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ABSTRACT

International Business Cycles: The Quantitative Role of Transportation Costs*

We evaluate the quantitative effects of introducing costs of transportation into an international trade model. We model these costs through the introduction of international transportation services sector. Costs of transportation have substantial long-run effects on welfare and may impact on the pattern of trade. Business cycle effects on relative price movements and on international comovements are, however, less pertinent since decreased trade volatility counteracts the effects of transportation cost variations. Nevertheless, it is also shown that costs of transportation combined with delivery lags go a long way towards resolving, in particular, the international comovement puzzle.

JEL Classification: E32, F31 and F41
Keywords: costs of transportation, delivery lags, home-bias in trade, international business cycles, international comovements, real exchange rates and terms of trade

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1 Introduction

Frictions in international trade of goods have recently come to the forefront of the research program in international macroeconomics. Obstfeld and Rogoff (2000) argue that costs of international transportation, tariff and non-tariff barriers, and related frictions, can help resolve six key puzzles in international macroeconomics (the "home-bias in trade puzzle", the "savings-investment puzzle", the "international comovement puzzle", the "portfolio home-bias puzzle", the "purchasing parity power puzzle", and the "exchange rate disconnect puzzle"). Their analysis, however, stops short of addressing the quantitative implications in fully specified general equilibrium models. This paper takes on part of this job and examines the quantitative implications of costs of international transportation for the first puzzle, the third puzzle and the "price puzzle" of Backus, Kehoe and Kydland (1994, 1995). The "home-bias in trade puzzle" consists of the observation that there is far more trade within countries than across countries, the "international comovement puzzle" relates to the size and ranking of international comovements of main macroeconomic aggregates, and the "price puzzle" concerns the high volatility of international relative prices in the data.

We examine these issues in a two-country model in which each of the two countries produce a single differentiated good. It is assumed that any good that is traded internationally must be handled by firms in an international transportation service sector. The approach generalizes the standard Samuelsonian (Samuelson, 1954) "iceberg" specification of transportation costs and assumes that transportation is associated with the use of factor inputs. Furthermore, in order to focus attention entirely on the separate contribution of the trade friction, we assume that asset markets are complete and that agents behave competitively.

We first examine the "home-bias in trade puzzle". We study the bias in total trade and evaluate the welfare costs of costs of transportation. We find that costs of transportation matter for the "home-bias in trade puzzle" but only if domestic and foreign goods are highly substitutable. For elasticities of substitution typically studied in the business cycle literature, the share of foreign trade does not depend much on costs of transportation. The welfare effects of changes in costs of transportation are, however, very large and insensitive to the assumed elasticity of substitution. A decrease in costs of international trade from 20 percent to 10 percent of the shipping value is found to be equivalent to a permanent increase in consumption of 3-4 percent. Our analysis assumes away congestion effects of trade, but since the effects of costs of transportation on trade may not be large, this is unlikely to bias our results too much.[1]

We then examine the implications for the "price puzzle". In a frictionless economy, Backus, Kehoe and Kydland (1994) show that terms of trade variability is limited for realistic parameter values and, importantly, much lower than in the data. The model's inability to account for high terms of trade variability derives from a relationship between the terms of trade and the marginal rate of transformation between domestic and foreign goods which links terms of trade variability and the variability of trade. Since trade variability is low in their model, terms of trade variability is also low. In our model, the c.i.f. (cost, insurance, freight) definition of the terms of trade will be linked directly to the marginal rate of transformation but the f.o.b. (free on board) terms of trade will differ from the c.i.f. terms of trade due to costs of transportation. Hence, in principle, for a given variability of trade, the variability of the f.o.b. terms of trade may be higher than in frictionless economies due to costs of transportation variations. However, with the introduction of costs of transportation the variability of international trade decreases since the price of imports (including transportation costs) increases more in times of high imports. The net effect on relative price volatility is therefore moderate. We also find that the implications for the "international comovement puzzle" are limited although, qualitatively, the effects go in the right direction.

After this we examine three extensions of the model. In our baseline model we assume that domestic companies transport domestic imports. This implies that the relevant terms of trade definition is the f.o.b. definition. In the first extension we alternatively assume that foreign companies transport domestic imports (in which case the relevant terms of trade definition is the c.i.f. definition). This assumption, however, is shown to be of minor importance for the terms of trade movements and for other business cycle features of the model. Next, we assume that there are limited possibilities for substituting labor across different sectors of the economy. We find that for sufficiently limited possibilities for cross-sectorial re-allocation of labor, there may be large volatility in relative prices. This, however comes at the cost of much too large investment variability and once this feature is taken into account the quantitative implications of limited scope for labor supply re-allocation are small.

We do, however, end on a more optimistic note. Our last experiment introduces another feature of international trade: delivery lags. Such lags are realistic given the geographical distances involved

[1] Our analysis allows for home-bias in preferences so that foreign goods have a lower utility weight than domestic goods. Without this aspect, the welfare effects of changes in costs of transportation would be even larger.

in international trade. In particular, we assume that the quantity of imports is pre-determined and must be set before the current period's stochastic shocks to the economy are realized. In this case we show that the model may be consistent with large variations in relative prices and that the model may account for the "international comovement puzzle". The reason is that since imports are pre-determined, any unexpected shock to the economy gives rise to large variations in relative prices and this also leads to a ranking of international comovements of main aggregates that is consistent with the data.

The remainder of the paper is organized as follows. Section 2 examines the business cycle features of OECD data and provides evidence on the size of costs of international transportation. Section 3 presents the model and its calibration. Section 4 examines the quantitative implications and Section 5 looks at the extensions of the model. Finally, Section 6 summarizes and concludes.

2 Empirical Regularities

2.1 Business Cycle Moments and Relative Prices

We examine quarterly data for a cross-section of 14 OECD economies (Australia, Austria, Canada, Denmark, France, Italy, Japan, the Netherlands, New Zealand, Spain, Sweden, Switzerland, the UK and the US) for the period 1970-2000 obtained from SourceOECD (see the appendix for details). Expenditure components are measured in per capita constant base year prices. Net exports are measured by the ratio of exports less imports to GDP (in current prices). The terms of trade are defined as the implicit import deflator divided by the implicit export deflator and the real exchange rate is the real effective exchange rate. We apply the Hodrick and Prescott (1997) filter (with a value of 1600 for the smoothing parameter) to isolate the business cycle moments. Table 1 reports the average of the moments and the extreme values of the moments.

The average standard deviation of output is 1.41 percent per quarter. Consumption is smoother than output while investments are exactly 3 times as variable as output. Output, consumption and investment are all very persistent, and consumption and investment are both procyclical. The standard deviation of exports (imports) is approximately 2.25 times (3 times) that of output. As we will see, the high variability of trade is one of the aspects that international trade models cannot easily account for. Net-exports are countercyclical and the average standard deviation of net exports is close to 1 percent per quarter, but this estimate varies from a low of 0.45 percent in the US to a high of 1.64 percent in New Zealand.

The terms of trade are persistent (the mean first-order autocorrelation coefficients is 0.88) and volatile with a mean standard deviation 2 to 2.5 times higher than that of output. There are, however, large cross-country differences in the terms of trade variability which varies from 1.17 percent per quarter in Austria to 5.30 percent in Japan. Real exchange rates vary slightly more than the terms of trade but are less persistent. The sixth column reports the cross-correlation between the real exchange rate and the terms of trade. The mean correlation in the sample is 0.39 indicating that there is a substantial - but non-perfect - positive relationship between these two relative prices. No such close relationship exists between either of these relative prices and output: The mean of the correlation between the terms of trade and output is -0.03 and the mean of the correlation between the real exchange rate and output is 0.07. Similarly, the mean of the contemporaneous correlation between the terms of trade and net-exports is numerically small but with large variations across countries (see Backus, Kehoe and Kydland, 1995, Tables 11.5 and 11.6 for similar findings).

