K_t = Y_t = e^{z_t}K_t^\alpha L_t^{1-\alpha},
\]

where \( K_t \), and \( L_t \) are the capital and labor inputs available at period \( t \), \( \delta \) is the depreciation rate of capital, \( Y_t \) is the output level, and \( z_t \) is the productivity level.

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6 The model in Kydland and Prescott (1982) is more sophisticated than the one in Cooley and Prescott (1994). Kydland and Prescott (1982) use ‘time-to-build’ in capital, inventory in the production function, and effectiveness of past leisure on the current utility conditions. With some simplification restrictions on Kydland and Prescott (1982), their model can be reduced to the model in Cooley and Prescott (1994). Although the performances of the model in Kydland and Prescott (1982) is better than those in Cooley and Prescott (1994), the qualitative results are fairly good in Cooley and Prescott (1994). For the simplicity, the model and simulation results from Cooley and Prescott (1994) are discussed in this section.
The data statistics and simulation results in Cooley and Prescott (1994) are in Table 2.4. The data statistics are calculated from the U.S. quarterly data 1970:1 - 1998:4. The relevant series have been logged and Hodrick-Prescott filtered with a smoothing parameter of 1,600. The data show that output volatility is 1.72% in the U.S. consumption and employment levels are less volatile than output. The consumption and employment volatility relative to output volatility are 0.75 and 0.63, respectively. The investment is 3.24 times more volatile than output. For the domestic co-movements, all the major variables are positively correlated with output. The correlations with output are 0.88 for consumption, 0.93 for investment, and 0.86 for employment level.

The predictions from the closed economy model are quite similar to the data statistics qualitatively. The output volatility is a bit short of the data statistic. The output volatility is 1.35%. Consumption and employment both are less volatile than output as the data statistics. Consumption and employment volatility relative to output volatility are 0.33 and 0.77, respectively. Investment is about 5.86 times more volatile than output. The model predicts that consumption, investment, and employment are positively correlated with output as the data statistics. The correlations with output in the model are 0.84 for consumption, 0.99 for investment, and 0.99 for employment level.

The intuition behind the positive co-movements of variables are as follows. A positive productivity shock in the economy increases the marginal productivity of capital. So, the investment level goes up, and the employment level also goes up due to the ‘make hay while sun shines effect’. These result in higher output level from the initial period of the shock. From the consumption smoothing effect, the
consumption level also increases. So, the economy experiences positive co-movements of macroeconomic variables.

However, a two-country stochastic dynamic general equilibrium model extended from a closed economy model does a poor job in explaining the co-movements of macroeconomic variables across countries. Backus, Kehoe, and Kydland (1992) extend the closed economy general equilibrium model in Kydland and Prescott (1982) into a two-country model under complete asset markets to investigate model predictions of international correlations. The resource constraint is

$$C_t + C_t^* + I_t + I_t^* = Y_t + Y_t^* = e^{z_t} K_t^\alpha L^{1-\alpha} + e^{z_t^*} K_t^* L^{1-\alpha},$$

where $^*$ denotes the foreign variable, and the investment $I_t = K_{t+1} - (1 - \delta) K_t$.

The results from the model in Backus, Kehoe, and Kydland (1993), which is the simplified version of the model in Backus, Kehoe, and Kydland (1992), are in Column 3 of Table 2.1. The model predictions are quite different from the data statistics. The model predicts that output, investment, and employment are negatively correlated across countries, whereas the data statistics are positive. The cross-country correlations in output, investment, and employment are -0.21, -0.94, and -0.78, respectively. Furthermore, the model predicts very high cross-country correlation in consumption, which is greater than the cross-country correlation in output. The cross-country consumption correlation is 0.88. In the data, however, the consumption correlation is lower than the output correlation across countries. They dubbed these failures of the

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7The two-country extension of the model in Cooley and Prescott (1994) is exactly the same as the model in Backus, Kehoe, and Kydland (1993). The main qualitative results from Backus, Kehoe, and Kydland (1992) are quite similar to those from Backus, Kehoe, and Kydland (1993). For the simplicity, the model and simulation results from Backus, Kehoe, and Kydland (1993) are discussed in this section.
model in predicting international correlations as ‘anomalies’ in a two-country general equilibrium model.

The effects of a positive productivity shock at home on home country variables are quite similar to the closed economy model. This shock increases home investment, employment, output, and consumption levels. Since marginal rate of returns in the home country has gone up, the foreign country invests in home firms instead of foreign firms up to the point where the expected marginal rates of returns are the same across countries. This results in a decrease in foreign investment. The employment level at foreign country also goes down due to the relatively low productivity level. Hence, foreign output also decreases. The results are negative correlations in output, investment, and employment across countries. However, foreign consumption increases from the initial period of the shock. If there are no goods market frictions, under complete asset markets, the two countries share country specific risks by trading full menu of state contingent bonds. The risk sharing condition can be represented in the model as

$$\frac{\partial U(C_t, L_t)}{\partial C_t} = \frac{\partial U(C^*_t, L^*_t)}{\partial C^*_t},$$  \hspace{1cm} (2.1)

which says that home and foreign countries trade state contingent bonds up to the point where marginal utilities of consumption for two countries are equalized all the time. So, under this risk sharing condition, good news at home (high home productivity) is also good news for foreign country. Hence, a positive shock at home country increases not only home consumption, but also foreign consumption. This results in very high cross-country consumption correlations in the model.

Researchers have tried to find out what drives low consumption correlation across countries, but still there are no clear explanations for it. This failure of two-country
general equilibrium models in explaining lower consumption correlation than the output correlation across countries is called the ‘international consumption correlation puzzle’.

### 2.3 Current State of the Literature

Literature begins with Backus, Kehoe, and Kydland (1992, 1993). They introduce goods market frictions by introducing quadratic ‘iceberg’ trade costs. Under the presence of the costs, the resource constraint becomes

\[
C_t + C_t^* + I_t + I_t^* = e^{\varepsilon t} K_t^\alpha L_t^{1-\alpha} + e^{\varepsilon t} K_t^* L_t^* - \tau (NX_t)^2,
\]

where \(NX_t\) is the net exports, \(NX_t = Y_t - C_t - I_t\) if home country is a net exporter, and \(NX_t = Y_t^* - C_t^* - I_t^*\) otherwise. \(\tau\) is a parameter for the trade costs. Due to the costs, when one country exports goods to the other of \(NX_t\) amount, \(\tau (NX_t)^2\) fraction of goods vanishes from the economy. In the modified model, it is costly to transfer goods to the other country. Hence, home and foreign countries do not share the risks completely as (2.1). With the trade costs, the risk sharing condition (2.1) becomes

\[
\frac{\partial U(C_t, L_t)}{\partial C_t} = \begin{cases} 
1 - 2\tau NX_t, & \text{if home is a net exporter}, \\
1/(1 - 2\tau NX_t), & \text{if foreign is a net exporter}.
\end{cases}
\]

The simulation results from Backus, Kehoe, and Kydland (1993) with the trade costs are in Column 3 of Table 2.5. Although the trade costs reduce the consumption correlation across countries, they find that these trade costs are not enough in improving the model predictions of cross-country correlations. The modified model still predicts negative correlations in output, investment, and employment, -0.05, -0.48,
and -0.7, respectively. The model also predicts very high consumption correlation, 0.89.

Since the findings from Backus, Kehoe, and Kydland (1992, 1993), researchers have attempted to resolve these ‘anomalies’ by introducing additional features in two-country general equilibrium models. There are two main approaches.

The first approach is to work with goods market frictions. Stockman and Tesar (1995) investigate how the presence of non-traded goods affects international business cycles. They introduce exogenously given traded and non-traded goods in a two-country general equilibrium model. In their model, each country produces two types of goods, traded and non-traded goods. Their model can be considered as a model in which one sector (the traded good sector) bears no costs in international trade, whereas the other sector (the non-traded good sector) bears extremely high costs in international trade. So, all the firms in the traded good sector export goods abroad, but all the firms in the other sector do not export goods abroad. The traded goods are different across countries. The aggregate consumption is defined as

$$C_t = \left[ (C_{ht}^{\theta} C_{ft}^{1-\theta})^{-\mu} + D_t^{\mu} \right]^{-\frac{1}{\mu}},$$

where $C_t$ is the aggregate consumption level, $C_{ht}$ and $C_{ft}$ are the consumption levels of traded goods produced at home and foreign countries, respectively. $D_t$ is the consumption level of the domestic non-traded good.

The simulation results are in Column 4 of Table 2.5. They find that these conditions increase output correlation, and decrease consumption correlation across countries, but not enough to resolve the consumption correlation puzzle. The output
correlation across countries is 0.64, and the consumption correlation is 0.78. Stockman and Tesar (1995) also introduced taste (preferences) shocks additionally. Under this specification, the aggregate consumption is defined as

$$C_t = \left[ \zeta_{ht} \left( C_{ht}^{\theta} C_{ft}^{1-\theta} \right)^{-\mu} + \zeta_{ft} D^{\mu}_t \right]^{-\frac{1}{\mu}},$$

where $\zeta_{it}$ ($i = h, f$) is a positive random variable with mean 1. $\zeta_{it}$ reduces the risk sharing conditions further, since high (low) value of $\zeta_{ht}$ relatively to $\zeta_{ft}$ drives consumers’ preferences toward traded (non-traded) goods. The taste shocks improves the model predictions for international correlations further. However, the consumption correlation is still higher than the output correlation in the modified model. The output correlation becomes 0.63, and the consumption correlation 0.68.

Using a simple two-country endowment economy model, Obstfeld and Rogoff (2000) suggest that many puzzles in international macroeconomics may be resolved by introducing ‘iceberg’ international trade costs, which is proportional costs to trade volumes. They explore how international trade costs, e.g., tariffs and shipping costs, affect international economy. In their model, aggregate consumption is defined as

$$C_t = \left( C_{ht}^{\varphi} + C_{ft}^{\varphi} \right)^{\frac{1}{\varphi}}.$$

Due to the trade costs, when one country exports goods to the other, only $1 - \tau$ ($0 < \tau < 1$) fraction of goods arrive. The resource constraints become

$$C_{ht}^* = (1 - \tau)(Y_t - C_{ht}), \quad C_{ft}^* = (1 - \tau)(Y_t^* - C_{ft}^*),$$

and the risk sharing condition (2.1) becomes

$$\frac{\partial U(C_t, L_t) / \partial C_{ht}}{\partial U(C_t^*, L_t^*) / \partial C_{ht}^*} = (1 - \tau), \quad \frac{\partial U(C_t, L_t) / \partial C_{ft}}{\partial U(C_t^*, L_t^*) / \partial C_{ft}^*} = \frac{1}{1 - \tau}.$$  

\footnote{They do not report the investment or employment correlations across countries.}
Due to international trading costs, marginal utilities of home and foreign consumptions are not equalized with foreign counterparts. This effect reduces the consumption correlation across countries.

Obstfeld and Rogoff (2000) consider $\tau = 0.25$ as a modest value for proportional costs. However, as Engel (2000)'s comments on Obstfeld and Rogoff (2000), $\tau = 0.25$ is too high to be implemented in the model if we consider zero costs for intranational trades in the model. Further more, in simulation exercises with 'iceberg' international trade costs, we find that we need to have extraordinarily high costs ($\tau > 0.30$) to have model improvements in explaining international co-movements of macroeconomic variables.

The other approach is to work with asset market imperfections. Baxter and Crucini (1995) investigate the effects of the financial market imperfection on international transmissions of business cycles. They introduce non-state contingent risk-free bonds. With this limited menu of assets, the risk sharing condition under complete asset markets (2.1) becomes

$$
\beta E_t \left[ \frac{\partial U(C_{t+1}, L_{t+1})}{\partial C_{t+1}} / \frac{\partial U(C_t, L_t)}{\partial C_t} \right] = \beta E_t \left[ \frac{\partial U(C^*_{t+1}, L^*_{t+1})}{\partial C^*_{t+1}} / \frac{\partial U(C^*_t, L^*_t)}{\partial C^*_t} \right].
$$

Consumers buy or sell risk-free bonds so that the expected inter-temporal rate of substitution, which is the price of the risk-free bonds, is the same across countries.

The simulation results from Baxter and Crucini (1995) are in Column 5 of Table 2.5. They find that this condition can induce the model to have positive international correlations in investment and output. The investment correlation is 0.12, and the output correlation is 0.06. However, their model fails to predict lower consumption correlation than output correlation across countries. The consumption correlation is
very high with 0.95. Their model also predicts negative correlations in employment, -0.67.9

Kehoe and Perri (2002) introduce imperfectly enforceable international loans into a two-country general equilibrium model to resolve the anomalies. In their model, any country may default on its national debt and go to an autarky economy from the period and onward. If a country finds that the value of autarky economy is better than that of international trade economy by paying its debt, the country does default on its debt. Hence, when a country lends to the other country, the lending country has to consider the defaulting chance. These enforcement constraints can be defined as

\[
\sum_{r=t}^{\infty} \sum_{s^r} \beta^{t-r} \pi(s^r|s^t) U(C(s^r), L(s^r)) \geq V(K(s^{t-1}), s^t),
\]

(2.2)

where \(s^t\) is the history of events up through and including period \(t\). \(\pi(s^r|s^t)\) is the conditional probability of \(s^r\) given \(s^t\). \(C(s^r)\) and \(L(s^r)\) is consumption and labor in \(s^r\). \(V(K(s^{t-1}), s^t)\) is the value of autarky from \(s^t\) onward. \(K(s^{t-1})\) is the capital level accumulated in \(s^{t-1}\), and available in \(s^t\). Due to these enforcement constraints, a country can borrow from the other country up to the point where (2.2) holds for all \(s^t\). Hence, the international asset market is endogenously incomplete for some states of the world.

The simulation results from Kehoe and Perri (2002) are in Column 6 of Table 2.5. Their model is quite successful in that the model is able to predict correct signs

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9The correlation statistics are based on the simulation results using a trend stationary productivity shocks. Baxter and Crucini (1995) also use a unit root process for the productivity shocks. Under the unit root process, the model predicts negative cross-country correlations in consumption, investment, and employment (-0.28, -0.50, and -0.56, respectively). The output correlation is 0.54 in the model.
for all international correlations. The output and employment correlations are about 1/2 of the data statistics. In the model, the output and employment correlations are 0.25 and 0.23, respectively. The investment correlation in the model, 0.33, is close to the data statistic, 0.29. However, their model still cannot resolve the consumption correlation puzzle. The model predicts higher consumption correlation than the output correlation, though the consumption correlation is very low compared to other models. The consumption correlation across countries is 0.29. Another failure of the model is that the model cannot explain counter-cyclical net export behavior. Data show that output and net exports are negatively correlated. This means that the high output is associated with current account deficit. However, the model predicts wrong sign for the correlation between output and net exports. The model predicts that the correlation between net exports and output is 0.27, whereas the data show that the correlation is -0.36.

Introducing additional conditions, goods market frictions or asset market imperfection, in two-country general equilibrium models improves the model performances in explaining co-movements of macroeconomic variables across countries. However, researchers also find that these conditions are not sufficient to explain international business cycles. The international consumption correlation puzzle is still a puzzle.
International Data Model predictions correlations from BKK (1993)

<table>
<thead>
<tr>
<th>International correlations</th>
<th>Data</th>
<th>Model predictions from BKK (1993)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>0.51</td>
<td>-0.21</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.32</td>
<td>0.88</td>
</tr>
<tr>
<td>Investment</td>
<td>0.29</td>
<td>-0.94</td>
</tr>
<tr>
<td>Employment</td>
<td>0.43</td>
<td>-0.78</td>
</tr>
</tbody>
</table>

Notes: These are correlations computed from quarterly data between the U.S. and an aggregate of 15 European countries 1970:1 - 1998:4 and from simulations of Backus, Kehoe, and Kydland (1993) model. Data statistics are from Kehoe and Perri (2002). BKK (1993) stands for the simulation results in Backus, Kehoe, and Kydland (1993). To detrend the time series, the relevant series have been logged and H-P filtered with a smoothing parameter of 1,600.

Table 2.1: International Correlations and Anomalies
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>0.51</td>
<td>-0.19</td>
<td>0.60</td>
</tr>
<tr>
<td>Austria</td>
<td>0.38</td>
<td>0.23</td>
<td>0.54</td>
</tr>
<tr>
<td>Canada</td>
<td>0.76</td>
<td>0.49</td>
<td>0.81</td>
</tr>
<tr>
<td>Finland</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>France</td>
<td>0.41</td>
<td>0.39</td>
<td>0.46</td>
</tr>
<tr>
<td>Germany</td>
<td>0.69</td>
<td>0.49</td>
<td>0.85</td>
</tr>
<tr>
<td>Italy</td>
<td>0.41</td>
<td>0.02</td>
<td>0.49</td>
</tr>
<tr>
<td>Japan</td>
<td>0.60</td>
<td>0.44</td>
<td>0.66</td>
</tr>
<tr>
<td>Netherlands</td>
<td>-</td>
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<tr>
<td>Norway</td>
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<td>-</td>
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<tr>
<td>Portugal</td>
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</tr>
<tr>
<td>Spain</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.42</td>
<td>0.40</td>
<td>0.48</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.55</td>
<td>0.42</td>
<td>0.64</td>
</tr>
</tbody>
</table>

Notes: These are correlations between the U.S. variable and foreign country counterpart. BKK (1993), Baxter (1995), and Pakko (1994) are from Backus, Kehoe, and Kydland (1993), Baxter (1995), and Pakko (1994). H-P filtered: Hodrick-Prescott filtered data; B-P filtered: Band-pass filtered data; and First differenced: First differenced data. All the relevant series have been logged and filtered with appropriate filters.

Table 2.2: Cross-Country Correlations in Output and Consumption
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Investment</td>
<td>Employment</td>
</tr>
<tr>
<td>Australia</td>
<td>0.16</td>
<td>-0.18</td>
</tr>
<tr>
<td>Austria</td>
<td>0.48</td>
<td>0.47</td>
</tr>
<tr>
<td>Canada</td>
<td>-0.01</td>
<td>0.53</td>
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<tr>
<td>France</td>
<td>0.22</td>
<td>0.26</td>
</tr>
<tr>
<td>Germany</td>
<td>0.55</td>
<td>0.52</td>
</tr>
<tr>
<td>Italy</td>
<td>0.31</td>
<td>-0.01</td>
</tr>
<tr>
<td>Japan</td>
<td>0.56</td>
<td>0.35</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.38</td>
<td>0.36</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.40</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Notes: These are correlations between the U.S. variable and foreign country counterpart. BKK (1993), and Baxter (1995) are from Backus, Kehoe, and Kydland (1993), and Baxter (1995). H-P filtered: Hodrick-Prescott filtered data; and B-P filtered: Band-pass filtered data. All the relevant series have been logged and filtered with appropriate filters.

Table 2.3: Cross-Country Correlations in Investment and Employment
<table>
<thead>
<tr>
<th>Statistics</th>
<th>Data</th>
<th>Model predictions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard deviation (in percent)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>1.72</td>
<td>1.35</td>
</tr>
<tr>
<td><strong>Standard deviation (relative to output)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>0.79</td>
<td>0.33</td>
</tr>
<tr>
<td>Investment</td>
<td>3.24</td>
<td>5.86</td>
</tr>
<tr>
<td>Employment</td>
<td>0.63</td>
<td>0.77</td>
</tr>
<tr>
<td><strong>Correlation with output</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>0.88</td>
<td>0.84</td>
</tr>
<tr>
<td>Investment</td>
<td>0.93</td>
<td>0.99</td>
</tr>
<tr>
<td>Employment</td>
<td>0.86</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Notes: The data statistics are from Kehoe and Perri (2002). They use the U.S. quarterly data 1970:1 - 1998:4. The relevant series have been logged and Hodrick-Prescott filtered with a smoothing parameter of 1,600. Model predictions are the simulation results in Cooley and Prescott (1994).

Table 2.4: Business Cycles: Closed Economy
<table>
<thead>
<tr>
<th>International correlations</th>
<th>Data</th>
<th>Goods market frictions</th>
<th>Asset market imperfection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>0.51</td>
<td>-0.05</td>
<td>0.64</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.32</td>
<td>0.89</td>
<td>0.78</td>
</tr>
<tr>
<td>Investment</td>
<td>0.29</td>
<td>-0.48</td>
<td>-</td>
</tr>
<tr>
<td>Employment</td>
<td>0.43</td>
<td>-0.70</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes: These are correlations computed from quarterly data between the U.S. and an aggregate of 15 European countries 1970:1 - 1998:4 and from simulations. BKK (1993) are the simulation results of Backus, Kehoe, and Kydland (1993) with quadratic international costs to trade volumes, ST (1995) are the results of Stockman and Tesar (1995), BC (1995) are the results of Baxter and Crucini (1995), and KP (2002) are the results of Kehoe and Perri (2002). To detrend the time series, the relevant series have been logged and H-P filtered with a smoothing parameter of 1,600.

Table 2.5: International Correlation Statistics from Modified Models
CHAPTER 3

CHARACTERISTICS OF EXPORTERS

Drawing upon research findings, this chapter discusses the motivation for introducing export penetration costs in a two-country general equilibrium model.

3.1 Exporters vs. Non-exporters

From the mid 1990s, firm level data of some countries became available to researchers. Using these firm-level data, researchers investigate determinants of firms’ export status, and other features of exporters.

Empirical research finds significant differences between exporters and non-exporters. Firm-level data show that exporters tend to have higher productivity than non-exporters. Using the U.S. Census Bureau’s Annual Survey of Manufacturers (ASM) 1984 - 1992, Bernard and Jensen (1999a) find that exporters have 13% - 16% higher total factor productivity. Girma, Greenaway, and Kneller (2002) use annual firm-level data 1988 - 1999 in the United Kingdom, and find that exporters’ total factor productivity levels are about 7.5% higher than non-exporters on average. Delgado, Fariñas, and Ruano (2002) use annual survey data of Spanish manufacturing firms 1991 - 1996. They find that the median productivity of the exporters is 7% higher
than that of non-exporters. Aw, Chung, and Roberts (1998) use Korean and Taiwan annual manufacturing censuses data of 5 industries, textiles, apparel, plastics, electrical machinery/electronics, and transportation equipment. Taiwan data covers the years 1981, 1986, and 1991, and Korean data covers the years 1983, 1988, and 1993. They find that on average exporters in Taiwan have about 11.8% to 27.6% higher total factor productivity than non-exporters across industries, and exporters in Korea have about 3.9% to 31.1% higher productivity than non-exporters across industries. Empirical research finds that these higher productivity of exporters are a major cause of firms being exporters. However, the research finds little evidence for the hypothesis that exporting status itself increases the productivity of a exporter. Bernard and Wagner (1998) find the similar results using annual survey data of manufacturing plants of all establishments with 20 or more employees in Lower Saxony, Germany from 1978 to 1992.

Another finding from firm-level data is that exporters are larger in size compared to non-exporters. Exporters tend to have higher capital per worker, and larger employment level compared to non-exporters. Using the Census Bureau’s ASM 1987, Bernard and Jensen (1995) find that compared to non-exporters, exporters have 47.8% higher capital per workers. Bernard and Jensen (1999a) find that the U.S. exporters have 20% - 45% larger employment level and 104.0% - 112.6% higher total shipments than non-exporters. Girma, Greenaway, and Kneller (2002) find that in the United Kingdom, exporters have 28.3% larger employment levels and about 24.5% higher total sales than non-exporters. German data from Bernard and Wagner (1998) show that employment levels of exporters are about 4.2 - 8.6 times higher than those of
non-exporters, and the sales of exporters are about 3.9 - 6.2 times higher than those of non-exporters.

### 3.2 Turnover Ratios in Export Status

Using start-up costs in partial equilibrium models, Baldwin (1988), Baldwin and Krugman (1989), and Dixit (1989a,b) explain the export hysteresis. Under the presence of the costs, only firms that can overcome the costs export goods abroad. Once a firm penetrates into a foreign market, there are no additional costs that the firm has to pay to remain in the foreign market. Hence, there are no reasons for an exporter to exit from the foreign market after entering the foreign market. This effect results in the export hysteresis. Empirical studies show that these entry costs are present. However, unlike the models’ suggestion, the research finds that not only non-exporters become exporters, but also a significant percentage of exporters exit from the foreign market.

Empirical research finds that there are significant export penetration and continuation costs in international trade and these costs are one of the major determinants in the exporting decisions of producers. These costs include higher foreign marketing and distribution costs, additional bureaucratic procedures, and required changes in product characteristics to match up to the tastes of foreign consumers and government regulations. Das, Roberts, and Tybout (2001) estimate export penetration and continuation costs using annual data of Colombian chemical producers 1982 - 1991. They divide the plants into 4 groups based on plant sizes (domestic market share). They find that export penetration costs are inversely related with plant sizes. a newly
exporting firm in the largest quartile pays 107.99 million pesos, whereas a newly exporting firm in the smallest quartile pays 242.17 million pesos as export penetration costs on average in 1986 pesos. Average export penetration costs for firms in the second and the third largest quartiles are 155.60 and 135.52 million pesos in 1986 pesos, respectively. These estimates suggest that penetrating into a foreign market is relatively easier for a large firm than a small firm. They also find that a continuing exporter pays 0.48 million pesos as continuation costs to remain in foreign markets. Average firm-level exports in 1986 was 587.50 million pesos. These means that a newly exporting firm pays about 18.4% - 41.2% of exports as entry costs on average, whereas a continuing exporter pays less than 1% of exports as continuation costs to remain in foreign markets on average.

Bernard and Wagner (1998), Aw, Chung, and Roberts (1998), and Bernard and Jensen (1999b) also find the significance of entry costs in international trade. Due to the start-up costs in models of Baldwin (1988), Baldwin and Krugman (1989), and Dixit (1989a,b), only non-exporters change their export status to exporters. All the firms in their models remain in foreign markets once they engage in foreign markets. So, their models cannot explain why a certain fraction of exporters exit from foreign markets. The empirical studies find that continuing exporters also pay relatively low costs to remain in the foreign market. These costs explain why some firms in the export sector exit from the foreign market. These 2 types of costs in international trade support the findings of the hysteresis, and the transition of export status.

Firm-level data show that there are substantial changes in the turnover ratios in export status, although a firm’s export status is persistent. Table 3.1 shows starter, stopper, and exporter ratios of the U.S., German, and Colombian plants. The U.S.
data are from Bernard and Jensen (2001). They use the Census Bureau’s Annual Survey of Manufacturers from the Longitudinal Research Database of the Bureau of the Census from 1984 to 1992. The balanced panel data cover the sample of 13,550 plants. The U.S. data show that starter ratios range from 12.59% - 16.40% over the sample periods. Stopper ratios range from 9.48% - 14.79% over the sample periods. The average stopper ratio (12.20%) is lower than the average starter ratio (14.39%). Exporter ratios are increasing over time. The ratios range from 48.66% - 54.02%. The average exporter ratio is 51.82% over the sample periods.

German data from Bernard and Wagner (1998) also show that a significant percentage of producers also change their export status over the sample periods 1979 - 1992. Starter ratios range from 3.01% - 5.58%, and stopper ratios from 4.64% - 6.45%. The average starter ratio (4.14%) is lower than the average stopper ratio (5.51%) over the sample periods. The exporter ratios are generally increasing over the sample periods. The ratios range from 36.66% - 45.27%. The average exporter ratio is 41.21% over the sample periods.

Colombian data formed by Roberts and Tybout (1997) show that starter ratios are relatively lower than those in German data, but stopper ratios are relatively higher than those in German data. They use annual plant-level data from Colombian manufacturing census 1981 - 1989 with the sample size of 2,369 plants. Starter ratios range from 2.6% - 4.3%, and stopper ratios from 16.8% - 1.7%. The average starter ratio (3.3%) is a lot lower than the average stopper ratio (11.5%) over the sample periods. These result in very low exporter ratio. The average exporter ratio is 11.8% over the sample periods.
Spanish, Moroccan, Mexican firm-level data also show a significant percentage of firms change their export status over time. Delgado, Fariñas, and Ruano (2002) find that on average about 11% - 16% of firms change their export status over the sample periods. Clerides, Lach, and Tybout (1998) show that in Morocco about 4.9% of non-exporters enter into the foreign market, and about 3.7% of exporters exit from the foreign market in the following period on average over the sample period 1984 - 1991.\(^\text{10}\) They also find that in Mexico about 4.8% of non-exporters start exporting goods abroad, and about 1.5% of exporters stop exporting goods abroad in the next period.\(^\text{11}\)

Figure 3.1 shows the patterns of starter, stopper, and exporter ratios of the U.S., Germany, and Colombia. Starter ratios in Figure 3.1.A show that the movements of German starter ratios are quite similar to those of Colombian starter ratios. The ratios increase from the initial sample periods and reach their peaks in 1985. The U.S. starter ratios show that the peak occurs in 1985 as the second peak of German starter ratios. Stopper ratios in Figure 3.1.B show that they are relatively stable compared to starter ratios. However, the movements of U.S. and Colombian stopper ratios are quite similar to those of German stopper ratios. The data also show that stopper ratios in all three countries are slightly decreasing over time. Exporter ratios in Figure 3.1.C show that they are generally increasing over time for all three countries. These increases due to the downward trended stopper ratios.


More interestingly, these turnover ratios in export status are positively correlated across countries. Table 3.2 shows the correlations of the starter, stopper, and exporter ratios between countries.\textsuperscript{12} The cross-country correlations in starter, stopper, and exporter ratios are 0.12, 0.69, and 0.83 between the U.S. and Germany, respectively. Signs of the correlations are robust to linear detrending. Linearly detrended data show that the correlations between the U.S. and Germany are 0.60 for starter ratios, 0.96 for stopper ratios, and 0.32 for exporter ratios. Colombian turnover ratios in export status are also positively correlated with German counterparts. The cross-country correlations in starter, stopper, and exporter ratios are 0.63, 0.62, and 0.79, respectively. After detrending the series, the correlations become 0.13 for starter ratios, 0.98 for stopper ratios, and 0.92 for exporter ratios.

The correlations of the turnover ratios in export status with the log of the real effective exchange rate (henceforth RER) are shown in the third part of Table 3.2. High value of RER implies the depreciation of the domestic currency. Starter ratios are positively correlated with RER, and stopper ratios are negatively correlated with RER for all 3 countries. Hence, the data suggest that high value of RER increases the probability of exporting for both previous exporters and non-exporters. However, the correlations between exporter ratios and RER show mixed signs. For the U.S. and Colombia, the correlations are strongly positive, 0.79 and 0.60, whereas German exporter ratios are negatively correlated with RER, -0.48.

\textsuperscript{12}Since the U.S. and Colombian data overlaps only for 3 years, international correlations between the U.S. and Colombian data are not calculated.
<table>
<thead>
<tr>
<th>Year</th>
<th>Starter Ratios</th>
<th>Stopper Ratios</th>
<th>Exporter Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>US&lt;sup&gt;a&lt;/sup&gt;</td>
<td>GR&lt;sup&gt;b&lt;/sup&gt;</td>
<td>CO&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>1979</td>
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<td>4.30</td>
<td>2.9</td>
</tr>
<tr>
<td>1985</td>
<td>-</td>
<td>5.58</td>
<td>4.3</td>
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<tr>
<td>1986</td>
<td>-</td>
<td>4.81</td>
<td>3.7</td>
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<tr>
<td>1987</td>
<td>13.61</td>
<td>3.79</td>
<td>2.6</td>
</tr>
<tr>
<td>1988</td>
<td>16.40</td>
<td>5.29</td>
<td>2.8</td>
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<tr>
<td>1989</td>
<td>12.59</td>
<td>4.74</td>
<td>4.2</td>
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<tr>
<td>1990</td>
<td>14.24</td>
<td>4.21</td>
<td>-</td>
</tr>
<tr>
<td>1991</td>
<td>13.40</td>
<td>4.21</td>
<td>-</td>
</tr>
<tr>
<td>1992</td>
<td>16.10</td>
<td>3.64</td>
<td>-</td>
</tr>
<tr>
<td>Average</td>
<td>14.39</td>
<td>4.14</td>
<td>3.3</td>
</tr>
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</table>

Sources: a. Recalculation of Table 5 in Bernard and Jensen (2001); b. Recalculation of Table 2 in Bernard and Wagner (1998); c. Table 2 in Roberts and Tybout (1997).

Notes: Starter ratio – the ratio of non-exporters that transition to exporter status to the number of last period exporters; Stopper ratio – the ratio of exporters that transition to non-exporter status to the number of last period non-exporters; Exporter ratio – the ratio of exporters to the number of all firms.