The last two columns of the table report the cross-country correlations of main aggregates. The results confirm those reported in Backus, Kehoe and Kydland (1992, 1994) and in Ravn (1997). The cross-country correlations are all positive but substantially lower than 1. Output is the variable that is most closely related across countries with a mean correlation of 0.33. The cross-country correlations of investments are similar to those of output. Consumption levels are also positively correlated across countries but the mean estimate is lower than the cross-country correlations of output and investment. Ambler, Cardia, and Zimmerman (1999) have investigated whether this ranking of correlations is statistically significant and find that the cross-country correlations of output and consumption are not significantly different in a sample that includes data from 1960 to 1991. However, they also find if one focuses on post 1973 data, output correlations *are* larger than the consumption correlations. Our sample periods starts in 1970 and include all of the 1990's in which case there is a larger difference between these correlations.

2.2 Transportation Costs

We compute costs of international transportation from US bilateral 4-digit Standard Industrial Classification (SIC) 1972-basis data for manufacturing imports taken from Feenstra (1996).[2] Our measure of costs of transportation is:

$$\tau_i = \frac{imp_i^{cif}}{imp_i^{fob}} - 1 \tag{1}$$

[2]Hummels (1999) examines instead the prices charged by international carriers.

where imp_i^{cif} is the c.i.f. value of imports of good i, and imp_i^{fob} is the f.o.b. value of imports. Table 2 reports the estimates of the "weighted" costs of transportation (equation (1) for *aggregate* US imports), and the mean and modal value of the transportation costs evaluated at the 4 digit level.

The estimated costs are substantial. For 1994 the mean of the costs across goods at the 4 digit level is 10.1 percent. This estimate excludes many other aspects of costs of trade such as administration costs, red-taping, informational costs, and tariffs (and the tariff equivalents of quotas and other trade restrictions). Hummels (1998) finds similar numbers in 2 digit SITC data for the US and the IMF typically uses an estimate of 11 percent transportation costs.[3] Costs of transportation have decreased substantially over time but the size of the decrease depends on the measure of costs. The "weighted" costs of transportation falls from 6.31 percent in 1974 to 3.49 percent in 1994 while the mean of the 4 digit costs of transportation decreases only from 14.4 percent to 10.1 percent. Hence, some of the decrease in the weighted costs is related to substitution towards imports of goods with lower costs of transportation.

Finally, since the mean of the costs of transportation across individual goods types is higher than the modal value of these costs, there is evidence that the "true" costs of transportation may be much higher than the measured costs of transportation in the sense that there is little or no trade in goods with high costs of transportation. Hummels (1998) investigates this in more detail and confirms the idea that there is substantial substitution away from goods with high costs of transportation.

3 The Model Economy

We introduce a sector that produces international transportation services into a two country model with specialization. The quantity of imports is assumed to depend on the input of foreign exports and on factor inputs thus generalizing the standard Samuelsonian "iceberg" specification (Samuelson, 1954). To focus attention on the friction in trade, we assume that there is a complete set of asset markets and that all agents in the economy behave competitively.

[3]Harrigan (1993) estimates transport costs to be 20 percent. There are, however, reasons to believe that this estimate might be assicated with measurement problems, see Hummels (1999).

3.1 Preferences and Technology

Each country is inhabited by a large number of identical infinitely lived agents. The agents in each country are represented by a stand-in agent with preferences given by:

$$U_{js} = E_s \sum_{t=s}^{\infty} \beta^{t-s} \left\{ \left[c_{jt}^{\theta} L_{jt}^{1-\theta} \right]^{1-\sigma} - 1 \right\} / (1-\sigma) \tag{2}$$

where E_s is the conditional expectations operator; β is the subjective rate of discount; c is consumption and L is leisure; θ is a share parameter, and $1/\sigma$ is the intertemporal elasticity of substitution.

The technological specification can be summarized by the following equations:

$$y_{jt} = \exp(z_{jt}) \left(k_{jt}^{y} \right)^{1-\alpha} \left(n_{jt}^{y} \right)^{\alpha} \tag{3}$$

$$y_{jt} = d_{jt} + x_{jt} \tag{4}$$

$$m_{jt} = \min \left[\pi_1 x_{it}, \pi_2 \left(k_{jt}^{tr} \right)^{1-\gamma} \left(n_{jt}^{tr} \right)^{\gamma} \right] \tag{5}$$

$$k_{jt+1}^{s} = (1-\delta) k_{jt}^{s} + \varphi_s \left(i_{jt}^{s} / k_{jt}^{s} \right) k_{jt}^{s}, \; s = y, tr \tag{6}$$

$$V_{jt} = \left[\omega_1 d_{jt}^{1-\rho} + \omega_2 m_{jt}^{1-\rho} \right]^{1/(1-\rho)} \tag{7}$$

$$V_{jt} = c_{jt} + g_{jt} + i_{jt} \tag{8}$$

$$L_{jt} + n_{jt}^{y} + n_{jt}^{tr} \leq T \tag{9}$$

Equation (3) is the production function for "output goods" (y denotes output; z is a stochastic technology shock; k^y (n^y) is input of capital (labor) and α is the labor share). Equation (4) is the resource constraint for the output goods which can be used either domestically (d), or exported (x).

A key relationship is given by the import technology in equation (5). Production of imports depends on inputs of foreign exports and on inputs of capital (k^{tr}) and labor (n^{tr}) and γ is the labor share in the transportation sector. The specification assumes complementarity between the inputs of foreign exports and domestic factors of production in the production of domestic imports, see also Crucini (1997). The parameter $\pi_1 \leq 1$ can be interpreted as "iceberg" costs[4] while the parameter π_2 indicates the importance of factor inputs. The inclusion of factor inputs allows us to model the transportation sector more realistically and gives rise to variations in the costs of transportation over time.[5]

Capital accumulation is given by equation (6) where δ is the rate of depreciation and i^s denotes

[4] The Samuelsonian "iceberg" is the special case when $\pi_2 \to \infty$. The restriction that $\pi_1 \leq 1$ is natural since to sell imports you need to buy foreign exports.

[5] Ravn and Mazzenga (1999) examine the more general case of a CES technology.

investment. The function $\varphi_s\left(i^s/k^s\right)k^s$ captures capital adjustment costs is increasing and concave in i^s/k^s and assumed to be consistent with a steady-state Tobin's Q of 1.

All domestic final uses of goods are specified by identical constant elasticity of substitution functions of domestic goods and imports. To simplify the notation we adopt the Armington (1969) aggregator in equation (7) where V is the output of final goods. ω_1 and ω_2 are share parameters, and $1/\rho$ is the elasticity of substitution between domestic goods and imports. The resource constraint for the final goods is given in (8) where g is government spending, and $i = i^y + i^{tr}$ is aggregate investment. The government finances its expenditures through lump-sum taxation of domestic agents. Finally, letting T denote the time endowment, the resource constraint for the use of time is given in equation (9).

Letting the domestic output good be the numeraire, aggregate output in current (Y_{jt}^{ag}) and constant prices (y_{jt}^{ag}) are given as:

$$Y_{jt}^{ag} = y_{jt} + \left(\frac{p_{jt}^m}{p_{jt}^x} - \frac{p_{it}^x/\pi_1}{p_{jt}^x}\right)m_{jt} \tag{10}$$

$$y_{jt}^{ag} = y_{jt} + \left(\frac{p_j^m}{p_j^x} - \frac{p_i^x/\pi_1}{p_j^x}\right)m_{jt} \tag{11}$$

$$y_{jt}^{tr} = \left(p_{jt}^m - p_{it}^x/\pi_1\right)m_{jt} \tag{12}$$

where variables without time subscripts are evaluated at the steady state, p^m is the price of imports, p^x the price of exports, and y^{tr} is value added in the transportation sector.

In this economy prices differ across markets due to costs of transportation but there are no goods market arbitrage opportunities.[6] Price differences are reflected in the differences between terms of trade evaluated at f.o.b. prices and at c.i.f. prices. The c.i.f. terms of trade equal the marginal rate of transformation between domestic and foreign goods evaluated at equilibrium quantities:

$$p_{jt}^{cif} = \frac{p_{jt}^m}{p_{jt}^x} = \frac{\omega_2}{\omega_1}\left(\frac{m_{jt}}{d_{jt}}\right)^{-\rho} \tag{13}$$

and costs of transportation are given as:

$$p_{jt}^{tr} = \frac{p_{jt}^m}{p_{it}^x} = \frac{1}{\pi_1} + \frac{\kappa}{\pi_2}\left(R_{jt}\right)^{1-\gamma}\left(W_{jt}\right)^{\gamma}\frac{1}{p_{it}^x} \tag{14}$$

where R_{jt} (W_{jt}) is the rental price of capital (the wage rate) and $\kappa = \gamma^{-\gamma}\left(1-\gamma\right)^{\gamma-1}$. Given this, the f.o.b. terms of trade follow as $p_{jt}^{fob} = p_{jt}^{cif}/p_{jt}^{tr}$.

[6] This aspect contrasts with the international business cycle models that allow for sticky prices and local currency pricing (see e.g. Betts and Devereux, 1996, 2000, or Chari, Kehoe and McGrattan, 2001). That literature assumes away any goods market arbitrage.

Notice from equation (13) that c.i.f. terms of trade variability is intrinsically linked to the elasticity of substitution, $1/\rho$, and to trade variability. In Backus, Kehoe, and Kydland (1994) this link is key to their finding of low terms of trade variability. In our setting variations in costs of transportation break this direct link as far as the f.o.b. terms of trade movements are concerned. Since we assume that domestic firms transport domestic imports, the f.o.b. terms of trade is the relevant price definition, and, hence, transport cost variations may be important for understanding terms of trade movements.

The real exchange rate for country j can be expressed as:

$$q_{jt} = \frac{Q_i}{Q_j} = \frac{1}{p_{jt}^{tr}} \left(\frac{\omega_2^{1/\rho} \left(p_{it}^{cif}\right)^{(\rho-1)/\rho} + \omega_1^{1/\rho}}{\omega_1^{1/\rho} \left(p_{jt}^{cif}\right)^{(1-\rho)/\rho} + \omega_2^{1/\rho}} \right)^{\rho/(\rho-1)} \tag{15}$$

where Q_j is the final goods price level. In the absence of frictions (in which case $p_{it}^{cif} = 1/p_{jt}^{cif}$) the real exchange rate will fluctuate in response to terms of trade movements if there is a preference for homegoods. When there are frictions in trade, variations in costs of transportation and differences in prices of tradables will contribute additionally to real exchange rate movements.[7]

One can show that the model has the following risk sharing implication:

$$\frac{u_c\left(c_{jt}, L_{jt}\right)}{u_c\left(c_{it}, L_{it}\right)} = \chi q_{jt} \tag{16}$$

where χ is a constant reflecting initial wealth and u_c denotes the real marginal utility of consumption. Backus and Smith (1993) derive such a condition in a model with non-traded goods, Chari, Kehoe, and McGrattan (2001) in a sticky price model, and Obstfeld and Rogoff (2000) in a model with "iceberg" costs of transportation, and it derives from the assumption of a complete set of contingent claims markets. The condition indicates that the real exchange rate may be important in accounting for why cross-country correlations of consumption are low.[8]

3.2 Calibration

We calibrate the model assuming that one period of time corresponds to one quarter. The parameter values are summarized in Table 3.

β is chosen to match an annual real interest rate of 4 percent. Households are assumed to spend 30 percent of their time endowment on market activities. The quarterly rate of depreciation of the

[7] Dumas (1992) have earlier shown in a model with trade in capital only that transportation costs may lead to high persistence of real exchange rates.

[8] Engel (2000) discusses this aspect of Obstfeld and Rogoff (2000), and Ravn (2001) tests this implication empirically.

capital stock is 2.5 percent and we assume that the labor share in the output sector is equal to 64 percent. We follow Backus, Kehoe and Kydland (1992, 1994) and assume that the intertemporal elasticity of substitution ($1/\sigma$) is equal to 0.5.

The average of the export and import shares of GDP is 27.4 percent among the 14 countries examined in Section 2, but this share varies from 10 percent in Japan and in the US to approximately 50 percent in the Netherlands. We use a compromise estimate of 20 percent for the steady-state trade share (denoted s_x), but examine the robustness of the results to the exact value of this parameter.

An important parameter is the elasticity of substitution between domestic goods and imported goods, $1/\rho$. Based on the most reliable estimates in Stern et al (1976), Backus, Kehoe and Kydland (1994) use a value of 1.5 while Obstfeld and Rogoff (2000) use a value of 6.[9] The parameter uncertainty is not entirely surprising since international trade entails a wide variety of different goods that are substitutes to domestic goods to varying degrees. In our baseline calibration we set this parameter equal to 1.5 but we also examine the sensitivity of the results to the value of $1/\rho$.

In Section 2 we showed that narrowly defined transportation costs have fallen from 14.4 percent in 1974 to 10.1 percent in 1994. These estimates do not include other costs of international trade such as administration costs, red-taping, and costs imposed by restrictions on trade. For that reason, along with Obstfeld and Rogoff (2000), we assume that the steady-state costs of transportation are equal to 20 percent.

To calibrate γ we use sector specific income data which are hard to obtain on a consistent basis. In OECD data, the labor share in transports, storage and communications is 59.5 percent. However, in data for the US, which exclude storage and communications, the labor shares in manufacturing and in transportations are identical. Alternative estimates can be obtained from studies of the production function in the transportation sector. A well-known study is Caves, Christensen and Tretheway (1983) who examine the US air transport industry. They find a labor share of 42.7 percent. We will first examine the case in which $\gamma = 0.64$ but also examine $\gamma = 0.427$ in order to evaluate the sensitivity of the results.

We calibrate π_1 and π_2 using information about the value added of the transportation sector relative to value added in the output sector. Evaluating equations (12) and (5) at the steady state implies that:

$$y^{tr}/y = \left(p^{tr}\pi_1 - 1\right) s_x \tag{17}$$

[9]Their choice is based on estimates by Trefler and Lai (1999) and Harrigan (1993) and on estimates of mark-ups of price over marginal costs in Cheung, Chinn and Fujii (1999) and Hummels (1998)

The average value added share of the transport, storage, and communications sector is around 7 percent. A conservative (high) estimate of the international transportation share of this number is 50 percent. Given this, we find that $\pi_1 = 0.984$. π_2 now follows as $\pi_2 = \pi_1 / \left(p^{tr}\pi_1 - 1\right)$.

The share parameters ω_1 and ω_2 are given as:

$$\omega_1 = \left[\frac{1 - s_x}{1 - s_x + p^{tr}\pi_1 s_x}\right]^{\rho} \tag{18}$$

$$\omega_2 = \left[\frac{\left(p^{tr}\right)^{1/\rho}\pi_1 s_x}{1 - s_x + p^{tr}\pi_1 s_x}\right]^{\rho} \tag{19}$$

which imply that $(\omega_1, \omega_2) = (0.842, 0.397)$.