Table 3.1: Starter, Stopper, and Exporter Ratios
<table>
<thead>
<tr>
<th>Statistics</th>
<th>U.S.</th>
<th>Germany</th>
<th>Colombia</th>
</tr>
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<tr>
<td><strong>International correlation: Levels</strong></td>
<td></td>
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<td></td>
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<tr>
<td>Starter ratios</td>
<td>0.12</td>
<td>1.00</td>
<td>0.63</td>
</tr>
<tr>
<td>Stopper ratios</td>
<td>0.69</td>
<td>1.00</td>
<td>0.62</td>
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<td>Exporter ratios</td>
<td>0.83</td>
<td>1.00</td>
<td>0.79</td>
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<td><strong>International correlation: Linearly detrended</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Starter ratios</td>
<td>0.60</td>
<td>1.00</td>
<td>0.13</td>
</tr>
<tr>
<td>Stopper ratios</td>
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<td>0.98</td>
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<td>Exporter ratios</td>
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<tr>
<td><strong>Correlation with RER</strong></td>
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<tr>
<td>Starter ratios</td>
<td>0.80</td>
<td>0.19</td>
<td>0.39</td>
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<tr>
<td>Stopper ratios</td>
<td>-0.13</td>
<td>-0.30</td>
<td>-0.60</td>
</tr>
<tr>
<td>Exporter ratios</td>
<td>0.72</td>
<td>-0.48</td>
<td>0.60</td>
</tr>
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</table>

Notes: The statistics in the U.S. and Colombia columns are the correlations of relevant variables with German counterparts. RER is the log of real effective exchange rates. High value of RER implies the depreciation of domestic currency.

Table 3.2: Correlations of the Turnover Ratios in Export Status
Figure 3.1: Turnover Ratios in Export Status
CHAPTER 4

A TWO-COUNTRY DYNAMIC GENERAL EQUILIBRIUM MODEL WITH EXPORT PENETRATION COSTS

This chapter develops a symmetric two-country general equilibrium model with export penetration costs based on empirical findings from firm-level data.

4.1 The World Environment

There are two countries, home and foreign. Each country is populated by a large number of identically and infinitely lived consumers. Each country has infinitely many monopolistically competitive intermediate good producers with mass of 1 indexed \( i \in (0, 1) \). Each intermediate good producer can price discriminate across countries, and sets prices in the local currency. An intermediate good producer uses capital and labor inputs to produce intermediate goods. When an intermediate good producer exports goods abroad, the producer has to pay international trading costs. The costs depends on the export status of the producer in the previous period. There is a (relatively) high initial entry cost \( \tau_0 \) that must be borne to gain entry into the export market. In subsequent periods, a lower but nonzero cost \( \tau_1 (< \tau_0) \), must be borne
to continue exporting to the foreign country. Competitive final good producers use home and foreign intermediate goods as inputs to production.\textsuperscript{13} The final goods are used for domestic consumption or investment. All the intermediate and final good producers are owned by domestic consumers.

In each period of time, the economy experiences an event $s_t$. Let $s^t = (s_0, \cdots, s_t)$ be the history of events from period 0 up to and including period $t$. The probability of a history $s^t$, conditional on the information available at period 0, is defined as $Pr(s^t|s^0)$. The initial realization of an event at period 0, $s_0$, is given.\textsuperscript{14}

### 4.2 Consumers

The representative domestic consumer maximizes expected lifetime utility,

$$\max \sum_{t=0}^{\infty} \sum_{s^t} \beta^t Pr(s^t|s^0)U[C(s^t), L(s^t)],$$  \hspace{1cm} (4.1)

subject to the budget constraint,

$$P(s^t)C(s^t) + \sum_{s^{t+1}} Q(s^{t+1}|s^t)B(s^{t+1})$$

$$\leq P(s^t)W(s^t)L(s^t) + B(s^t) + \Pi(s^t) + P(s^t)T(s^t),$$  \hspace{1cm} (4.2)

where $\beta$ is the discount factor. $U[\cdot]$ is an instantaneous utility function. $C(s^t)$ and $P(s^t)$ are the final good consumption and the price level, respectively. $L(s^t)$ is the labor supply. $W(s^t)$ is the real wage rate. $Q(s^{t+1}|s^t)$ is the nominal price of the state contingent bond $B(s^{t+1})$ given $s^t$. $B(s^t)$ is the amount of state contingent bonds for $s^t$ that the consumer bought at period $t - 1$. The state contingent bond $B(s^t)$

---

\textsuperscript{13}Final good production technology does not require capital or labor inputs. The final good production technology regulates the preferences of a country on home and foreign goods.

\textsuperscript{14}The history of events, $s^t$, maps onto the state of the world.
pays 1 unit of home currency if $s^t$ occurs, and 0 otherwise. A complete set of state contingent bonds is available to consumers. $\Pi(s^t)$ is the sum of profits of domestic intermediate and final good producers. $T(s^t)$ is the transfer from the government. The instantaneous utility function is given as

$$U(C, L) = \frac{[C^\gamma(1 - L)^{1-\gamma}]^{1-\sigma}}{1-\sigma},$$  \hspace{1cm} (4.3)$$

where $1/\sigma$ is the inter-temporal elasticity of substitution, and $\gamma$ is the share parameter for consumption in the composite commodity.

Similarly, the foreign representative consumer maximizes expected lifetime utility,

$$\max \sum_{t=0}^{\infty} \sum_{s^t} \beta^tPr(s^t|s^0)U[C^*(s^t), L^*(s^t)],$$  \hspace{1cm} (4.4)$$

subject to the budget constraint,

$$P^*(s^t)C^*(s^t) + \sum_{s^{t+1}} \frac{Q(s^{t+1}|s^t)}{e(s^t)}B^*(s^{t+1}) \leq P^*(s^t)W^*(s^t)L^*(s^t) + \frac{B^*(s^t)}{e(s^t)} + \Pi^*(s^t) + P^*(s^t)T^*(s^t),$$  \hspace{1cm} (4.5)$$

where $^*$ denotes the foreign variables. $e(s^t)$ is the nominal exchange rate with home currency as numeraire.

The first order conditions for the home and foreign representative consumers’ utility maximization problems give the labor supply functions

$$\frac{-U_L(s^t)}{U_C(s^t)} = W(s^t), \quad \frac{-U^*_L(s^t)}{U^*_C(s^t)} = W^*(s^t),$$  \hspace{1cm} (4.6)$$

the price of the state contingent bonds

$$Q(s^{t+1}|s^t) = \beta Pr(s^{t+1}|s^t) \frac{U_C(s^{t+1})}{U_C(s^t)} \frac{P(s^t)}{P(s^{t+1})},$$  \hspace{1cm} (4.7)$$

$$= \beta Pr(s^{t+1}|s^t) \frac{U^*_C(s^{t+1})}{U^*_C(s^t)} \frac{e(s^t)P^*(s^t)}{e(s^{t+1})P^*(s^{t+1})},$$  \hspace{1cm} (4.7)$$
and the real exchange rate

\[ q(s^t) = \frac{e(s^t)P^*(s^t)}{P(s^t)} = \kappa \frac{U_C^*(s^t)}{U_C(s^t)}, \quad (4.8) \]

where \( U_C(s^t) \), and \( U_L(s^t) \) denote the derivatives of the utility function with respect to its arguments. \( \kappa = q(s^0)U_C(s^0)/U_C^*(s^0) \).\(^{15}\) The wage rate, \( W(s^t) \), is equal to the ratio of marginal disutility of labor and the marginal utility of consumption. The price of a state contingent bond, \( Q(s^{t+1}|s^t) \), equals to the inter-temporal marginal rate of substitution times the conditional probability of the history of events \( s^{t+1} \) given the current history of events \( s^t \). Under the complete asset market condition, the real exchange rate, \( q(s^t) \), is proportional to the ratio of marginal utility of consumption at foreign to that at home.

### 4.3 Final Good Producers

The representative final good producer purchases intermediate goods from domestic and foreign producers to produce final goods. The production technology of the firm is given by a constant elasticity of substitution (henceforth CES) function

\[ D(s^t) = \left\{ a_1 \left[ \int_0^1 y^d(h, i, s^t)^\theta di \right]^{\frac{\theta}{\rho}} + a_2 \left[ \int_{i \in E^*(s^t)} y^d(f, i, s^t)^\theta di \right]^{\frac{\theta}{\rho}} \right\}^{\frac{1}{\theta}}, \quad (4.9) \]

where \( D(s^t) \) is the output of final goods. \( y^d(h, i, s^t) \), and \( y^d(f, i, s^t) \) are inputs of intermediate goods produced at home and foreign countries, respectively. \( a_1 \) and \( a_2 \) are home bias parameters. \( a_1 > a_2 \) means a greater preference toward home intermediate goods than foreign intermediate goods. \( E^*(s^t) = \{ i \in (0, 1) \mid \text{the } i_{th} \text{ firm is a foreign exporter in } s^t \} \). All the domestic intermediate goods are available

\(^{15}\)For the derivation of the real exchange rate, see Appendix A. In simulation exercises, \( \kappa \) is normalized to be 1.
to domestic final good producers. However, due to the trade costs, only a fraction
\[ N^*(s^t) = \int_{i \in E^*(s^t)} 1 \, di \]
of foreign intermediate goods are available to home final good producers. From the properties of the CES function, the elasticity of substitution between intermediate goods that are produced at the same country is \( 1/(1 - \theta) \), and the elasticity of substitution between home and foreign aggregate inputs is \( 1/(1 - \rho) \).

The final goods market is competitive. In each period \( t \), given the final good price at home \( P(s^t) \), the \( i_{th} \) home intermediate good price at home \( P(h, i, s^t) \) for \( i \in (0, 1) \), and the \( i_{th} \) foreign intermediate good price at home \( P(f, i, s^t) \) for \( i \in E^*(s^t) \), a home final good producer chooses inputs \( y^d(h, i, s^t) \) for \( i \in (0, 1) \), and \( y^d(f, i, s^t) \) for \( i \in E^*(s^t) \) to maximize profits,

\[
\max P(s^t)D(s^t) - \int_0^1 P(h, i, s^t)y^d(h, i, s^t)di
- \int_{i \in E^*(s^t)} P(f, i, s^t)y^d(f, i, s^t)di,
\tag{4.10}
\]
subject to the production technology (4.9). Solving the problem in (4.10) gives the input demand functions,

\[
y^d(h, i, s^t) = a_1^{-\rho} \left[ P(h, i, s^t) \right]^{\frac{1}{\rho-1}} \left[ P(h, s^t) \right]^{\frac{1}{\rho-1}} D(s^t),
\tag{4.11}
\]

\[
y^d(f, i, s^t) = a_2^{-\rho} \left[ P(f, i, s^t) \right]^{\frac{1}{\rho-1}} \left[ P(f, s^t) \right]^{\frac{1}{\rho-1}} D(s^t),
\tag{4.12}
\]

where \( P(h, s^t) = \left[ \int_0^1 P(h, i, s^t)^{\frac{\theta}{\rho-1}} di \right]^{\frac{\rho-1}{\theta}} \), and \( P(f, s^t) = \left[ \int_{i \in E^*(s^t)} P(f, i, s^t)^{\frac{\theta}{\rho-1}} di \right]^{\frac{\rho-1}{\theta}} \).

The zero-profit condition in the perfectly competitive market gives the price level of the final goods,

\[
P(s^t) = \left[ a_1^{-\rho} P(h, s^t)^{\frac{\theta}{\rho-1}} + a_2^{-\rho} P(f, s^t)^{\frac{\theta}{\rho-1}} \right]^{\frac{1}{\theta}}.
\tag{4.13}
\]
4.4 International Trading Costs

An intermediate good producer can sell its product without frictions in the domestic market. It is costly, however, to sell its product abroad. Producers that export to the foreign country face two sets of international trading costs. To enter the foreign market, an intermediate good producer has to pay a (relatively) high initial entry costs $\tau_0$. From the following period, to continue exporting to the foreign country, the producer has to pay a lower but nonzero continuation costs $\tau_1 (< \tau_0)$. The export penetration costs ($\tau_0$) and continuation costs ($\tau_1$) are collected from foreign exporting firms by the domestic government, and distributed lump-sum to the domestic consumers. The government’s budget constraint is given by

$$T(s^t) = \int_{i \in X^*(s^t)} \{[1 - m^*(i, s^{t-1})]\tau_0 + m^*(i, s^{t-1})\tau_1\} \, di,$$  \hspace{1cm} (4.14)

where $m^*(i, s^t)$ is the indicator function for the export status of the $i_{th}$ intermediate good producer in $s^t$. $m^*(i, s^t) = 1$ if the $i_{th}$ foreign intermediate good producer is an exporter in $s^t$, 0 otherwise.\(^{16}\)

4.5 Intermediate Good Producers

An intermediate good firm produces differentiated goods with a Cobb-Douglas production technology,

$$F(i, s^t_i) = A(i, s^t_i)K(i, s^{t-1}_i)^\alpha L(i, s^t_i)^{1-\alpha} = y(h, i, s^t_i) + y^*(h, i, s^t_i), \hspace{1cm} (4.15)$$

\(^{16}\)In reality, most of the costs are paid to agents that help exporting firms, not to the foreign government. However, no matter to whom the costs are paid initially, the payment goes to consumers ultimately. Another question arises from the fact that not all costs are paid to the foreign country. Some of them are paid to domestic agents. The simulation exercises show that the results are not sensitive to the fractions of costs that are paid to the foreign country. To make matters simple, it is assumed that the costs are paid to the foreign government throughout the dissertation.
where $s^t_i$ is the history of the firm-specific events from period 0 up to and including period $t$.\(^{17}\) $\alpha$ is the share parameter for capital input in the composite input. $y(h, i, s^t_i)$ and $y^*(h, i, s^t_i)$ are amounts of goods sold at home and foreign intermediate goods markets in $s^t_i$, respectively. $A(i, s^t_i)$ is the productivity of the $i_{th}$ firm in $s^t_i$. $K(i, s^t_{i-1})$ and $L(i, s^t_i)$ are capital, and labor inputs of the firm in $s^t_i$, respectively. Capital used in the production is augmented by investment of final goods, $I(i, s^t_i)$. The law of motion for capital is given by

$$K(i, s^t_i) = (1 - \delta)K(i, s^t_{i-1}) + I(i, s^t_i), \quad (4.16)$$

where $\delta$ is the depreciation rate.

An intermediate good producer’s productivity is composed of a country-wide productivity $z(s^t)$, and a firm-specific productivity $\eta(i, s^t_i)$.

$$\ln A(i, s^t_i) = z(s^t) + \eta(i, s^t_i). \quad (4.17)$$

$z(s^t)$ is correlated across countries and evolves according to a vector autoregressive process (VAR) with the foreign country-wide productivity, $z^*(s^t)$,

$$Z(s^t) = M Z(s^{t-1}) + \nu(s^t), \quad \nu(s^t) \overset{iid}{\sim} N(0, \Omega), \quad (4.18)$$

where $M$ is a coefficient matrix. $Z(s^t) = [z(s^t), z^*(s^t)]'$ and $\nu(s^t) = [\epsilon(s^t), \epsilon^*(s^t)]'$.

The firm-specific productivity is independently, identically distributed across countries, firms, and time, $\eta(i, s^t_i) \overset{iid}{\sim} N(0, \sigma^2_\eta)$.