We calibrate the adjustment cost parameters such that the variability of investment is approximately four times the variability of output. We assume that $(\ln z_{1t}, \ln z_{2t})'$ is generated by:

$$\begin{pmatrix} \ln z_{1t} \\ \ln z_{2t} \end{pmatrix} = \begin{pmatrix} a_1 \\ a_2 \end{pmatrix} + \begin{pmatrix} \kappa_1 & \kappa_2 \\ \kappa_3 & \kappa_4 \end{pmatrix} \begin{pmatrix} \ln z_{1t-1} \\ \ln z_{2t-1} \end{pmatrix} + \begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{pmatrix} \tag{20}$$

where $\begin{pmatrix} \epsilon_{1t} & \epsilon_{2t} \end{pmatrix}' \sim n.i.d.\,(0, \sum_\epsilon)$. We use the estimation results in Backus, Kehoe and Kydland (1992) and assume that $\kappa_1 = \kappa_4 = 0.906$ and $\kappa_2 = \kappa_3 = 0.088$, $\sigma^2_{\epsilon_1} = \sigma^2_{\epsilon_2} = 0.00852^2$, $E\left(\epsilon_1\epsilon_2\right) = 0.256\sigma^2_\epsilon$. The estimation of the technology shock process, however, is associated with substantial uncertainty due to problems with measuring capital stocks and hours of work. Reynolds (1993), for example, experiments with different measures of capital and labor inputs and finds that the estimates of the cross-country spill-over coefficients, κ_2 and κ_3, vary across alternative measurements. Hence, we also experiment with an alternative specification in which we assume there are no spill-overs and no correlation of the shocks, $\kappa_1 = \kappa_4 = 0.95$, $\kappa_2 = \kappa_3 = 0$, $\sigma^2_{\epsilon_1} = \sigma^2_{\epsilon_2} = \sigma^2_\epsilon = 0.00852^2$, $E\left(\epsilon_1\epsilon_2\right) = 0$.

Government spending shocks are assumed to generated by first-order autoregressive processes:

$$\ln g_{jt} = (1 - \kappa_g)\ln g + \kappa_g \ln g_{jt-1} + \vartheta_t \tag{21}$$

where $\vartheta_t \sim i.i.d.\,(0, \sigma^2_\vartheta)$. We assume that $\kappa_g = 0.95$ and $\sigma_\vartheta = 0.02$.

4 Results

We first examine the steady-state properties and after that we investigate the business cycle moments. The latter are evaluated by solving the model numerically and simulating it 1000 times for time periods of 120 quarters. We filter the simulated data with the Hodrick and Prescott (1997) filter and report the average value of the statistics over the 1000 experiments.[10]

4.1 The Home Bias in Trade Puzzle

The so-called "home-bias in trade puzzle" is motivated by McCallum's (1995) analysis of trade between and among Canadian provinces and US states, and consists of the fact that there appears to be substantial home-bias in the trade of goods. McCallum (1995) found that inter-Canadian trade is up to 20 times larger than Canadian-US trade even after controlling for distance and other plausible variables, and while subsequent contributions have questioned the size of this estimate, the puzzle remains in both a qualitative and quantitative sense.

Obstfeld and Rogoff (2000) examine whether the introduction of costs of international transportation can account for this puzzle. They focus on the home-bias in consumption but we extend this to the bias in total trade. We also examine the welfare effects of changes in costs of transportation. Let $[c(p^{tr}), L(p^{tr})]$ denote the steady-state levels of consumption and leisure given costs of transportation of the size p^{tr} and define $V(c(p^{tr}), L(p^{tr}))$ as lifetime utility of the steady-state allocation. We calculate the welfare effects of a change in costs of transportation from p_0^{tr} to p_1^{tr} by computing $\tau(p_1^{tr}, p_0^{tr})$ such that $V[(1-\tau(p_1^{tr}, p_0^{tr}))\, c(p_0^{tr}), L(p_0^{tr})] = V[c(p_1^{tr}), L(p_1^{tr})]$. $\tau(p_1^{tr}, p_0^{tr})$ is given as:

$$\tau\left(p_1^{tr}, p_0^{tr}\right) = 1 - \frac{c(p_1^{tr})}{c(p_0^{tr})} \left(\frac{L(p_1^{tr})}{L(p_0^{tr})}\right)^{(1-\theta)/\theta} \tag{22}$$

$\tau(p_1^{tr}, p_0^{tr})$ has the interpretation of the compensating variation in consumption. We examine the results for three different values of the elasticity of substitution between domestic and foreign goods: The baseline parametrization ($1/\rho = 1.5$), the case considered by Obstfeld and Rogoff (2000) ($1/\rho = 6$), and a case earlier examined by Backus, Kehoe and Kydland (1994, 1995) ($1/\rho = 0.5$). We assume that the initial steady-state import share is 20 percent and that the initial costs of transportation are 20 percent. Table 4 contains the results on trade bias and welfare effects for costs of transportation between 10 and 30 percent.

The trade effects of changes in costs of transportation depend crucially on $1/\rho$. For $1/\rho = 1.5$ a drop in the costs of transportation from 20 percent to 10 percent implies a very moderate increase in the trade share to 22.2 percent. In the high elasticity case, the effects are much more dramatic and 10 percentage point drop in costs of transportation increases the trade share to 29.7 percent while

[10] We use a quadratic approximation of the objective function around the non-stochastic steady-state. To increase numerical precision, the variables were log-transformed along the lines suggested by Christiano (1990).

for $1/\rho = 0.5$ the trade share remains roughly constant. Hence, whether costs of transportation can account for the "home-bias in trade puzzle" is intrinsically linked to the degree of substitutability between domestic and foreign goods.

The welfare effects of changes in costs of transportation are more intriguing. We find large welfare effects: A drop in the costs of transportation from 20 percent to 15 percent is equivalent to a permanent increase in consumption of just above 1.5 percent. The large welfare effects are due to the assumption that countries are specialized in production. If we use the estimates of the costs of transportation from Table 3, the welfare gain arising from the drop in costs of transportation of the size observed during 1974-1994 is of a size of 1.5-2.5 percent.

An important insight is that the welfare effects are relatively insensitive to the value of the elasticity of substitution. The reason is that although the effects of transaction costs on trade shares are lower when domestic and foreign goods are less substitutable, the effect of changes in trade shares on welfare are more dramatic when this elasticity is low. The intuition is that a low elasticity of substitution makes foreign goods less dispensable. These calculations are carried out under the assumption of home-bias in preferences (since ω_1 and ω_2 are calibrated to match the steady-state trade shares). Had we not allowed for such home-bias, the welfare effects would have been even larger. Furthermore, recall that the effects on overall trade are quite small for the two cases with moderate elasticity of substitution between domestic and foreign goods. Hence, even if we had allowed for congestion effects in international trade, the welfare effects might still be substantial (but surely smaller). It is beyond the scope of the present paper to analyze this in more detail but this may be an interesting extension of our analysis.

4.2 The Price Puzzle

We now turn to the question of whether frictions in trade gives rise to larger variations in international relative prices. In a frictionless environment, Backus, Kehoe, and Kydland (1994) find that terms of trade variability is a factor 6-7 times lower than what is observed in the data. Furthermore, in stark contrast to the data, in their setting real exchange rate variability is even smaller.[11] The question is whether costs of transportation are important for this issue.