\(^{17}\)The firm-specific history of events, $s^t_i$, maps onto the firm-specific state, which is composed of the state of the world, the $i_{th}$ firm’s capital input available at period $t$, $K(i, s^t_{i-1})$, the export status of the $i_{th}$ producer at period $t - 1$, $m(i, s^t_{i-1})$, and the productivity of the $i_{th}$ producer at period $t$, $A(i, s^t_i)$. 
Each period, an intermediate good producer at home maximizes the expected discounted value of the firm after the realization of $s_t^i$,

$$V[i, s_t^i; \eta(i, s_t^i), K(i, s_t^{i-1}), m(i, s_t^{i-1})]$$

$$= \max \sum_{t=0}^{\infty} \sum_{s_t^i} \sum_{\eta(i, s_t^i)} \Pr[\eta(i, s_t^i)]Q(s_t^i)\Pi(i, s_t^i),$$

(4.19)

where $\Pi(i, s_t^i) = P(h, i, s_t^i)y(h, i, s_t^i) - P(s_t^i)W(s_t^i)L(i, s_t^i) - P(s_t^i)I(i, s_t^i)$

$$+ m(i, s_t^i) \left\{ e(s_t^i)P^*(h, i, s_t^i)y^*(h, i, s_t^i) - e(s_t^i)P^*(s_t^i)[m(i, s_t^{i-1})\tau_1$$

$$+ (1 - m(i, s_t^{i-1}))\tau_0] \right\},$$

(4.20)

subject to the production technology (4.15), the law of motion for capital (4.16), and the constraints that supplies to home and foreign intermediate goods market $y(h, i, s_t^i)$ and $y^*(h, i, s_t^i)$ are equal to demands by home and foreign final good producers $y^d(h, i, s_t^i)$ and $y^d^*(h, i, s_t^i)$ from (4.11) and its foreign analogue. Here, $\Pr[\eta(i, s_t^i)]$ is the probability of $\eta(i, s_t^i)$. $Q(s_t^i)$ is the price of one unit of home currency in $s_t^i$ in an abstract unit of account. Since firms are owned by domestic consumers, $Q(s_t^{i+1})/Q(s_t^i)$ should be the same as the inter-temporal marginal rate of substitution. From the bond price condition (4.7), $Q(s_t^{i+1})/Q(s_t^i) = Q(s_t^{i+1}|s_t^i)$.

Let the value of the $i_{th}$ producer if it exports in $s_t^i$ be

$$V_1[i, s_t^i; \eta(i, s_t^i), K(i, s_t^{i-1}), m(i, s_t^{i-1})]$$

$$= \max \sum_{t=0}^{\infty} \sum_{s_t^i} \sum_{\eta(i, s_t^i)} \Pr[\eta(i, s_t^i)]Q(s_t^i|s_t^0) \left\{ P(h, i, s_t^i)y(h, i, s_t^i)$$

$$- P(s_t^i)W(s_t^i)L(i, s_t^i) - P(s_t^i)I(i, s_t^i) + e(s_t^i)P^*(h, i, s_t^i)y^*(h, i, s_t^i)$$

$$- e(s_t^i)P^*(s_t^i)[m(i, s_t^{i-1})\tau_1 + (1 - m(i, s_t^{i-1}))\tau_0] \right\},$$

(4.21)
and the value of the \(i_{th}\) producer if it does not export in \(s_i^t\) be

\[
V_0 [i, s_i^t; \eta(i, s_i^t), K(i, s_i^{t-1}), m(i, s_i^{t-1})] \\
= \max \sum_{t=0}^{\infty} \sum_{s^t} \Pr[\eta(i, s_i^t)]Q(s^t|s^0) \left\{ P(h, i, s_i^t)y(h, i, s_i^t) \right. \\
- P(s^t)W(s^t)L(i, s_i^t) - P(s^t)I(i, s_i^t) \right\}.
\]

Then, the actual value of \(i_{th}\) producer can be defined as

\[
V [i, s_i^t; \eta(i, s_i^t), K(i, s_i^{t-1}), m(i, s_i^{t-1})] \\
= \max \left\{ V_1 [i, s_i^t; \eta(i, s_i^t), K(i, s_i^{t-1}), m(i, s_i^{t-1})] , \\
V_0 [i, s_i^t; \eta(i, s_i^t), K(i, s_i^{t-1}), m(i, s_i^{t-1})] \right\}.
\]

The values of a producer depends on its export status and are monotonically increasing and continuous in \(\eta(i, s_i^t)\), and \(V_1\) intersects \(V_0\) from below only once.\(^{18}\) Hence, the firm-specific productivity of marginal entrants among last period exporters and non-exporters, \(\eta_1(s_i^t)\) and \(\eta_0(s_i^t)\), satisfy

\[
V_1 [i, s_i^t; \eta(i, s_i^t), K(i, s_i^{t-1}), 1] \\
- V_0 [i, s_i^t; \eta(i, s_i^t), K(i, s_i^{t-1}), 1] \\
\begin{cases} 
\geq 0, & \text{if } \eta(i, s_i^t) \geq \eta_1(s_i^t), \\
< 0, & \text{if } \eta(i, s_i^t) < \eta_1(s_i^t), 
\end{cases}
\]

\[
V_1 [j, s_j^t; \eta(j, s_j^t), K(j, s_j^{t-1}), 0] \\
- V_0 [j, s_j^t; \eta(j, s_j^t), K(j, s_j^{t-1}), 0] \\
\begin{cases} 
\geq 0, & \text{if } \eta(j, s_j^t) \geq \eta_0(s_i^t), \\
< 0, & \text{if } \eta(j, s_j^t) < \eta_0(s_i^t). 
\end{cases}
\]

Among last period exporters, if the firm-specific productivity \(\eta(i, s_i^t)\) is greater (less) than \(\eta_1(s_i^t)\), the producer will (will not) export goods abroad in \(s_i^t\). Among last period non-exporters, if the firm-specific productivity \(\eta(j, s_j^t)\) is greater (less) than \(\eta_0(s_i^t)\), the producer will (not) export goods abroad in \(s_i^t\). Thus, from (4.24), (4.25),

\(^{18}\)If the difference between \(\tau_0\) and \(\tau_1\) is very large, \(V_1 [i, s_i^t; \eta, K, 1] > V_0 [i, s_i^t; \eta, K, 1]\) for all \(\eta \in (-\infty, \infty)\) for some \(s_i^t\). Since the data show that some of previous exporters exit from foreign markets each period, it is assumed through out the dissertation that the difference is not that large.
and the independence of the firm-specific productivity, the percentage of exporters in state $s^t$ among exporters and non-exporters in state $s^{t-1}$, $n_1(s^t)$ and $n_0(s^t)$, respectively, can be defined as

$$n_1(s^t) = \frac{\int_{i \in E^*(s^t)} \frac{1}{N(s^{t-1})} \, di}{\int_{i \in E^*(s^t) \cap i \notin E^*(s^{t-1})} \frac{1}{1 - N(s^{t-1})} \, di} = Pr[\eta(i, s^t) > \eta_1(s^t)],$$

(4.26)

$$n_0(s^t) = \frac{\int_{i \in E^*(s^t) \cap i \notin E^*(s^{t-1})} \frac{1}{1 - N(s^{t-1})} \, di}{\int_{i \in E^*(s^t)} \frac{1}{N(s^{t-1})} \, di} = Pr[\eta(i, s^t) > \eta_0(s^t)].$$

(4.27)

Then, the percentage of exporters in state $s^t$ among all intermediate good producers, $N(s^t)$, evolves as

$$N(s^t) = n_1(s^t)N(s^{t-1}) + n_0(s^t)[1 - N(s^{t-1})].$$

(4.28)

Figure 4.1 illustrates the values of firms across firm-specific productivity depending on export status. In the absence of trade costs, the value of a firm if it exports is always greater than that if it does not, given a firm-specific productivity. All the firms, hence, will export goods abroad. However, in the presence of international trade costs, it is not optimal for some firms to export goods abroad. The values of exporting firms shift downwards by the amount of trade costs, $\tau_0$ or $\tau_1$ depending on the export status last period. Since the costs for new exporters are higher than the costs for continuing exporters, $\tau_0 > \tau_1$, the values of new exporters are always lower than those of continuing exporters. This results in $\eta_1(s^t) < \eta_0(s^t)$ for all $s^t$. Hence, the probability of being an exporter in state $s^t$ is always higher for last period exporters than last period non-exporters ($n_1(s^t) > n_0(s^t)$).

4.6 An Equilibrium

In an equilibrium, variables satisfy several resource constraints. The final goods market clearing conditions are given by $C(s^t) + I(s^t) = D(s^t)$, and $C^*(s^t) + I^*(s^t) =$
\(D^*(s^t)\). The intermediate goods market clearing conditions are 
\[ y^d(h, i, s^t) = y(h, i, s^t) \]
for \(i \in (0, 1)\), 
\[ y^d(f, i, s^t) = y(f, i, s^t) \]
for \(i \in \mathcal{E}^*(s^t)\), 
\[ y^{ds}(f, i, s^t) = y^*(f, i, s^t) \]
for \(i \in (0, 1)\), and 
\[ y^{ds}(h, i, s^t) = y^*(h, i, s^t) \]
for \(i \in \mathcal{E}(s^t)\). The labor market clearing conditions are 
\[ L(s^t) = \int_0^1 L(i, s^t) di \]
and 
\[ L^*(s^t) = \int_0^1 L^*(i, s^t) di \]
The profits of firms are distributed to the stock holders, 
\[ \Pi(s^t) = \int_0^1 \Pi(i, s^t) di \]
and 
\[ \Pi^*(s^t) = \int_0^1 \Pi^*(i, s^t) di \]
The government budget constraint is given by (4.14) and foreign analogue. The international bond market clearing condition is given by 
\[ B(s^t) + B^*(s^t) = 0. \]

Under the normalization of 
\[ P(s^t) = P^*(s^t) = 1, \]
an equilibrium of the economy is a collection of allocations for home consumers \(C(s^t), L(s^t), B(s^{t+1})\); allocations for foreign consumers \(C^*(s^t), L^*(s^t), B^*(s^{t+1})\); allocations for home final goods producers 
\(D(s^t), y^d(h, i, s^t)\) for \(i \in (0, 1)\), and 
\(y^d(f, i, s^t)\) for \(i \in \mathcal{E}^*(s^t)\); allocations for foreign final good producers 
\(D^*(s^t), y^{ds}(f, i, s^t)\) for \(i \in (0, 1)\), and 
\(y^{ds}(h, i, s^t)\) for \(i \in \mathcal{E}(s^t)\); allocations and prices for home intermediate good producers 
\(L(i, s^t), I(i, s^t), y(h, i, s^t)\) and 
\(P(h, i, s^t)\) for \(i \in (0, 1)\), 
\(y^*(h, i, s^t)\) and 
\(P^*(h, i, s^t)\) for \(i \in \mathcal{E}(s^t)\); allocations and prices for foreign intermediate good producers 
\(L^*(i, s^t), I^*(i, s^t), y^*(f, i, s^t)\) and 
\(P^*(f, i, s^t)\) for \(i \in \mathcal{E}^*(s^t)\), 
\(y^*(f, i, s^t)\) and 
\(P^*(f, i, s^t)\) for \(i \in (0, 1)\); the export statuses of home and foreign intermediate good producers 
\(m(i, s^t)\) and 
\(m^*(i, s^t)\) for \(i \in (0, 1)\); prices of real wages 
\(W(s^t), W^*(s^t)\), and bond prices 
\(Q(s^{t+1}|s^t)\) that satisfy the following conditions: (i) the consumer allocations solve the consumer’s problem; (ii) the final good producers’ allocations solve their profit maximization problems; (iii) the intermediate good producers’ allocations, prices, and export statuses solve their profit maximization problems; (iv) the market clearing conditions hold.
4.7 Parameterizations

For the simulation exercises, we need to determine the parameter values of the model. The summary table for the parameter values used in the simulation exercises are in Table 4.1.

In the steady state, the real interest rate is equal to \((1 - \beta)/\beta\). The annual real return to capital is around 4%. This gives \(\beta = 0.99\). The steady state constraint gives \(Y = C + \delta K\). Dividing both sides by \(K\), \(\delta = \frac{Y}{K} \left(1 - \frac{C}{Y}\right)\). With the annual capital output ratio of 2.5 and consumption to output ratio of 0.75 as the average of the post-war U.S. data, \(\delta = 0.025\). The curvature parameter, \(\sigma\), determines the inter-temporal elasticity of substitution and the relative risk aversion of consumers. Empirical studies using the U.S. time series, such as that of Eichenbaum, Hansen, and Singleton (1988), suggest that \(\sigma\) lies between 0.5 and 3. In this research \(\sigma\) is set to be equal to 2, which is widely used in the business cycle literature, e.g., Backus, Kehoe, and Kydland (1992), Stockman and Tesar (1995), Kollmann (1997), and Kehoe and Perri (2002). The parameter \(\theta\) determines an intermediate good producer’s mark-up. Schmitt-Grohé (1997) reports the summary results of empirical studies on estimating the mark-up. The estimates in the literature range widely from 3% to 70%. Based on Basu and Fernald (1994), \(\theta\) is set to be equal to 0.9, which is also used in Chari, Kehoe, and McGrattan (2000). \(\theta = 0.9\) gives an intermediate good producer’s mark-up about 11%. \(\rho\) determines the elasticity of substitution between home and foreign aggregates, \(1/(1 - \rho)\). Using the U.S. quarterly data of 163 industries at the 3-digit SIC level from 1980:1-1988:4, Gallaway, McDaniel, and Rivera (2003) estimate that the elasticities range from 0.14 to 3.49. Reinert and Roland-Holst (1992) estimate the elasticities using the U.S. monthly data of 309 industries at the 4-digit SIC level from
1989:1-1995:12. Their estimates range from 0.52 to 4.83. In the simulation exercises, \( \rho \) is set to be 1/3 so that the elasticity to be equal to 1.5 as in Backus, Kehoe, and Kydland (1992) and Chari, Kehoe, and McGrattan (2000). In the model, the share of output that goes to labor is \( \theta(1 - \alpha) \).\(^{19}\) In the post-war U.S. data, the share is about 2/3. This implies \( \alpha = 0.259 \), given the parameter value \( \theta = 0.9 \). The share parameter for consumption in the composite commodity, \( \gamma \), is set to be equal to 0.294. This value is obtained from the observation that the average time devoted to work is 1/4 of the total available time, and the consumption-output ratio is about 0.75 in the post-war period. \( n_0(s^t) \) and \( n_1(s^t) \) determine the persistence of intermediate good producers’ export statuses. As in Table 3.1, Bernard and Jensen (1999a) find that about 87.8 percent of exporters continue exporting in the next period, and among those that did not export last period, about 85.6 percent of firms remain in the non-exporter status. Since the imports to GDP ratio in the U.S. is about 0.15, the entry costs \( \tau_0 \), \( \tau_1 \), and home bias parameter \( a_2 \) are set jointly so that exports to output ratio is equal to 0.15, and annual persistence of export status to be 0.867 in the steady state with the normalization of \( a_1 = 1 \). This gives \( a_2 = 0.321 \), \( \tau_0 = 0.087 \), and \( \tau_1 = 0.022 \).\(^{20}\) With these parameter values, on average, a new exporter pays about 9.6% of exports as entry costs, and a continuing export pays about 0.3% of exports to remain in the foreign market in the steady state.

There are several parameter values for the country-wide productivity process. Backus, Kehoe, and Kydland (1992) and Baxter and Crucini (1995) estimate the parameter values for the country-wide productivity process. They commonly find high

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\(^{19}\)See Appendix A for the derivation.

\(^{20}\)Under the zero export penetration costs, \( \tau_0 = \tau_1 = 0 \), \( a_2 \) set to be equal to 0.315 to match the exports to output ratio of 0.15.
persistence in the process, high values for diagonal terms in $M$, but little evidence of international ‘spillover’ effects (positive values for off-diagonal terms in $M$ with large standard errors) on the country-wide productivity. The benchmark model follows the parameter values used in Kollmann (1996) and Kehoe and Perri (2002).

$$M = \begin{bmatrix} 0.95 & 0 \\ 0 & 0.95 \end{bmatrix},$$

with $\text{Var}[\epsilon(s_t)] = \text{Var}[\epsilon^*(s_t)] = \sigma^2 = 0.007^2$, and $\text{Corr}[\epsilon(s_t), \epsilon^*(s_t)] = 0.25$. In the sensitivity analyses, the model with the ‘spillover’ effect as in Backus, Kehoe, and Kydland (1992) is also simulated.

It is very difficult to estimate parameters for the firm-specific productivity process. It depends heavily on the sample of the firms. If very small firms are included in the sample, the size of the variance becomes very large. If only large firms, such as firms that can be found in S&P 500 are included in the sample, the size of the variance becomes very small. Bernard, Eaton, Jensen, and Kortum (2000) estimate the distribution across plants of value added per workers using ASM 1992. They find that the sample standard deviation of the productivity across firms is about 0.76. However, the estimate cannot be employed directly due to the differences in production functions and the processes of technology shocks. As a benchmark $\sigma_\eta = 0.30$ is used. For the robustness of the simulation results, various values of the standard deviation for the firm-specific productivity is also exercised.