It is worth pointing out that part of the high observed the terms of trade variability may be due to the use of oil. In some OECD countries, energy products account for a large fraction of

[11] A log-linear approximation implies that the standard deviation of the real exchange rate is $|\omega_1^{1/\rho} - \omega_2^{1/\rho}| = |1 - 2s_x| < 1$ times the standard deviation of the terms of trade when there are no frictions.

overall terms of trade variability. Based on this observation, Backus and Crucini (2000) introduce oil supply into an international business cycle model and find a large increase in the implied terms of trade variability. However, the standard deviation of the ex-energy terms of trade is only around 32 percent lower than the standard deviation of the overall terms of trade (see Backus and Crucini, 2000, Table 3, p.191), implying a standard deviation of the ex-energy terms of trade of roughly 2.18 percent. This number is still far above the terms of trade variability implied by frictionless models.

Table 5 reports the business cycle properties of the model. The first column is the case without costs of transportation. Apart from excess smoothness of exports and imports, the model does relatively well in reproducing the variability, persistence, and comovements with output of the expenditure components.[12] However, due to the low variability of exports and imports the model fails spectacularly to account for relative price variability. In the model economy, the standard deviation of the terms of trade is 0.60 percent while in the data the corresponding number is 3.19 percent (or 2.18 percent if we focus on the ex-energy definition). This problem is even more grave as far as the real exchange rate is concerned.

The second column of Table 5 reports the results for the baseline calibration of the model with frictions in trade. We measure the terms of trade using the f.o.b. definition since domestic imports are transported by domestic companies.[13] It is instructive first to examine the impulse responses of the model. Figure 1 illustrates the response to technology shocks comparing the model with (left column) and without (right column) costs of transportation. A positive shock to domestic technology increases domestic output, investment, consumption, and imports. The terms of trade worsen and the real exchange rate depreciates due to the decrease in relative domestic marginal costs. Moreover, the effects are very similar in the two economies apart from the impact on exports and imports which are more muted in the economy with frictions due to the rise in costs of transportation. Figure 2 examines the response to government spending shocks. The response of the expenditure components are once again very similar in the two economies, but there is now a noticeable effect on the f.o.b. terms of trade. Nevertheless, the differences in the quantitative responses are moderate. Hence, while introducing frictions per se lead to larger relative price movements due to the variations in costs, the smaller variations in trade counteract this effect.

Table 5 confirms these insights: The quantitative effects of costs of transportation are limited.

[12] The low variability of exports and imports translates into excess smoothness of net-exports. Nevertheless, the model reproduces the countercyclical behavior of net-exports.

[13] For the same reason, the computation of net-exports involves the f.o.b. definition of the terms of trade.

Terms of trade variability increases from 0.60 percent per quarter to 0.66 percent per quarter. Furthermore, since the real exchange rate and the terms of trade are almost perfectly correlated, real exchange rate variability increases only marginally (from 0.36 percent per quarter to 0.39 percent per quarter). It is noticeable that the small increase in terms of trade variability comes at the cost of even lower variability of exports and net-exports as we have highlighted above.

As we discussed in Section 3, in this economy there is a link between the marginal rate of transformation between domestic goods and foreign goods and movements in the c.i.f. definition of the terms of trade. Costs of transportation break this direct link as far as the f.o.b. terms of trade are concerned. Nevertheless, we still find moderate effects of the introduction of costs of transportation on the (f.o.b.) terms of trade. The reason for this is that although transportation cost variations increase f.o.b. terms of trade volatility, this is countered by a decrease in trade variability. The latter effect is due to costs of transportation increasing along with the increase in imports which gives rise to smaller variation in international trade. This counters the tendency for transportation cost variations to increase f.o.b. terms of trade variability. In other words, the conflict between price and quantity variability is inherited by the model extended with frictions in trade.

However, before concluding too firmly against costs of transportation as a source of relative price variability, we examine in the remaining columns of Table 5 the robustness of the results to changes in key parameter values. Column 3 examines the case when the capital share in the transportation sector is increased to 57.3 percent (the value implied by Caves, Christensen and Tretheway's, 1983, estimate). This implies larger variations in costs of transportation over the business cycle since the output elasticity with respect to labor, the more flexible input, decreases. However the volatility of foreign trade decreases even further, and the net-effects on relative price variability are small.

Column 4 examines a case with a steady state export share equal to 40 percent. This change in the calibration (which implies less taste for home-goods) is associated with a significant increase in the volatility of net-exports. Furthermore, due to the increase in the variability of trade, the model also implies larger terms of trade variability which increases approximately 35 percent relative to our baseline parametrization. However, this comes at the cost of much lower real exchange rate variability since the taste for home-goods decreases. Hence, while larger openness has attractive implications as far as the volatility of trade and the terms of trade are concerned, it worsens the problem as far as the real exchange rate is concerned.

In columns 5 ($1/\rho = 0.5$) and 6 ($1/\rho = 6$) we vary the degree of substitutability between domestic and foreign goods. The low substitution case leads to a large increase in terms of trade variability since, for a given variability in trade, the implied change in relative prices is larger. Quantitatively this effect is large (terms of trade variability of increases 70 percent and real exchange rate variability by 50 percent). However, this calibration leads to a substantial negative correlation between net-exports and the terms of trade well outside the correlation that can be observed in any of the countries surveyed in Section 2. When the elasticity is equal to 6 instead there are almost no variations in the relative prices making the price puzzle even worse.

The last case examines the effects of changing the technology shock processes and assumes that $\kappa_1 = \kappa_4 = 0.95$ and $\kappa_2 = \kappa_3 = 0.0$, $E(\epsilon_1 \epsilon_2) = 0$. This process is less persistent than the baseline parametrization and the shocks are more of an idiosyncratic nature. The quantitative results are reported in column 7. The variability of the terms of trade increases to 1 percent per quarter and exchange rate variability rises to 0.58 percent per quarter. These estimates are around 50 percent higher than the estimates for the baseline calibration. However, the alternative calibration also implies much too low variability of net-exports due to the lower persistence of the shocks.

All in all, the results indicate that frictions in international trade in the form of costs of transportation may not be crucial for the price puzzle.

4.3 The International Comovements Puzzle

As we highlighted in Section 3, costs of transportation may also be important for the "international comovement puzzle". Although we found small effects on relative prices, it is possible that the effects may be more important as far as international comovements are concerned.[14]

We report the results in Table 6. In the absence of frictions in trade, the model implies a cross-country correlation of 0.86, a correlation of -0.68 between investment levels while output levels are roughly uncorrelated across locations. These moments are clearly in contrast to the data. The moments of the baseline model, however, are only moderately different and while the qualitative features of the effects of transportations costs go in the right direction (lower cross-country consumption correlations and higher cross-country correlations of output and investment), the quantitative effects are far too small to matter much. This is mainly due to the small effects on real exchange rate movements.

Furthermore, this insensitivity of the results hold consistently across all the sensitivity experiments that we examined above with the exception of the last case where we alter the driving process of

[14]Crucini (1997) have earlier examined this issue in a similar set-up and confirms that transactions costs may be quantitatively important.

the exogenous shocks. Ironically, assuming that the technology shocks are unrelated across countries increases the output and investment cross-country correlations. This is due to the larger variations in relative prices that make the wedge between marginal utilities more important thereby lowering the consumption correlation. Furthermore, the low persistence of the technology shocks and lack of spill-overs across countries imply that the frictions in trade partially prevent countries from sharing the risk of idiosyncratic shocks. It should be noted that the decline in the cross-country correlation of consumption levels is as large as that predicted by other currently popular theories that build on either sticky prices or on asset market imperfections. Nevertheless, the model is still at odds with the data since it fails to account for (a) the ranking of the cross-country correlations, and (b) the positive cross-country correlations of output and investment discussed in Section 2.

5 Extensions

In this section we will examine whether realistic extensions of the transportation technology are important for addressing the business cycle implications of international transportation.

5.1 Foreign Transportation

We first examine the importance of the modelling of the country of origin of the firms that transports domestic imports. We assumed above that all domestic imports are transported by domestic companies. In reality, imports are transported by domestic and foreign companies and the international shipping industry, in particular, is dominated by a few very large international carriers. This assumption may be important for the results because the variations in the costs of transportation no longer will depend directly on the domestic factor costs. Furthermore, when foreign companies transport the domestic imports the relevant terms of trade definition is the c.i.f. definition and net exports must now be defined including such costs and we saw above that c.i.f. and f.o.b. terms of trade behave differently in response to shocks to the economy.

Hence, we now assume that domestic imports are transported by foreign companies and replace equation (5):

$$m_{jt} = \min\left[\pi_1 x_{it}, \pi_2 \left(k_{it}^{tr}\right)^{1-\gamma} \left(n_{it}^{tr}\right)^{\gamma}\right] \tag{23}$$

The first column of Table 7 reports the business cycle moments assuming that foreign companies transport the domestic imports. The main consequence of this assumption is to increase the variability of exports and net-exports since costs of transportation rise less sharply in response to an increase in domestic technology than when domestic firms transport the domestic imports. However, the effects on the terms of trade are very minor and the standard deviation of the terms of trade is actually lower than in the baseline model. Given the minor nature of the change in the implied moments, we believe that this intriguing aspect of international transportation is not fundamental to understanding how costs of transportation affects the business cycle features of the model.

5.2 Limited Labor Flexibility

In the baseline model we assumed that labor can be freely re-allocated across sectors. We now examine the importance of this assumption and assume that the labor supply to these two sectors are imperfect substitutes. Preferences are now given by:

$$U_{js} = E_s \sum_{t=s}^{\infty} \beta^{t-s} \left\{ \left[c_{jt}^{\theta} \left[T - \left(\mu_1 \left(n_{jt}^{y} \right)^{1-\xi} + \mu_2 \left(n_{jt}^{tr} \right)^{1-\xi} \right)^{1/(1-\xi)} \right]^{(1-\theta)} \right]^{1-\sigma} - 1 \right\} \tag{24}$$

where $1/\xi$ is the elasticity of substitution between labor supplied to the output sector and labor supplied to the transportation sector. For $\xi > 0$ the present specification limits the sectorial re-allocation of labor.

We know of no direct estimates of $1/\xi$. Instead we investigate the properties of the model for alternative values of this parameter. Table 7 lists the results for $1/\xi = 2$ (column 2) and $1/\xi = 5/8$ (column 3). The results for $1/\xi = 2$ are very similar to those from the baseline model where the two types of labor supply are perfect substitutes. However, for the low elasticity case, $1/\xi = 5/8$, the properties of the model change dramatically. We find that for this parametrization, the implied standard deviation of the f.o.b. definition of the terms of trade is equal to 1.57 percent per quarter. Moreover, the real exchange rate volatility is 3 times higher than in the standard model (1.27 percent per quarter vs. 0.39 percent per quarter in the baseline model). In fact, for a low enough degree of substitutability between the two types of labor supply, the model can generate very large relative price variability, see Figure 3 which plots the standard deviation of relative prices for a range of different values of the elasticity $1/\xi$.

However, as Table 7 and Figure 3 also indicate, the increase in relative price variability comes at the cost of too high variability in net-exports. The reason is that low degrees of substitution in labor supply imply that any rise in labor supplied to the output sector must be accompanied by a rise in labor supplied to the transportation sector which increases the volatility of trade. Furthermore, the decrease in the flexibility of labor supply increases the volatility of investments dramatically and the large observed effects are mainly due to counterfactual high volatility of investments. To investigate this we also examine a case where we increase capital adjustment costs along with ξ so that the model has approximately the same variability of aggregate investments as in the baseline model. The results are reported in column 4 and now the effects of changes in ξ are very minor. In other words, assuming that labor supplied to the two sectors are imperfect substitutes is to a large extent equivalent to assuming smaller capital adjustment costs.

5.3 Time and Transportation

So far we have focused upon costs of transportation as a source of friction introduced by the geographical aspect of international trade. However, transportation also takes time and international delivery lags due to the large geographical distances involved in parts of international trade may be important because they imply that decisions on whether to import foreign goods are associated with uncertainty. The simplest way to model this aspect is to introduce delivery lags in the transportation technology. However, the minimum delivery lag in our model is 3 months which appears somewhat long. We model this friction by assuming instead that imports are pre-determined (the quantity of imports is decided upon before the current period's shocks to technology and government expenditure are realized). This assumption has been applied earlier to the modelling of variables where "lumpiness" is considered important, see e.g. Christiano's (1988) analysis of inventory investment.[15]

We assume that the law of one price holds in the sense that the price of domestic goods sold to domestic agents is the same as the price of domestic goods sold to foreign agents. With this assumption, the c.i.f. terms of trade are also uniquely defined as the price at which the market for imports clear.[16] When imports are pre-determined the driving processes for the shocks become particularly important since the decision on the quantity of imports will be determined by agents' expectations of the state of the economy given information sets that exclude the current period's shocks.

The results are reported in columns 5 (the Backus, Kehoe and Kydland, 1992, calibration of the technology shocks) and 6 (the alternative calibration of the technology shock processes). For the baseline parametrization of the technology shock process, we find an increase in the terms of trade

[15] In Ravn and Mazzenga, 1999, we examine the case with standard delivery lags.

[16] In general, the introduction of delivery lags imply that there is no unique definition of the terms of trade, see Backus, Kehoe and Kydland (1994).

variability to around 0.80 percent and the standard deviation of the real exchange rate increases to 0.55 percent per quarter. For the alternative specification of the stochastic process for the technology shocks, the standard deviation of the terms of trade rises even further to above 1 percent per quarter. We also find that the pattern of international comovements may be sensitive to the introduction of delivery lags but that this depends on the technology shock process. For the baseline parametrization of the technology shocks, the effects on the pattern of international comovements are limited (this confirms the result in Backus, Kehoe and Kydland, 1994). However, comparing Tables 6 and 7, reveals that the cross country comovements are significantly affected when we apply the alternative technology shock process and we find a large drop in the cross-country consumption correlation.

In the last column we combine the assumptions of pre-determined imports and lack of spill-overs in technology with the low elasticity of substitution between domestic and foreign goods($1/\rho = 0.5$). In this case, the model implies a standard deviation of the terms of trade that is close to the estimate in the data. Furthermore, this case generates a ranking of international comovements that, in contrast to any of the previous experiments, is consistent with what is observed in the data. Although this comes at the cost of low persistence of the relative prices, it is interesting that the model goes a long way in solving the discrepancy between theory and data as far as the price puzzle and the international comovement puzzle are concerned. We note once more that, counter-intuitively, once one does not allow for spill-overs in technology, output and investment are closer correlated across countries.

The large impact on prices is due to the fact that when an un-expected shock occurs, the quantity of imports is pre-determined. Hence, when domestic productivity rises, the relative price of imports rises more sharply because the quantity of imports cannot be adjusted. These larger variations in the terms of trade in turn leads to larger real exchange rate movements and to lower cross-country consumption correlations. Furthermore, the less persistent are the shocks to the economy, the larger are the movements in relative prices and the less tendency for negative cross-country comovements of output and investment. The latter effect is due to the fact that the negative comovements of output and investment are driven mainly by production re-location in response to differences in productivity. In the face of delivery lags and less persistent shocks to the economy, such re-locations of production are less pronounced and trade becomes, relatively speaking, more important for the transmission of shocks between countries.