The model is simulated for 100 times with 200 periods using the linearization methods suggested by King, Plosser, and Rebelo (1988a,b), and Klein (2000).
Figure 4.1: Value of Firms
<table>
<thead>
<tr>
<th></th>
<th>( \beta = 0.99 )</th>
<th>( \sigma = 2 )</th>
<th>( \theta = 0.9 )</th>
<th>( \rho = 1/3 )</th>
<th>( \gamma = 0.294 )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preferences</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td>( \alpha = 1/3 )</td>
<td>( \delta = 0.025 )</td>
<td>( a_1 = 1 )</td>
<td>( a_2 = 0.321 )</td>
<td></td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( M = \begin{bmatrix} 0.95 &amp; 0 \ 0 &amp; 0.95 \end{bmatrix} )</td>
<td>( Var(\epsilon) = Var(\epsilon^*) = \sigma_\epsilon^2 = 0.007^2 )</td>
<td>( Corr(\epsilon, \epsilon^*) = 0.25 )</td>
<td>( \sigma_\eta = 0.30 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trade costs</strong></td>
<td>( \tau_0 = 0.087 )</td>
<td>( \tau_1 = 0.022 )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Under the zero export penetration costs, \( \tau_0 = \tau_1 = 0 \), and \( a_2 = 0.315 \).

Table 4.1: Parameter Values
CHAPTER 5

FINDINGS

This chapter discusses the results from simulation exercises. To evaluate the importance of export penetration and continuation costs in explaining international business cycles, the results from the model with the costs are compared with those from the model without the costs. The sensitivity analyses are also performed in the simulation exercises.

5.1 Benchmark Model

This section discusses the simulation results from the benchmark model (the model without the export penetration costs) and the model with the costs. By investigating the responses of variables to a country-wide productivity shock, this section also discusses the role of export penetration costs on international transmission of business cycles.

5.1.1 Co-movements of macroeconomic variables

Column 3 in Table 5.1 shows the simulation results from the benchmark model (the model without the costs). The results show that the cross-country investment
correlation, 0.06, is too low to match the data statistic, 0.29. The cross-country employment correlation, 0.21, is about the half of the data statistic, 0.43. Similarly to Backus, Kehoe, and Kydland (1992) the consumption correlation across countries, 0.55, is about 57% higher than the output correlation across country, 0.35. Hence, the consumption correlation puzzle remains as a puzzle in the model without export penetration costs.

The simulation results with export penetration costs are in column 4 of Table 5.1. The overall performance of the model with the costs is quite successful in that all the cross-country correlations become closer to the data statistics. More importantly, the model with the costs generates low cross-country consumption correlation, 0.27, that lies below the output correlation, 0.46. The model also generates the cross-country investment correlation, 0.28, that is almost matched with data statistic, 0.29, and the employment international correlation, 0.57, that is about 32% higher than the data statistic, 0.43. Therefore, the simulation results suggest that the entry costs associated with international trade critically affect co-movements of international macroeconomic variables.

5.1.2 Responses to a productivity shock

To compare how the mechanisms for international transmissions of business cycles are different between models with and without export penetration costs, the responses of variables to a positive one standard deviation home country-wide productivity shock are plotted in Figure 5.1. Figure 5.1 G shows the responses of the turnover ratios in export status. When there is a positive country-wide productivity shock at home, home intermediate good producers experience a reduction in costs of production.
Hence, an increased number of producers transition from non-exporter to exporter status, and fewer producers transition from exporter to non-exporter status. These result in an increase in the measure of exporters at home. The foreign intermediate good producers’ experience is different. Even though foreign producers experience unchanged country-wide productivity, they experience an increase in home country demand for their goods. The increase in demand raises foreign producer profits from exporting. Hence, a larger number of producers transition from non-exporter to exporter status, and fewer producers transition from exporter to non-exporter status. These movements result in an increase in the measure of exporters at foreign.

The increases in the measure of exporters both at home and foreign are critical in the movements of macroeconomic variables. Since exporters have higher productivity, capital, employment, and output levels than non-exporters, the increases in the measure of exporters both at home and foreign imply the increases in investment, employment, and output levels in both countries. Hence, for several periods following the shock, employment and investment levels increase both at home and foreign (Figure 5.1 C and D). Output levels in both countries also rise with the increases in inputs (Figure 5.1 A). For several periods following the shock, a large fraction of output is devoted to investment, so relatively small fraction of output is available for consumption. Due to international trade costs, only some of home intermediate goods produced with high productivity are available at foreign country. However, all the variety of home intermediate goods are available at home country. Hence, consumption at home increases from the initial period of the shock, whereas consumption at foreign decreases initially for higher future consumption (Figure 5.1 B). These opposite
movements of consumption at home and foreign make the consumption correlation across countries be lower than the output correlation across countries.

5.1.3 Movements of the turnover ratios in export status

The simulation results for the turnover ratios in export status with annualized parameter values are in Table 5.2. Parameter values of the model is changed so that the model simulation reflects the annual data. Annualized parameter values are $\beta = 0.96$, $\delta = 0.10$, persistence of country-wide productivity shocks to be 0.83, and $\sigma_\epsilon = 0.015$. The export penetration costs are changed so that the annual persistence of producers’ export status is equal to 0.867.

The data statistics show positive co-movements in the turnover ratios in export status. The correlations of starter, stopper, and exporter ratios between the U.S. and Germany are 0.12, 0.69, and 0.83, respectively. The correlations between Colombia and Germany are 0.63, 0.62, and 0.79, respectively. The results show that the export penetration costs model predicts the positive co-movements of the turnover ratios in export status between home and foreign, 0.64, 0.90, and 0.93 for starter, stopper and exporter ratios. Hence, the model provides all the correct signs for international correlations in the turnover ratios in export status.

However, the simulation results for the correlations between the turnover ratios in export status and real exchange rates give mixed results. The data show the positive correlation between starter ratios and the real exchange rates in the U.S., 0.80, but the model predicts slightly negative correlation, -0.05. The model also under predicts the correlation between exporter ratios and real exchange rates, 0.06 to 0.73, even
though the model predicts the correct sign for the correlation between stopper ratios and real exchange rates.

5.2 Sensitivity Analysis

This section discusses simulation results under various model modifications. This section investigates how the results changes over the volatility of the firm-specific productivity, and persistence of export status. This section also discusses the simulation results under incomplete asset market condition, and separable preferences.

5.2.1 Volatility of the firm-specific productivity: $\sigma_\eta$

International correlations based on various values of $\sigma_\eta$ are plotted in Figure 5.2. The volatility in the figure ranges from 0.05 to 0.70. The figure shows that all the cross-country correlations are quite stable up to the volatility of 0.40. In the range of 0.05 to 0.40 for the volatility of firm-specific productivity, output correlations range from 0.44 to 0.51, consumption correlations from 0.24 to 0.28, investment correlations from 0.24 to 0.42, and employment correlations from 0.55 to 0.64. For the range of 0.40 to 0.60 for the volatility, high value of $\sigma_\eta$ results in high cross-country correlations in output, investment, and employment, but low cross-country correlations in consumption. Over the range, the results show that the consumption correlations are always lower than the output correlations, and all the correlations, output, consumption, investment, and employment, are positive. Hence, with plausible values for $\sigma_\eta$, the model generates positive cross-country correlations in output, consumption, consumption, investment, and employment.

\[\sigma_\eta\]

\[\text{Bernard, Eaton, Jensen, and Kortum (2000) estimate the distribution across plants of value added per workers using the U.S. Annual Survey of Manufactures 1992. They find that the standard deviation of productivity across firms is about 0.76.}\]
investment, and employment, and the consumption correlations that lies below the output correlations.

5.2.2 Persistence of export status

The simulation results with high and low persistence of turnover ratios in export status are in Table 5.3. The models with low and high persistence have 0.75 and 0.94 for the annual persistence of export status, respectively. The results show that low (high) persistence drives the cross-country correlations of output, investment, and employment to be high (low) and the correlation of consumption to be low (high). Even though very high persistence of export status drives the cross-country correlations in output, consumption, investment, and employment to be close to the correlations generated by the model without costs, the model still generates all the correct signs for the cross-country co-movements and produces cross-country consumption correlations that are lower than output correlations.

5.2.3 Incomplete asset market

In the benchmark model, it is assumed that the asset market is perfect, so home and foreign consumers can buy or sell a complete menu of state contingent bonds. To see how the break down of this assumption affects the results in the model, the model is modified so that only non-state contingent risk-free bonds issued by home consumers are available to consumers. The budget constraint for home consumers with the bond becomes

\[
P(s^t)C(s^t) + \overline{Q}(s^t)\overline{B}(s^t) \\
\leq P(s^t)W(s^t)L(s^t) + \overline{B}(s^{t-1}) + \Pi(s^t) + P(s^t)T(s^t), \quad (5.1)
\]
where $Q(s^t)$ is the nominal price of the uncontingent risk-free bond $B(s^t)$ at period $t$. $B(s^t)$ is the amount of the bonds that the consumer buys at period $t$. The bond $B(s^t)$ pays 1 unit of home currency at period $t + 1$ regardless of the state at period $t + 1$, $s^{t+1}$. Under this constraint, the equation for the real exchange rate (4.8) changes to

$$\sum_{s^{t+1}} Pr(s^{t+1}|s^t) \frac{U_C(s^{t+1}|s^t)P(s^t)}{U_C(s^t)P(s^{t+1})} = \sum_{s^{t+1}} Pr(s^{t+1}|s^t) \frac{U_C^*(s^{t+1})q(s^t)P(s^t)}{U_C^*(s^t)q(s^{t+1})P(s^{t+1})}. \quad (5.2)$$

The results with the modified model are in Table 5.4.\textsuperscript{22} Without the trade costs, the incomplete asset market assumption lowers the consumption correlation across countries, and increases the employment correlation compared to the correlations under complete asset market condition. However, the modified model still generates the consumption correlation, 0.47, which is higher than the output correlation, 0.35, very low investment correlation, 0.07, and low employment correlation, 0.28.

The trade costs model with the incomplete asset market can generate correct signs and magnitudes for cross-country correlations. The international consumption correlation, 0.19, is lower than the data statistic, 0.32, and lower than the output correlation, 0.47. The investment correlation, 0.28, almost matches with the data statistic, 0.29, and the employment correlation, 0.60, is higher than the data statistic, 0.43. Overall, the incomplete asset market condition does not provide any additional improvements in the performance of the model predictions as long as the export penetration costs are already considered in the model.

\textsuperscript{22}In simulation, very small quadratic costs on bonds are imposed, so that the law of motion for bonds is stationary.
5.2.4 Separable preferences

One alternative preference specification that is widely used in the business cycle literature is the separable preferences as in Chari, Kehoe, and McGrattan (2000). The function for the separable preferences is defined as

\[ U(C, L) = \frac{C^{1-\sigma}}{1-\sigma} + \psi \frac{(1 - L)^{1-\gamma}}{1-\gamma}. \]

The results with this separable preferences are in Table 5.5. In the simulation \( \psi = 2.433 \), and \( \sigma = \gamma = 2 \) are used.

The model without export penetration costs have very bad predictions for international co-movements of macroeconomic variables. The model predicts procyclical net exports with the positive correlation between net export-output ratio and output, 0.24, and negative cross-country correlation in employment, -0.27. The consumption correlation across country is very high, 0.69, and the output correlation across countries is low, 0.31.

When the export penetration costs are introduced in the model, the model can generate correct signs for the correlations. The model with the trade costs predicts counter cyclical net exports with the negative correlation between net export-output ratio and output, -0.38, and the employment international correlation becomes positive, 0.49, which is close to the data statistic, 0.43. However, the separable preferences models both with and without the trade costs fail to have lower consumption correlation than the output correlation across countries, even though the costs reduce the consumption correlation and increase the output correlation.
5.2.5 Spillover

In Backus, Kehoe, and Kydland (1992), it is assumed that the process for the country-wide productivity has spillover effects (non-zero values for off-diagonal terms in the coefficient matrix $M$). The results using their productivity process specification are reported in Table 5.6.\textsuperscript{23}

Similarly to Backus, Kehoe, and Kydland (1992), the modified model without export penetration costs predicts negative cross-country correlations in investment and employment, -0.63 and -0.58, respectively. The model also predicts higher consumption correlation than output correlation. The consumption correlation is 0.78, and the output correlation is 0.10.

The modified model with export penetration costs also fails to show correct signs for international correlations in investment and employment, although the costs make the correlations be closer to the data statistics. The investment and employment correlations are -0.43 and -0.11, respectively. The model also predicts higher cross-country consumption correlation, 0.68, than the output correlation, 0.14, even though the costs lowers the difference between these two correlations. Overall, the costs contributes the model to have international correlations to be close to the data statistics, although the model still predicts wrong signs for international correlations.

\textsuperscript{23}For the process of the productivity, the modified model uses $M = \begin{bmatrix} 0.906 & 0.088 \\ 0.088 & 0.906 \end{bmatrix}$ with $\sigma^2 = 0.00852^2$, and $\text{Corr}(\epsilon(s^t), \epsilon^*(s^t)) = 0.258$. 
<table>
<thead>
<tr>
<th>Statistics</th>
<th>Data</th>
<th>No Cost Model</th>
<th>Cost Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard deviation (in percent)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>1.72</td>
<td>1.27</td>
<td>1.73</td>
</tr>
<tr>
<td>Net exports/output</td>
<td>0.15</td>
<td>0.15</td>
<td>0.39</td>
</tr>
<tr>
<td><strong>Standard deviation (relative to output)</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>0.79</td>
<td>0.41</td>
<td>0.22</td>
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<tr>
<td>Investment</td>
<td>3.24</td>
<td>4.41</td>
<td>5.96</td>
</tr>
<tr>
<td>Employment</td>
<td>0.63</td>
<td>0.46</td>
<td>0.66</td>
</tr>
<tr>
<td><strong>Domestic correlation with output</strong></td>
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<td></td>
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<tr>
<td>Consumption</td>
<td>0.88</td>
<td>0.96</td>
<td>0.61</td>
</tr>
<tr>
<td>Investment</td>
<td>0.93</td>
<td>0.97</td>
<td>0.98</td>
</tr>
<tr>
<td>Employment</td>
<td>0.86</td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td>Net exports/output</td>
<td>-0.36</td>
<td>-0.39</td>
<td>-0.38</td>
</tr>
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<td><strong>International correlation</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>0.51</td>
<td>0.35</td>
<td>0.46</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.32</td>
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<td>Investment</td>
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<tr>
<td>Employment</td>
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<td><strong>Persistence</strong></td>
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<tr>
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<td>0.91</td>
<td>0.67</td>
<td>0.69</td>
</tr>
<tr>
<td>Employment</td>
<td>0.95</td>
<td>0.68</td>
<td>0.69</td>
</tr>
<tr>
<td>Net export/output</td>
<td>0.61</td>
<td>0.70</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Notes: The statistics in the data column are from Kehoe and Perri (2002). The model statistics are computed from a simulation of 100 iterations with 200 periods, where the relevant series have been logged and H-P filtered with a smoothing parameter of 1,600. Net export-output ratios are not logged.

Table 5.1: Business Cycle Statistics: Benchmark Model
Statistics | US | Germany | Colombia | Model
---|---|---|---|---
**International correlation**
Starter ratios | 0.12 | 1.00 | 0.63 | 0.64
Stopper ratios | 0.69 | 1.00 | 0.62 | 0.90
Exporter ratios | 0.83 | 1.00 | 0.79 | 0.93

**Correlation with real exchange rate**
Starter ratios | 0.80 | 0.19 | 0.39 | -0.05
Stopper ratios | -0.13 | -0.30 | -0.60 | -0.15
Exporter ratios | 0.72 | -0.48 | 0.60 | 0.06

Notes: The statistics in the U.S. and Colombia columns are the correlations of relevant variables with German counterparts. The model statistics are computed from a simulation of 1000 iterations with 200 periods. The relevant series are non-filtered levels. Real exchange rates are the log of real effective exchange rates. High value of RER implies the depreciation of domestic currency. The parameter values are modified so that the model can reflect the annual data.

Table 5.2: Correlations of the Turnover Ratios in Export Status
<table>
<thead>
<tr>
<th>Statistics</th>
<th>Data</th>
<th>Benchmark</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard deviation (in percent)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>1.72</td>
<td>1.73</td>
<td>1.71</td>
<td>1.74</td>
</tr>
<tr>
<td>Net exports/output</td>
<td>0.15</td>
<td>0.39</td>
<td>0.33</td>
<td>0.43</td>
</tr>
<tr>
<td><strong>Standard deviation (relative to output)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>0.79</td>
<td>0.22</td>
<td>0.23</td>
<td>0.22</td>
</tr>
<tr>
<td>Investment</td>
<td>3.24</td>
<td>5.96</td>
<td>5.80</td>
<td>6.08</td>
</tr>
<tr>
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<td>0.66</td>
<td>0.66</td>
<td>0.66</td>
</tr>
<tr>
<td><strong>Domestic correlation with output</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>0.88</td>
<td>0.61</td>
<td>0.60</td>
<td>0.61</td>
</tr>
<tr>
<td>Investment</td>
<td>0.93</td>
<td>0.98</td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td>Employment</td>
<td>0.86</td>
<td>0.98</td>
<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td>Net exports/output</td>
<td>-0.36</td>
<td>-0.38</td>
<td>-0.33</td>
<td>-0.41</td>
</tr>
<tr>
<td><strong>International correlation</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>0.51</td>
<td>0.46</td>
<td>0.52</td>
<td>0.42</td>
</tr>
<tr>
<td>Consumption</td>
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<td>0.27</td>
<td>0.23</td>
<td>0.30</td>
</tr>
<tr>
<td>Investment</td>
<td>0.29</td>
<td>0.28</td>
<td>0.42</td>
<td>0.19</td>
</tr>
<tr>
<td>Employment</td>
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<td>0.57</td>
<td>0.66</td>
<td>0.51</td>
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<tr>
<td><strong>Persistence</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>0.87</td>
<td>0.71</td>
<td>0.71</td>
<td>0.71</td>
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<tr>
<td>Consumption</td>
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<td>0.89</td>
<td>0.88</td>
<td>0.90</td>
</tr>
<tr>
<td>Investment</td>
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<td>0.69</td>
<td>0.69</td>
<td>0.69</td>
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<tr>
<td>Employment</td>
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<td>Net export/output</td>
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</tr>
</tbody>
</table>

Notes: Low and high persistence models have the annual persistence of exporting behaviors of 75%, and 94%, respectively. The statistics in the data column are from Kehoe and Perri (2002). The model statistics are computed from a simulation of 100 iterations with 200 periods, where the relevant series have been logged and H-P filtered with a smoothing parameter of 1,600. Net export-output ratios are not logged.

Table 5.3: Business Cycle Statistics: High and Low Persistence of Export Status
<table>
<thead>
<tr>
<th>Statistics</th>
<th>Data</th>
<th>Benchmark No costs</th>
<th>Benchmark Costs</th>
<th>Incomplete No costs</th>
<th>Incomplete Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard deviation (in percent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Output</td>
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<td>1.27</td>
<td>1.73</td>
<td>1.27</td>
<td>1.72</td>
</tr>
<tr>
<td>Net exports/output</td>
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<td>0.15</td>
<td>0.39</td>
<td>0.17</td>
<td>0.40</td>
</tr>
<tr>
<td>Standard deviation (relative to output)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
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<td>0.41</td>
<td>0.22</td>
<td>0.43</td>
<td>0.23</td>
</tr>
<tr>
<td>Investment</td>
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<td>5.96</td>
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<td>5.96</td>
</tr>
<tr>
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<td>0.45</td>
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<tr>
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<td></td>
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</tr>
<tr>
<td>Consumption</td>
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<td>0.62</td>
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</tr>
<tr>
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<td>-0.38</td>
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<td>-0.39</td>
</tr>
<tr>
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<td>0.35</td>
<td>0.46</td>
</tr>
<tr>
<td>Consumption</td>
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<td>0.57</td>
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</tr>
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<tr>
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<td>0.89</td>
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<td>0.68</td>
<td>0.69</td>
</tr>
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<td>0.67</td>
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<td>0.67</td>
</tr>
</tbody>
</table>

Notes: The statistics in the data column are from Kehoe and Perri (2002). The model statistics are computed from a simulation of 100 iterations with 200 periods, where the relevant series have been logged and H-P filtered with a smoothing parameter of 1,600. Net export-output ratios are not logged.

Table 5.4: Business Cycle Statistics: Incomplete Asset Market
<table>
<thead>
<tr>
<th>Statistics</th>
<th>Data</th>
<th>Benchmark No costs</th>
<th>Benchmark Costs</th>
<th>Separable No costs</th>
<th>Separable Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard deviation (in percent)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>1.72</td>
<td>1.27</td>
<td>1.73</td>
<td>0.92</td>
<td>1.45</td>
</tr>
<tr>
<td>Net exports/output</td>
<td>0.15</td>
<td>0.15</td>
<td>0.39</td>
<td>0.09</td>
<td>0.32</td>
</tr>
<tr>
<td><strong>Standard deviation (relative to output)</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>0.79</td>
<td>0.41</td>
<td>0.22</td>
<td>0.41</td>
<td>0.15</td>
</tr>
<tr>
<td>Investment</td>
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<td>0.66</td>
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</tr>
<tr>
<td><strong>Domestic correlation with output</strong></td>
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<td></td>
</tr>
<tr>
<td>Consumption</td>
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<td>0.94</td>
<td>0.43</td>
</tr>
<tr>
<td>Investment</td>
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<td>0.98</td>
<td>0.97</td>
<td>0.98</td>
</tr>
<tr>
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<td>0.98</td>
<td>0.98</td>
<td>0.97</td>
<td>0.98</td>
</tr>
<tr>
<td>Net exports/output</td>
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<td>-0.39</td>
<td>-0.38</td>
<td>0.24</td>
<td>-0.38</td>
</tr>
<tr>
<td><strong>International correlation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>0.51</td>
<td>0.35</td>
<td>0.46</td>
<td>0.31</td>
<td>0.40</td>
</tr>
<tr>
<td>Consumption</td>
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<td>0.27</td>
<td>0.69</td>
<td>0.50</td>
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<td>0.28</td>
<td>0.17</td>
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<td>0.43</td>
<td>0.21</td>
<td>0.57</td>
<td>-0.27</td>
<td>0.49</td>
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<tr>
<td><strong>Persistence</strong></td>
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<td></td>
</tr>
<tr>
<td>Output</td>
<td>0.87</td>
<td>0.69</td>
<td>0.71</td>
<td>0.69</td>
<td>0.70</td>
</tr>
<tr>
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<td>0.74</td>
<td>0.89</td>
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<td>0.68</td>
<td>0.69</td>
<td>0.71</td>
<td>0.68</td>
</tr>
<tr>
<td>Net export/output</td>
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<td>0.70</td>
<td>0.67</td>
<td>0.92</td>
<td>0.68</td>
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</tbody>
</table>

Notes: The statistics in the data column are from Kehoe and Perri (2002). The model statistics are computed from a simulation of 100 iterations with 200 periods, where the relevant series have been logged and H-P filtered with a smoothing parameter of 1,600. Net export-output ratios are not logged.

Table 5.5: Business Cycle Statistics: Separable Preferences
<table>
<thead>
<tr>
<th>Statistics</th>
<th>Data</th>
<th>Benchmark</th>
<th></th>
<th>Spillover</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No costs</td>
<td>Costs</td>
<td>No costs</td>
<td>Costs</td>
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<tr>
<td>Standard deviation (in percent)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>1.72</td>
<td>1.27</td>
<td>1.73</td>
<td>1.45</td>
<td>1.87</td>
</tr>
<tr>
<td>Net exports/output</td>
<td>0.15</td>
<td>0.15</td>
<td>0.39</td>
<td>0.30</td>
<td>0.62</td>
</tr>
<tr>
<td>Standard deviation (relative to output)</td>
<td></td>
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<td>0.41</td>
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</tr>
<tr>
<td>Domestic correlation with output</td>
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<td></td>
<td></td>
</tr>
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<td>Consumption</td>
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<td>0.90</td>
<td>0.84</td>
</tr>
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<td>0.98</td>
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<td>0.94</td>
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<tr>
<td>Employment</td>
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<td>0.92</td>
<td>0.98</td>
</tr>
<tr>
<td>Net exports/output</td>
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<td>-0.39</td>
<td>-0.38</td>
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<td>International correlation</td>
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<td>Output</td>
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<td>0.28</td>
<td>-0.63</td>
<td>-0.43</td>
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<tr>
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<tr>
<td>Persistence</td>
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<tr>
<td>Output</td>
<td>0.87</td>
<td>0.69</td>
<td>0.71</td>
<td>0.67</td>
<td>0.68</td>
</tr>
<tr>
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<td>0.69</td>
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<tr>
<td>Employment</td>
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<td>0.68</td>
<td>0.69</td>
<td>0.62</td>
<td>0.65</td>
</tr>
<tr>
<td>Net export/output</td>
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<td>0.70</td>
<td>0.67</td>
<td>0.60</td>
<td>0.61</td>
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</table>

Notes: The statistics in the data column are from Kehoe and Perri (2002). The model statistics are computed from a simulation of 100 iterations with 200 periods, where the relevant series have been logged and H-P filtered with a smoothing parameter of 1,600. Net export-output ratios are not logged.

Table 5.6: Business Cycle Statistics: Spillover
A. Output

No Costs Model  Costs Model

B. Consumption

No Costs Model  Costs Model

C. Employment

Figure 5.1: Responses of Variables to $z(s^t)$ Shock  (Continued)
Figure 4.1 (Continued)

D. Investment

No Costs Model

Costs Model

E. Capital

No Costs Model

Costs Model

F. Real Exchange Rate, Terms of Trade, and Net Export-Output Ratio

No Costs Model

Costs Model

(Continued)
G. Turnover Ratios in Export Status

**Starter Ratios:** \( n_0 \) and \( n_0^* \)

**Stopper Ratios:** \( 1 - n_1 \) and \( 1 - n_1^* \)

**Exporter Ratios:** \( N \) and \( N^* \)
Figure 5.2: International Correlations depending on $\sigma_\eta$.
CHAPTER 6

CONCLUSIONS

This dissertation investigated the effects of the fixed costs associated with export penetration on international business cycles. It is found that the export penetration costs contribute to the model to reproduce the firm-level dynamics in the export sector, unlike other international business cycle models with international goods market frictions, e.g., the model with quadratic costs to trade volumes in Backus, Kehoe, and Kydland (1992), the model with tradable and non-tradable in Stockman and Tesar (1995), and the model with proportional costs to trade volumes in Obstfeld and Rogoff (2000). More importantly, it is found that the firm-level dynamics in the export sector are critical for the model to replicate the cross-country correlations of macroeconomic variables.

Due to trade costs, the model emphasizes that exporters and non-exporters have different firm characteristics that conform to the empirical evidence. Relative to non-exporters, exporters tend to have higher productivity, have higher levels of output using higher levels of capital and labor inputs. A positive home country-wide productivity shock reduces production costs for home producers and increases the demand for foreign goods. This results in positive cross-country co-movements in the turnover ratios in export status as data.
The positive cross-country co-movements in turnover ratios in export status together with the different firm characteristics between exporters and non-exporters contribute additional positive co-movements in investment, employment and output levels across countries. For several periods following the shock, a large fraction of output is devoted to investment, so relatively small fraction of output are available for consumption. Due to international trade costs, only some of home intermediate goods produced with high productivity is available at foreign country. However, all the variety of home intermediate goods are available at home country. Hence, consumption at home increases from the initial period of the shock, whereas consumption at foreign decreases initially for higher future consumption. These result in the cross-country consumption correlation that lies below the output correlation. Hence, the model successfully generates cross-country correlations in international macroeconomic variables with correct signs and magnitudes. A key result of the model is that fixed costs associated with export penetration generate the consumption correlation that lies below the output correlation thus providing a resolution to the international consumption correlation puzzle.

This dissertation focused on the importance of the firm-level dynamics driven by the export penetration costs in explaining international co-movements of macroeconomic variables. To simplify the analyses, the trend components in productivity and export status are excluded throughout the research. By introducing these trend components in the analyses, the research can be extended to the study for the growth of international trades. We observe that the trade volumes (exports and imports) to GDP ratios have been increased over time. At the same time, the exporter ratios of a country have also been increased. One possible answer for the relation is the decrease
in tariffs. However, tariffs alone is not enough to explain these growth of international trades and exporter ratios. To have a better understanding in the growth patterns of international trades, it is worthwhile to investigate what are the major causes for the increase in exporter ratios, and how the increases in the ratios are related with the increase in international trades.
APPENDIX A

THE MODEL SOLUTIONS

• The Consumer’s Problem

The first order conditions for the home consumer are:

\[-U_L(s^t) = W(s^t),\]  \hspace{1cm} (A.1)

\[Q(s^{t+1}|s^t) = \beta Pr(s^{t+1}|s^t) \frac{U_C(s^{t+1})P(s^t)}{U_C(s^t)P(s^{t+1})}.\]  \hspace{1cm} (A.2)

Similarly, the first order conditions for the foreign consumer are:

\[-U_L^*(s^t) = W^*(s^t),\]  \hspace{1cm} (A.3)

\[Q^*(s^{t+1}|s^t) = \beta Pr(s^{t+1}|s^t) \frac{U_C^*(s^{t+1})P^*(s^t)}{U_C^*(s^t)P^*(s^{t+1})},\]  \hspace{1cm} (A.4)

\[Q(s^{t+1}|s^t) = \beta Pr(s^{t+1}|s^t) \frac{U_C^*(s^{t+1})e(s^t)P^*(s^t)}{U_C^*(s^t)e(s^{t+1})P^*(s^{t+1})}.\]  \hspace{1cm} (A.5)

From the state contingent bond equations (A.2) and (A.5), we get

\[\frac{U_C(s^{t+1})P(s^t)}{U_C(s^t)P(s^{t+1})} = \frac{U_C^*(s^{t+1})e(s^t)P^*(s^t)}{U_C^*(s^t)e(s^{t+1})P^*(s^{t+1})}.\]  \hspace{1cm} (A.6)

Let’s define the real exchange rate as \(q(s^t) = \frac{e(s^t)P^*(s^t)}{P(s^t)}\). Then, from the iteration of (A.6), we get

\[q(s^t) = \kappa \frac{U_C^*(s^t)}{U_C(s^t)},\]  \hspace{1cm} (A.7)
where $\kappa = q(s^0)U_C(s^0)/U_C^*(s^0)$. $\kappa$ is normalized to be 1 in simulation exercises. The wage rate, $W(s^t)$, is equal to the ratio of marginal disutility of labor and the marginal utility of consumption. The price of a state contingent bond, $Q(s^{t+1}|s^t)$, equals to the inter-temporal marginal rate of substitution times the conditional probability of the history of events $s^{t+1}$ given the current history of events $s^t$. Under the complete asset market condition, the real exchange rate, $q(s^t)$, is proportional to the ratio of marginal utility of consumption at foreign to that at home.


**The Final Good Producer’s Problem**

The first order conditions for the home final good producer give the input demand functions

$$y^d(h, i, s^t) = a_1^{1-\rho} \left[ \frac{P(h, i, s^t)}{P(h, s^t)} \right]^{\frac{1}{\rho-1}} \left[ \frac{P(h, s^t)}{P(s^t)} \right]^{\frac{1}{\rho-1}} D(s^t), \quad (A.8)$$

$$y^d(f, i, s^t) = a_2^{1-\rho} \left[ \frac{P(f, i, s^t)}{P(f, s^t)} \right]^{\frac{1}{\rho-1}} \left[ \frac{P(f, s^t)}{P(s^t)} \right]^{\frac{1}{\rho-1}} D(s^t), \quad (A.9)$$

where $P(h, s^t) = \left[ \int_0^1 P(h, i, s^t) \frac{\theta}{\rho} di \right]^{\frac{\theta-1}{\rho}}$, and $P(f, s^t) = \left[ \int_{i \in E^*(s^t)} P(f, i, s^t) \frac{\theta}{\rho} di \right]^{\frac{\theta-1}{\rho}}$. The zero-profit condition in the perfectly competitive market gives the price level of the final goods,

$$P(s^t) = \left[ a_1^{1-\rho} P(h, s^t)^{\frac{\theta}{\rho-1}} + a_2^{1-\rho} P(f, s^t)^{\frac{\theta}{\rho-1}} \right]^{\frac{\rho-1}{\rho}}. \quad (A.10)$$

The final goods are used for domestic consumption or investment. The resource constraint for the final goods gives

$$D(s^t) = C(s^t) + I(s^t). \quad (A.11)$$
The Intermediate Good Producer’s Problem

The first order conditions for the \(i^{th}\) home intermediate good producer give

\[
\frac{P(h, i, s_t)}{P(s_t)} = q(s_t) \frac{P^*(h, i, s_t)}{P^*(s_t)} = \frac{W(s_t)}{\theta F_L(i, s_t)}.
\]

\[
P(s_t) = \sum_{s^{t+1}} \sum_{\eta(i, s_t^{t+1})} \frac{Q(s^{t+1})}{Q(s_t)} P_r[\eta(i, s_t^{t+1})] \left\{ \left( \frac{\alpha}{1 - \alpha} \right) \cdot \frac{P(s^{t+1}) W(s^{t+1}) L(i, s_t^{t+1})}{K(i, s_t^t)} + P(s^{t+1})(1 - \delta) \right\}.
\]

(A.13)

The marginal cost of production is equal to \(W(s_t)/F_L(i, s_t^t)\). Hence, intermediate good producers set their prices with a constant mark-up. The law of one price holds for any exported goods all periods, even though an intermediate good producer can price discriminate across countries. Since firms in a country are owned by domestic consumers, clearly \(Q(s^{t+1})/Q(s_t) = Q(s^{t+1}|s_t)\).