This mechanism may be seen as complementary to the effects of incomplete asset markets as analyzed by Baxter and Crucini (1995). These authors find limited effects of incomplete asset markets for the baseline parametrization of technology shocks that we investigate above. However, when allowing for a process with more permanent shocks (and no spill-overs), they find a large increase in the cross country correlation of output while the cross-country correlations of consumption and investment drop. In their model the incomplete markets assumption affects the cross-country co-movements due to the difference in wealth effects between complete and incomplete markets scenarios and this effect is only sufficiently strong when technology shocks are very persistent (and unrelated across countries). It is possible that the combination of incomplete markets and delivery lags may bring about interesting insights because the existence of delivery lags make it harder to share the idiosyncratic risk and incomplete markets may further enhance the tendency for lower consumption correlations due to wealth effects. Such an analysis is beyond the scope of the present paper but could be interesting to pursue in future work.

6 Summary and Conclusions

We have examined the quantitative implications of frictions in international trade. We studied a flexible price environment and asked whether costs of transportation are important for three key puzzles in international macroeconomics. We showed that costs of transportation can have large welfare costs while their effects on the pattern of trade depend crucially on the degree of substitutability between domestic and foreign goods. Next, we examined whether such costs also have important consequences for the business cycle properties of international trade models but found a negative answer to this question. The main reason for this is that there are two opposing effects of costs of transportation: First, fluctuations in such costs add to relative price variability but, secondly, variations on costs of transportation also lower the variations in trade implying smaller relative price movements. The net effect of these two forces is very small for realistic parameter values.

Nevertheless, we ended on a more optimistic note since delivery lags - another important feature of international trade - appear to be important for the international transmission of shocks and may also be important for the "price puzzle". We think it may be worthwhile to look more into the effects of such delivery lags for the transmission of shocks between and within countries and model such frictions more rigorously.

The paper is related to the large and rapidly developing literature that has focused upon models with imperfect competition, sticky prices and pricing to markets combined with local currency pricing (see e.g. Betts and Devereux, 1996, 2000, Chari, Kehoe and McGrattan, 2001, or Lane, 2001 for a recent survey). These contributions have focused upon the implications for real exchange rates and have shown that (when contracts are sufficiently long) the variability of real exchange rates may be consistent with the predictions of such models in the face of nominal demand shocks. While this literature is very promising, we believe that the present analysis is equally interesting. The sticky price/pricing to markets cum local currency pricing literature allows for deviations from the law of one price but it is usually left unanswered how such price differences can persist. Transactions costs of the type studied in the present model is a main candidate for given firms the ability to price discriminate.

7 References

Ambler, S., E. Cardia, and C. Zimmermann, 2000. International Business Cycles: What are the Facts? Working paper, University of Montreal.

Armington, P., 1969. A Theory of Demand for Products Distinguished by Place of Production. IMF Staff Papers 27, 488-526.

Backus, D.K., and M.J. Crucini, 2000. Oil Prices and the Terms of Trade. Journal of International Economics 50, 185-213..

Backus, D.K., P.J. Kehoe and F.E. Kydland, 1992. International Real Business Cycles. Journal of Political Economy 101, 745-775.

Backus, D.K., P.J. Kehoe and F.E. Kydland, 1994. Dynamics of the Trade Balance and the Terms of Trade: The J-Curve? American Economic Review 84, 84-103.

Backus, D.K., P.J. Kehoe and F.E. Kydland, 1995. International Business Cycles: Theory and Evidence. In Thomas F. Cooley (ed.), Frontiers of Business Cycle Research, Princeton, New Jersey: Princeton University Press.

Backus, D.K., and G.N. Smith, 1993. Consumption and Real Exchange Rates in Dynamic Economies with Non-Traded Goods. Journal of International Economics 35, 297-316.

Baxter, M. and M.J. Crucini, 1995. Business Cycles and the Asset Structure of Foreign Trade. International Economic Review 36(4), 821-54.

Betts, C., and M. Devereux, 1996. The Exchange Rate Dynamics in a Model of Pricing-to-Market. European Economic Review 40(3-5), 1007-1021.

Betts, C., and M. Devereux, 2000. Exchange Rate Dynamics in a Model of Pricing-to-Markets. Journal of International Economics 50(1), 215-44.

Caves, D.W., L.J. Christensen, and M.W. Tretheway, 1983. Productivity Performance of the US Trunk and Local-Service Airlines in the Era of Deregulation. Economic Inquiry 21(3), 312-24.

Chari, V.V., P.J. Kehoe, and E. McGrattan, 2001. Can Sticky Prices Generate Volatile and Persistent Real Exchange Rates? Staff Report 277, Research Department, Federal Reserve Bank of Minneapolis.

Cheung, Y., M Chinn, and E. Fujii, 1999. Market Structure and the Persistence of Sectoral Real Exchange Rates. NBER working paper no. 7408.

Christiano, L.J., 1988. Why Does Inventory Investment Fluctuate So Much? Journal of Monetary Economics 21(2-3), 247-80.

Christiano, L.J., 1990. Solving the Stochastic Growth Model by Linear Quadratic Approximation and by Value Function Iteration. Journal of Business and Economic Statistics 8(1), 23-26.

Crucini, M.J., 1997. International Comovement: Is Theory Really Ahead of International Business Cycle Measurement? Manuscript, Ohio State University.

Dumas, B., 1992. Dynamic Equilibrium and the Real Exchange Rate in a Spatially Separated World. Review of Financial Studies 5(2), 153-80.

Engel, C., 2000. Comments on Obstfeld and Rogoff's 'The Siz Major Puzzles in International Macroeconomics: Is there a Common Cause?'. NBER Macroeconomics Annual 15.

Feenstra, R.C. NBER Trade Database, Disk1: U.S. Imports, 1972-1994: Data and Concordances. NBER Working Paper no. 5515, March 1996.

Harrigan, J., 1993. OECD Imports and Trade Barriers in 1983. Journal of International Economics 35(1-2), 91-111.

Hodrick, R., and E.C. Prescott, 1997. Post-war U.S. Business Cycles: an Empirical Investigation. Journal of Money, Credit, and Banking, 29, 1-16.

Hummels, D., 1998. Toward a Geography of Trade Costs. Manuscript, University of Chicago.

Hummels, D., 1999. Transport Costs and the Growth of World Trade. Manuscript, University of Chicago.

Lane, P.R., 2000. The New Open Economy Macroeconomics: A Survey. Journal of International Economics 54(2), 235-66.

McCallum, J., 1995. National Borders Matter: Canada-US Regional Trade Patterns. American Economic Review 85, 615-23.

Obstfeld, M., and K. Rogoff, 2000. The Six Major Puzzles in International Macroeconomics: Is There a Common Cause? NBER Macroeconomics Annual 15, 339-390.

Ravn, M.O., 1997. International Business Cycles in Theory and in Practise. Journal of International

Money and Finance 16(2), 255-83.

Ravn, M.O. and E. Mazzenga, 1999. Frictions in International Trade and Relative Price Movements. UPF working paper no. 318 (updated, 1999).

Ravn, M.O., 2001. Consumption Dynamics and Real Exchange Rates. CEPR discussion paper no. 2940.

Reynolds, P., 1993. International Comovements in Aggregate Productivity: An Empirical Analysis. Working paper, USC.

Samuelson, P.A., 1954. The Transfer Problem and the Transport Costs, II: Analysis of Effects of Trade Impediments. Economic Journal 64, 264-89.

Stern, R., J. Francis, and B. Schumacher, 1976. Price Elasticities in International Trade. London: MacMillan.

Trefler, D., and H. Lai, 1999. The Gains from Trade: Standard Errors with the CES Monopolistic Competition Model. Working paper, University of Toronto.