The resource constraint is defined as

\[
y(h, i, s_t^i) + m(i, s_t^i) y^*(h, i, s_t^i) = A(i, s_t^t) K(i, s_t^{t-1})^\alpha, L(i, s_t^t) ^{1-\alpha}.
\]

(A.14)

From the demand functions for intermediate goods (A.8) and (A.9), and the price decisions (A.12), the labor demand function can be obtained from (A.14).

\[
L(i, s_t^i) = \left[ \frac{W(s_t)}{\theta(1 - \alpha)} \right] ^{\frac{\mu}{\nu}} A(i, s_t^i) ^{\frac{1-\mu}{\alpha}} K(i, s_t^{t-1}) ^{1-\nu} \left\{ \left[ \frac{P(h, s_t)}{P(s_t)} \right] ^\mu D_t + m(i, s_t^i) a_2 ^{1-\rho} q(s_t) ^{\frac{1}{1-\sigma}} \left[ \frac{P^*(h, s_t)}{P^*(s_t)} \right] ^\mu D_t \right\} ^\nu,
\]

(A.15)

where \(\nu = \frac{\theta-1}{1-\theta(1-\alpha)}\), and \(\mu = \frac{1}{1-\theta} - \frac{1}{1-\rho}\).

Since \(\eta(i, s_t^i)\) follows an \(i.i.d.\) normal distribution, it can be found from (A.13) that \(K(i, s_t^i)\) is independent of \(\eta(i, s_t^i)\). However, \(K(i, s_t^i)\) depends on the export status of the firm, \(m(i, s_t^i)\), and the state of the world, \(s_t\).

\[
K(i, s_t^i) = \begin{cases} K_0(s_t) & \text{if } m(i, s_t^i) = 0, \\ K_1(s_t) & \text{if } m(i, s_t^i) = 1. \end{cases}
\]

(A.16)
Hence, the sufficient statistics for the distribution of the capital among home intermediate good producers are $K_0(s^t)$, $K_1(s^t)$, and $N(s^t)$.

**Marginal Exporters**

Let $L_{m,m'}(i, s^t_i)$ and $I_{m,m'}(i, s^t_i)$ be the sub-optimal levels of labor inputs and investment for the $i_{th}$ firm when $m(i, s^{t-1}_i) = m$ and $m(i, s^t_i) = m'$, respectively. Clearly $I_{m,m'}(i, s^t_i) = I_{m,m'}(s^t_i) = K_{m'}(s^t_i) - (1 - \delta)K_m(s^t_i)$. From the mark-up pricing (A.12), the value of the $i_{th}$ firm can be rewritten as

$$V_{m'}[i, s^t_i; \eta(i, s^t_i), K_m(s^{t-1}), m] = \left[1 - \frac{\theta}{\theta(1 - \alpha)}\right] P(s^t) W(s^t) L_{m,m'}(i, s^t_i)$$

$$- P(s^t) I_{m,m'}(s^t_i) - m'e(s^t) P^*(s^t) \tau_m$$

$$+ \sum_{s^{t+1}} \sum_{\eta(i, s^{t+1}_i)} Q(s^{t+1} | s^t) V_{m(i,s^{t+1}_i)}[i, s^{t+1}_i; \eta(i, s^{t+1}_i), K_{m'}(s^t), m']$$,

where $m, m' \in \{0, 1\}$. The firm-specific productivity of marginal exporters among last period exporters and non-exporters, $\eta_1(s^t)$ and $\eta_0(s^t)$, satisfy

$$V_1[\zeta_j, s^t_{\zeta_j}; \eta_j(s^t), K_j(s^{t-1}), m] = V_0[\zeta_j, s^t_{\zeta_j}; \eta_j(s^t), K_j(s^{t-1}), m],$$

where $m, j \in \{0, 1\}$. $\zeta_j$ is the identity of the firm which satisfies $\eta(\zeta_j, s^t_{\zeta_j}) = \eta_j(s^t)$ and $m(\zeta_j, s^t_{\zeta_j}) = m$. The marginal exporter conditions (A.18) can be rewritten as

$$0 = \left[1 - \frac{\theta}{\theta(1 - \alpha)}\right] P(s^t) W(s^t) \left[L_{m,1}(\zeta_j, s^t_{\zeta_j}) - L_{m,0}(\zeta_j, s^t_{\zeta_j})\right]$$

$$- P(s^t)[K_{1}(s^t) - K_{0}(s^t)] - e(s^t) P^*(s^t) \tau_m$$

$$+ \sum_{s^{t+1}} \sum_{\eta(\zeta_j, s^{t+1}_{\zeta_j})} Q(s^{t+1} | s^t) \left\{V_{m(\zeta_j,s^{t+1}_{\zeta_j})}[\zeta_j, s^{t+1}_{\zeta_j}; \eta(\zeta_j, s^{t+1}_{\zeta_j}), K_1(s^t), 1]$$

$$- V_{m(\zeta_j,s^{t+1}_{\zeta_j})}[\zeta_j, s^{t+1}_{\zeta_j}; \eta(\zeta_j, s^{t+1}_{\zeta_j}), K_0(s^t), 0]\right\},$$

(A.19)
\[ L_{m,m'}(i, s_t^1) = \left[ \frac{W(s^t)}{\theta(1-\alpha)} \right]^{\frac{1}{\nu}} e^{\frac{1}{1-\alpha}[\nu(s^t)+\eta(i, s_t^i)]} K_m(s^{t-1})^{1-\nu} \cdot \left[ \left( \frac{P(h, s_t^i)}{P(s_t^i)} \right)^\mu D_t + m'a^2 \tilde{q}(s^t) \tilde{q}(s_t^i) \left( \frac{P^*(h, s_t^i)}{P^*(s_t^i)} \right)^\mu D_t^\nu \right]^{\nu}. \quad (A.20) \]

Among last period exporters, if the firm-specific productivity \( \eta(i, s_t^i) \) is greater (less) than \( \eta_1(s^t) \), the producer will (will not) export goods abroad in \( s^t \). Among last period non-exporters, if the firm-specific productivity \( \eta(j, s_j^i) \) is greater (less) than \( \eta_0(s^t) \), the producer will (not) export goods abroad in \( s^t \). Thus, the percentage of exporters in \( s^t \) among non-exporters and exporters in \( s^{t-1} \), \( n_0(s^t) \) and \( n_1(s^t) \), respectively, can be defined as

\[ n_m(s^t) = 1 - \Phi[\eta_m(s^t)], \quad (A.21) \]

where \( m = \{0, 1\} \). \( \Phi(\eta) \) is the c.d.f. of \( \eta(i, s_t^i) \). \( N(s^t) \) is the percentage of exporters in \( s^t \) among all intermediate good producers. \( N(s^t) \), evolves as

\[ N(s^t) = n_1(s^t)N(s^{t-1}) + n_0(s^t)[1 - N(s^{t-1})]. \quad (A.22) \]

- **Aggregate Variables**

  **Capital and Investment**

The aggregate capital at home in \( s^t \) is defined as

\[ K(s^t) = \int_{i \in \mathcal{E}(s^t)} K_1(s^t) di + \int_{i \notin \mathcal{E}(s^t)} K_0(s^t) di = [1 - N(s^t)]K_0(s^t) + N(s^t)K_1(s^t). \quad (A.23) \]

The aggregate investment at home in \( s^t \) is defined as

\[ I(s^t) = K(s^t) - (1-\delta)K(s^{t-1}). \quad (A.24) \]
Labor Demands

The average labor demands in $s^t$ from last period non-exporters and exporters, $L_0(s^t)$ and $L_1(s^t)$, can be defined as

$$L_0(s^t) = \frac{\int_{i\in E(s^{t-1})} L(i, s^t) di}{1 - N(s^{t-1})}, \quad L_1(s^t) = \frac{\int_{i\in E(s^{t-1})} L(i, s^t) di}{N(s^{t-1})}.\]$$

Since $\eta(i, s^t)$ follows an identical independent normal distribution, From (A.20)

$$L_m(s^t) = \left[ \frac{W(s^t)}{\theta (1 - \alpha)} \right]^{\frac{\alpha}{\nu}} e^{\frac{1 - \nu}{\alpha} z(s^t)} K_m(s^{t-1})^{1 - \nu} \left\{ \left[ \left( \frac{P(h, s^t)}{P(s^t)} \right)^\mu D_t \right]^e \int_{\eta m(s^t)} e^{\frac{1 - \nu}{\alpha} \phi(\eta)} d\eta + \left[ \left( \frac{P(h, s^t)}{P(s^t)} \right)^\mu D_t + a_2 \frac{\mu}{\nu} q(s^t)^{\frac{1}{1 - \nu}} \left( P^*(h, s^t)^{\frac{\mu}{\nu}} D_t \right)^\nu \int_{\eta m(s^t)} e^{\frac{1 - \nu}{\alpha} \phi(\eta)} d\eta \right\}, \quad (A.25)$$

where $m = \{0, 1\}$. $\phi(\eta)$ is the p.d.f. of $\eta(i, s^t)$. The aggregate labor demand at home can be defined as

$$L(s^t) = [1 - N(s^{t-1})]L_0(s^t) + N(s^{t-1})L_1(s^t). \quad (A.26)$$

Capital Decision Rules

We can rewrite the capital decision rules (A.13) as

$$1 = \sum_{s^{t+1}} Q(s^{t+1}|s^t) \frac{P(s^{t+1})}{P(s^t)} \left[ \left( \frac{\alpha}{1 - \alpha} \right) \frac{W(s^{t+1})}{K_m(s^{t+1})} + (1 - \delta) \right]. \quad (A.27)$$

Price Indices

From the mark-up pricing (A.12), and the labor demand function for the $i_{th}$ firm, the price of the $i_{th}$ firm can be rewritten as

$$\left[ \frac{P(h, i, s_i^t)}{P(s^t)} \right]^{\theta_{10}} = \left[ \frac{W(s^t)}{\theta (1 - \alpha)} \right]^{\frac{\alpha}{\nu}} K_{m(i,s_i^t)}^{1 - \nu} e^{\frac{1 - \nu}{\alpha} [z(s^t) + \eta(i, s_i^t)]} \left\{ \left( \frac{P(h, s^t)}{P(s^t)} \right)^\mu D(s^t) + m(i, s_i^t) a_2 \frac{\mu}{\nu} q(s^t)^{\frac{1}{1 - \nu}} \left( P^*(h, s^t)^{\frac{\mu}{\nu}} D(s^t)^\nu \right)^\nu \right\}, \quad (A.28)$$

$$\left[ \frac{P^*(h, i, s_i^t)}{P^*(s^t)} \right]^{\theta_{10}} = q(s^t)^{\frac{1}{1 - \nu}} \left[ \frac{P(h, i, s_i^t)}{P(s^t)} \right]^{\theta_{10}}. \quad (A.29)$$
Then, the aggregate export price \( P^*(h, s^t) \) can be expressed as

\[
\left[ \frac{P^*(h, s^t)}{P^*(s^t)} \right]^{\theta \gamma} = \left[ \frac{W(s^t)}{\theta(1 - \alpha)} \right]^{\frac{\nu}{\gamma} + \frac{1}{\gamma - 1}} q(s^t)^{\frac{1}{\gamma - 1}} e\left(\frac{1 - \nu}{\alpha}\right) z(s^t) \left\{ \left[ \frac{P(h, s^t)}{P(s^t)} \right]^{\mu} D(s^t) \right. \\
+ a_2 \nu q(s^t)^{\frac{1}{\gamma - 1}} \left[ \frac{P^*(h, s^t)}{P^*(s^t)} \right]^{\mu} D^*(s^t) \left\}^{\nu - 1} \\
\cdot \left\{ [1 - N(s^t)] K_0(s^{t-1})^{1 - \nu} \int_{\eta_0(s^t)}^{\infty} e\left(\frac{1 - \nu}{\alpha}\right) \phi(\eta) d\eta \\
+ N(s^t) K_1(s^{t-1})^{1 - \nu} \int_{-\infty}^{\eta_1(s^t)} e\left(\frac{1 - \nu}{\alpha}\right) \phi(\eta) d\eta \right\}. \tag{A.30}
\]

Similarly, the aggregate home price \( P(h, s^t) \) can be expressed as

\[
\left[ \frac{P(h, s^t)}{P(s^t)} \right]^{\theta \gamma} = q(s^t)^{\frac{1}{\gamma - 1}} \left[ \frac{P^*(h, s^t)}{P^*(s^t)} \right]^{\frac{\theta}{\gamma - 1}} \left[ \frac{W(s^t)}{\theta(1 - \alpha)} \right]^{\frac{\nu}{\gamma} + \frac{1}{\gamma - 1}} \\
\cdot e\left(\frac{1 - \nu}{\alpha}\right) z(s^t) \left\{ \left[ \frac{P(h, s^t)}{P(s^t)} \right]^{\mu} D(s^t) \right. \\
\left. + a_2 \nu q(s^t)^{\frac{1}{\gamma - 1}} \left[ \frac{P^*(h, s^t)}{P^*(s^t)} \right]^{\mu} D^*(s^t) \left\}^{\nu - 1} \\
\cdot \left\{ [1 - N(s^t)] K_0(s^{t-1})^{1 - \nu} \int_{-\infty}^{\eta_0(s^t)} e\left(\frac{1 - \nu}{\alpha}\right) \phi(\eta) d\eta \\
+ N(s^t) K_1(s^{t-1})^{1 - \nu} \int_{-\infty}^{\eta_1(s^t)} e\left(\frac{1 - \nu}{\alpha}\right) \phi(\eta) d\eta \right\}. \tag{A.31}
\]

From the aggregate price index (A.10),

\[
1 = a_1 \gamma \left[ \frac{P(h, s^t)}{P(s^t)} \right]^{\frac{\theta}{\gamma - 1}} + a_2 \gamma \left[ \frac{P(f, s^t)}{P(s^t)} \right]^{\frac{\theta}{\gamma - 1}}. \tag{A.32}
\]

**Values of Firms**

Let \( V_m(s^t), m = \{0, 1\} \), be the average values of firms among the firms that have the same export status, \( m \), in \( s^{t-1} \). Clearly

\[
V_0(s^t) = \frac{1}{1 - N(s^{t-1})} \int_{i \notin \xi(s^{t-1})} V \left[ i, s^t; \eta(i, s^t), K_0(s^{t-1}), 0 \right] di,
\]

\[
V_1(s^t) = \frac{1}{N(s^{t-1})} \int_{i \in \xi(s^{t-1})} V \left[ i, s^t; \eta(i, s^t), K_1(s^{t-1}), 1 \right] di.
\]
These average values of firms can be rewritten as

\[ V_m(s^t) = \left[ 1 - \frac{\theta(1 - \alpha)}{\theta(1 - \alpha)} \right] P(s^t)W(s^t)L_m(s^t) - P(s^t) \left\{ [1 - n_m(s^t)]K_0(s^t) \
+ n_m(s^t)K_1(s^t) \right\} + (1 - \delta)P(s^t)K_m(s^{t-1}) - n_m(s^t)e(s^t)P^*(s^t)\tau_m \n+ \sum_{s^{t+1}} Q(s^{t+1}|s^t) \left\{ [1 - n_m(s^t)]V_0(s^{t+1}) + n_m(s^t)V_1(s^{t+1}) \right\} , \quad (A.33) \]

and the difference between \( V_1(s^t) \) and \( V_2(s^t) \) gives

\[ V_1(s^t) - V_0(s^t) = \left[ 1 - \frac{\theta(1 - \alpha)}{\theta(1 - \alpha)} \right] P(s^t)W(s^t)[L_1(s^t) - L_0(s^t)] \n- P(s^t) \left\{ [n_0(s^t) - n_1(s^t)][K_0(s^t) - K_1(s^t)] \right\} \n+ (1 - \delta)P(s^t)[K_1(s^{t-1}) - K_0(s^{t-1})] \n- e(s^t)P^*(s^t)[n_1(s^t)\tau_1 - n_0(s^t)\tau_0] \n+ [n_1(s^t) - n_0(s^t)]\sum_{s^{t+1}} Q(s^{t+1}|s^t)[V_1(s^{t+1}) - V_0(s^{t+1})]. \quad (A.34) \]

The conditions for marginal exporters (A.19) can be rewritten as

\[ 0 = \left[ 1 - \frac{\theta(1 - \alpha)}{\theta(1 - \alpha)} \right] P(s^t) \left[ \frac{W(s^t)}{\theta(1 - \alpha)} \right]^{\frac{\mu + \theta - 1}{\theta - 1}} e^{(\frac{1 - \nu}{\alpha})[z(s^t) + \eta_m(s^t)]} K_m(s^{t-1})^{1-\nu} \n\cdot \left\{ \left( \frac{P(h, s^t)}{P(s^t)} \right)^\mu D_t + a_2^{-\nu} q(s^t)^{1-\nu} \left( \frac{P^*(h, s^t)}{P^*(s^t)} \right)^\mu D_t^* \right\}^{\nu} \n- \left[ \left( \frac{P(h, s^t)}{P(s^t)} \right)^\mu D_t \right]^{\nu} \right\} - P(s^t)[K_1(s^t) - K_0(s^t)] - e(s^t)P^*(s^t)\tau_m \n+ \sum_{s^{t+1}} Q(s^{t+1}|s^t)[V_1(s^{t+1}) - V_0(s^{t+1})]. \quad (A.35) \]

Notice that by substituting \([V_1(s^{t+1}) - V_0(s^{t+1})]\) with (A.34), (A.35) becomes a static equation.

**Exports and Imports**

The real imports are defined as

\[ IM(s^t) = \int_{i \in \mathcal{E}^*(s^t)} P(f, i, s^t)y(f, i, s^t) \frac{P(s^t)}{P(s^t)} di \n= a_2^{\frac{1}{\rho}} \left[ \frac{P(f, s^t)}{P(s^t)} \right]^{\frac{\rho}{\rho - 1}} D(s^t). \quad (A.36) \]
Similarly, the real exports are defined as

$$EX(s^t) = \int_{i \in E(s^t)} \frac{e(s^t)P^*(h, i, s^t)g^*(h, i, s^t)}{P(s^t)} di$$

$$= a_2^{\frac{1}{\gamma}} q(s^t) \left[ \frac{P^*(h, s^t)}{P^*(s^t)} \right]^{\frac{\gamma}{\gamma-1}} D^*(s^t).$$  \hspace{1cm} (A.37)

The gross domestic product, $Y(s^t)$ is defined as

$$Y(s^t) = C(s^t) + I(s^t) + NX(s^t),$$  \hspace{1cm} (A.38)

where $NX(s^t) = EX(s^t) - IM(s^t)$, the real net exports.

**Incomplete Asset Market**

Under the incomplete asset market environment as in (5.1), the foreign consumer’s budget constraint becomes

$$P^*(s^t)C^*(s^t) + \frac{\overline{Q}(s^t)\overline{B}^*(s^t)}{e(s^t)} \leq P^*(s^t)W^*(s^t)L^*(s^t) + \frac{\overline{B}^*(s^t-1)}{e(s^t)} + \Pi^*(s^t) + P^*(s^t)T^*(s^t).$$

The first order conditions give

$$\overline{Q}(s^t) = \sum_{s^{t+1}} P_r(s^{t+1}|s^t) \frac{U_C(s^{t+1})P(s^t)}{U_C(s^t)P(s^{t+1})}$$

$$= \sum_{s^{t+1}} P_r(s^{t+1}|s^t) \frac{U^*_C(s^{t+1})e(s^t)P^*(s^t)}{U^*_C(s^t)e(s^{t+1})P^*(s^{t+1})}. \hspace{1cm} (A.39)$$

$$P^*(s^t)C^*(s^t) + \frac{\overline{Q}(s^t)\overline{B}^*(s^t)}{e(s^t)} = \left[ \frac{1}{\theta(1-\alpha)} \right] P^*(s^t)W^*(s^t)L^*(s^t) - P^*(s^t)T^*(s^t)$$

$$+ \frac{\overline{B}^*(s^{t-1})}{e(s^t)} - \frac{P(s^t)}{e(s^t)} \left[ n_0^*(s^t)\tau_0 + n_1^*(s^t)\tau_1 \right]$$

$$+ P^*(s^t) \left[ n_0^*(s^t)\tau_0 + n_1^*(s^t)\tau_1 \right]. \hspace{1cm} (A.40)$$
Hence, The equation for the real exchange rate (A.7) is replaced by (A.39), and the budget constraint (A.40) is newly introduced with the additional variable \( \overline{B}'(s^t) \).

• An Equilibrium

Under the normalization of price indices, \( P(s^t) = P^*(s^t) = 1 \), we have 6 dynamic equations:\(^{24}\)

1. (A.27) and foreign analogue for \( K_0(s^t) \) and \( K^*_0(s^t) \), and \( K_1(s^t) \) and \( K^*_1(s^t) \);
2. (A.34) and foreign analogue for \( V_1(s^t) - V_0(s^t) \) and \( V^*_1(s^t) - V^*_0(s^t) \);

and, 37 other static equations:

1. (A.1) and foreign analogue for \( W(s^t) \) and \( W^*(s^t) \);
2. (A.7) ((A.39 under the incomplete asset market condition) for \( q(s^t) \);
3. (A.11) and foreign analogue for \( D(s^t) \) and \( D^*(s^t) \);
4. (A.21) and foreign analogue for \( n_0(s^t) \) and \( n^*_0(s^t) \), and \( n_1(s^t) \) and \( n^*_1(s^t) \);
5. (A.22) and foreign analogue for \( N(s^t) \) and \( N^*(s^t) \);
6. (A.23) and foreign analogue for \( K(s^t) \) and \( K^*(s^t) \);
7. (A.24) and foreign analogue for \( I(s^t) \) and \( I^*(s^t) \);
8. (A.25) and foreign analogue for \( L_0(s^t) \) and \( L^*_0(s^t) \), and \( L_1(s^t) \) and \( L^*_1(s^t) \);
9. (A.26) and foreign analogue for \( L(s^t) \) and \( L^*(s^t) \);
10. (A.30) and foreign analogue for \( P^*(h, s^t) \) and \( P(f, s^t) \);
11. (A.31) and foreign analogue for \( P(h, s^t) \) and \( P^*(f, s^t) \);
12. (A.32) and foreign analogue for \( P(s^t) \) and \( P^*(s^t) \);
13. (A.35) and foreign analogue for \( \eta_0(s^t) \), \( \eta^*_0(s^t) \), \( \eta_1(s^t) \), and \( \eta^*_1(s^t) \)\(^{25}\);

\(^{24}\)\( Q(s^{t+1}|s^t) \) is substituted by other variables using (A.2) and (A.5).

\(^{25}\)By substituting \( [V_1(s^{t+1}) - V_0(s^{t+1})] \) with (A.34), (A.35) becomes a static equation.
14. (A.36) and foreign analogue for $IM(s^t)$ and $IM^*(s^t)$;

15. (A.37) and foreign analogue for $EX(s^t)$ and $EX^*(s^t)$;

16. (A.38) and foreign analogue for $Y(s^t)$ and $Y^*(s^t)$.

Under the imperfect asset market condition, we have one more equation

17. (A.40) for $B^*(s^t)$. 
APPENDIX B

PARAMETERIZATIONS

This chapter describes the steps for parameterizations using the most general model, benchmark model with positive export penetration costs, $\tau_0 > \tau_1 > 0$.

The steady state can be found by dropping $s^t$, and solving for a fixed point. In the steady state, trade is balanced, $NX = 0$, and the real exchange rate, $q$, equals to 1. From the zero profit condition in the final goods market and the mark-up pricing of intermediate good firms,

$$ Y = C + \delta K $$
$$ = \int_0^1 P(h, i)F(i)di = \frac{1}{\theta(1-\alpha)}WL. \quad (B.1) $$

Under the nonseparable utility function, $U(C, L) = [C^\gamma(1-L)^{1-\gamma}]/(1-\sigma)$, (A.1) and (B.1) give

$$ Y = C + \delta K = \frac{WL}{\theta(1-\alpha)} $$
$$ = \left(\frac{1-\gamma}{\gamma}\right)\left(\frac{L}{1-L}\right)\frac{C}{\theta(1-\alpha)}. \quad (B.2) $$

Hence, in the steady state, consumption, $C$, the wage rate, $W$, and GDP, $Y$, are proportional to capital, $K$.

$$ C = \xi_C K, \quad W = \xi_W K, \quad Y = \xi_Y K, \quad (B.3) $$

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where $\xi_C = \delta \left[ \frac{1}{\theta(1-\alpha)} \left( \frac{1-\gamma}{\gamma} \right) \left( \frac{L}{1-L} \right) - 1 \right]^{-1}$, $\xi_W = \left( \frac{1-\gamma}{\gamma} \right) \frac{\xi_C}{1-L}$, and $\xi_Y = \xi_C + \delta$. Given starter and stopper ratios, $n_0$ and $n_1$, the law of motion for the exporter ratio (A.22) gives

$$N = \frac{n_0}{1 - n_1 + n_0}, \quad \text{(B.4)}$$

and starter and stopper ratios equations (A.21) gives

$$\eta_m = \Phi^{-1}(1 - n_m), \quad m = \{0, 1\}. \quad \text{(B.5)}$$

From the definition of imports, $IM$, (A.36) and the price index (A.10), home and foreign price indices, $P(h)$ and $P(f)$ can be expressed as

$$P(h) = a_{\frac{1}{\rho}}^\frac{2}{\sigma} (1 - TR)^{\frac{\rho-1}{\sigma}}, \quad \text{(B.6)}$$

where $TR = \frac{IM}{Y}$. The capital accumulation rules (A.27) gives

$$\frac{WLm}{K_m} = \frac{1 - \alpha}{\alpha} \left[ \frac{1}{(1 - \delta)} \right] - \delta \frac{Y}{K}. \quad \text{m = 0, 1.} \quad \text{(B.7)}$$

The real interest rate determines the time discount factor, $\beta$. The real interest rate is equal to $(1 - \beta)/\beta$ in the steady state. $\rho$ is determined by the elasticity of substitution between home and foreign aggregate, $1/(1-\rho)$. The capital depreciation rate, $\delta$, can be obtained from (B.1), given consumption-GDP ratio $C_Y$ and GDP-capital ratio $Y_K$. By dividing both sides of (B.1) by $Y$, we have $C_Y = 1 - \delta Y_K$. Hence, $\delta = (1 - C_Y) Y_K$. The productivity parameter value, $\alpha$, can be derived from (B.1), given mark-up pricing parameter of intermediate producers $\theta$ and labor income to GDP ratio $WL Y$. $\alpha = 1 - \frac{WLY}{\theta}$. The preference parameter value, $\gamma$ can be obtained from (B.2). Under the nonseparable utility function, $U(C, L) = \left[ \frac{C_Y \gamma (1-L)}{1-\sigma} \right]$; (A.1)and (B.2) give

$$\frac{C}{Y} = \left( \frac{\gamma}{1-\gamma} \right) \left( \frac{1-L}{L} \right) \theta(1-\alpha). \quad \text{(B.8)}$$
Other parameter values, $\tau_0$, $\tau_1$, and $a_2$ can be derived by the system of equations. Given starter and stopper ratios, $n_0$ and $n_1$, together with the normalization of $a_1 = 1$, $K_0$, $K_1$, $\tau_0$, $\tau_1$, $V_0$, $V_1$, and $a_2$ solve labor demand equations (A.25), marginal exporter conditions (A.35), average values of firms (A.33), and foreign price index (A.30).
APPENDIX C

SOLVING THE LINEARIZED SYSTEM

To employ these methods, we need to modify the system of equations derived by the model.

**Step 1:** Log-linearize the system of 43 equations around the steady state.

**Step 2:** Arrange static equations as functions of state variables and marginal exporters’ firm-specific productivity levels. From 37 static equations, we can have 37 linear equations for 37 variables as functions of state variables $X(s^t) = \{\hat{N}(s^t), \hat{N}^*(s^t), \hat{K}_0(s^t), \hat{K}_0^*(s^t), \hat{K}_1(s^t), \hat{K}_1^*(s^t)\}'$, and $Z(s^t) = \{\hat{z}(s^t), \hat{z}^*(s^t)\}'$. The notation $\hat{}$ denotes the percentage deviation of the variable from the steady state ($\hat{X}(s^t) = \ln(X(s^t)) - \ln(X))$.

**Step 3:** Arrange 6 dynamic equations as functions of state variables by using the results in **Step 2**.

By rearranging the system of equations, we can have the form

$$M_1 E_t X(s^{t+1}) + M_2 X(s^t) + M_3 X(s^{t-1}) = M_4 Z(s^t).$$  \hspace{1cm} (C.1)
Rearranging the system of equations in (C.1), we can have the modified system of the equations that is directly applicable to the methods by King, Plosser, and Rebelo (1988a,b), or Klein (2000).

\[
\begin{bmatrix}
M_2 & M_1 \\
I & 0
\end{bmatrix}
E_t \begin{bmatrix}
\mathcal{X}(s^t) \\
\mathcal{X}(s^{t+1})
\end{bmatrix} =
\begin{bmatrix}
-M_3 & 0 \\
0 & I
\end{bmatrix}
\begin{bmatrix}
\mathcal{X}(s^{t-1}) \\
\mathcal{X}(s^t)
\end{bmatrix} +
\begin{bmatrix}
M_4 \\
0
\end{bmatrix}
Z(s^t). \tag{C.2}
\]

**Step 4:** Using the method of Klein (2000) solve the system of equations in (C.2).
APPENDIX D

DATA DESCRIPTION

• Data for Business Cycles Statistics

The U.S. data are from the Federal Reserve Bank of St. Louis economic database (FRED). Output, consumption, investment, and employment are real gross domestic production, real personal consumption expenditures, real fixed private investment, and civilian employment, respectively. Net Exports are calculated from the International Monetary Fund publication, Directions of Trade Statistics. They are the U.S. exports toward EU15 minus the U.S. imports from EU15.

An Aggregate of 15 European Countries (EU15) are from Organisation for Economic Co-operation and Development, Main Economic Indicators. Output, consumption, investment, and employment are real gross domestic product, real private final consumption expenditures, real gross fixed capital formation, and civilian employment, respectively. 15 European countries are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom. Aggregate values are calculated using totals obtained by the addition of constant prices data expressed at 1995 price levels and converted into the U.S. dollars using fixed 1995 Purchasing Power Parities.
• Data for Turnover Ratios in Export Status

Colombian data are from Table 2.A in Roberts and Tybout (1997). The table is obtained from annual plant-level data of the Colombian manufacturing census for the years 1981 - 1989. The data covers 19 major industries in Colombian manufacturing sector. There are 2,396 plants in the group. RER is the real effective real exchange rates. High value of RER implies the depreciation of the domestic currency.

German firm-level data are from the recalculation of Table 2 in Bernard and Wagner (1998). The table is obtained from an annual survey of manufacturing establishments. The data covers all establishments with 20 or more employees in Lower Saxony, Germany for the years 1978 - 1992. The real effective real exchange rate (RER) data are from International Monetary Fund, *International Financial Statistics CD-Rom*, June 2000. RER is based on trade weighted relative wholesale price indices. High value of RER implies the depreciation of the domestic currency.

The U.S. data are from the recalculation of Table 5 in Bernard and Jensen (2001). The table is obtained from the Annual Survey of Manufacturer from the Longitudinal Research Database of the Bureau of the Census. The data covers 13,550 plants for the years 1984 - 1992. The real effective real exchange rate data are from International Monetary Fund, *International Financial Statistics CD-Rom*, June 2000. RER is based on trade weighted relative wholesale price indices. High value of RER implies the depreciation of the domestic currency.
BIBLIOGRAPHY


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