Figure 1. Response to a 1 Percent Domestic Technology Shock

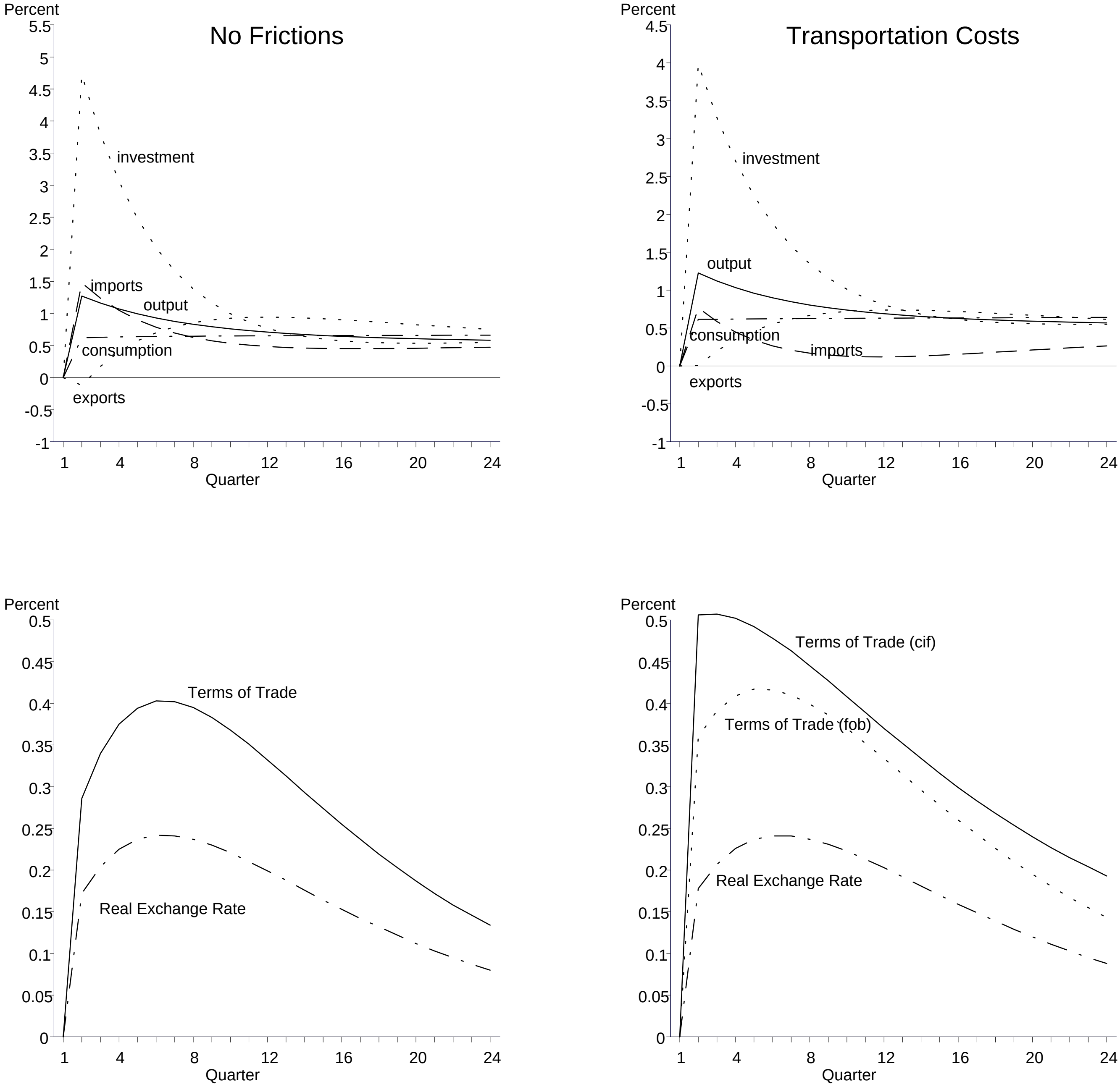

Figure 2. Response to a 1 Percent Domestic Government Spending Shock

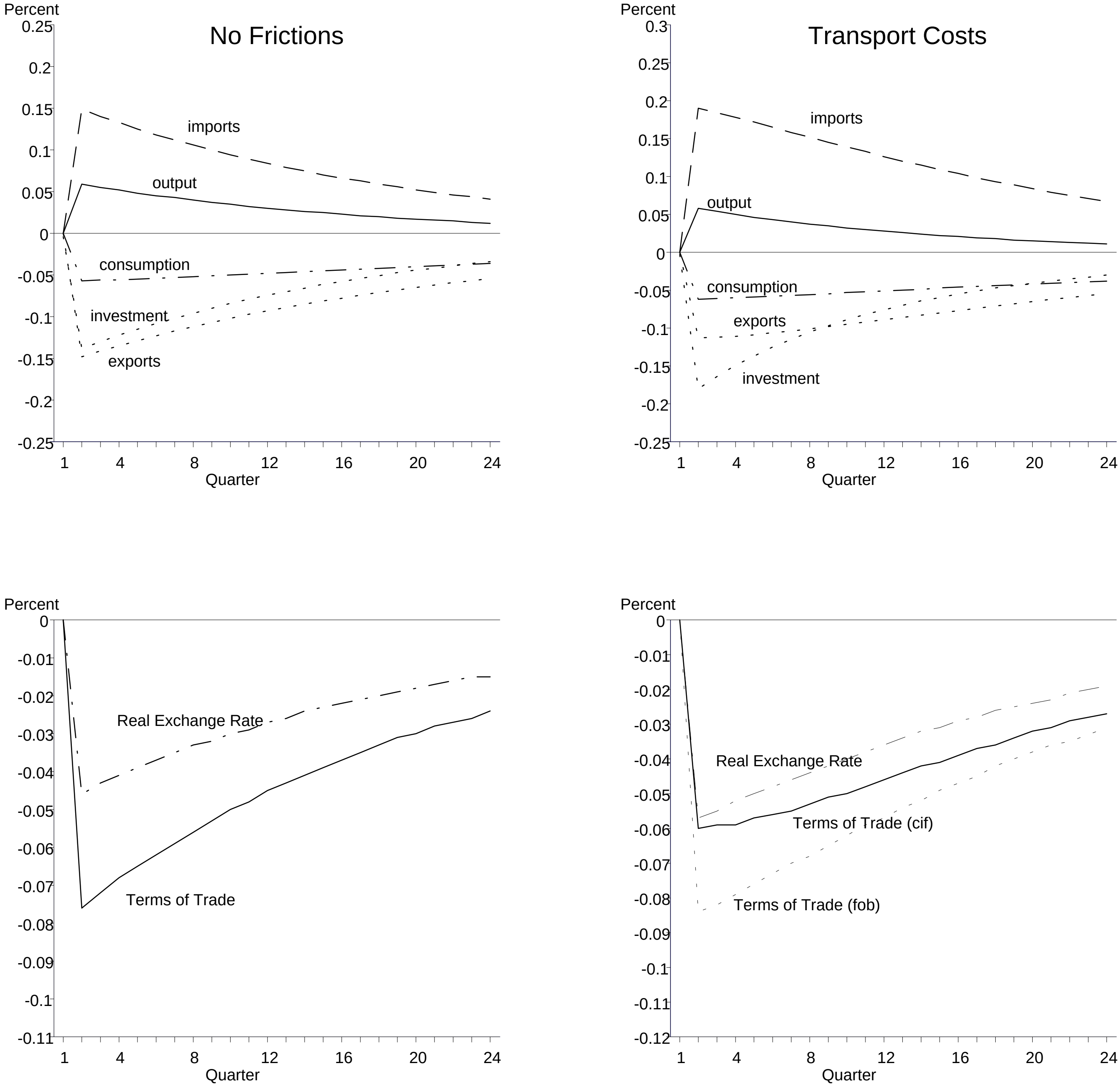

Figure 3. Imperfect Labor Substitutability

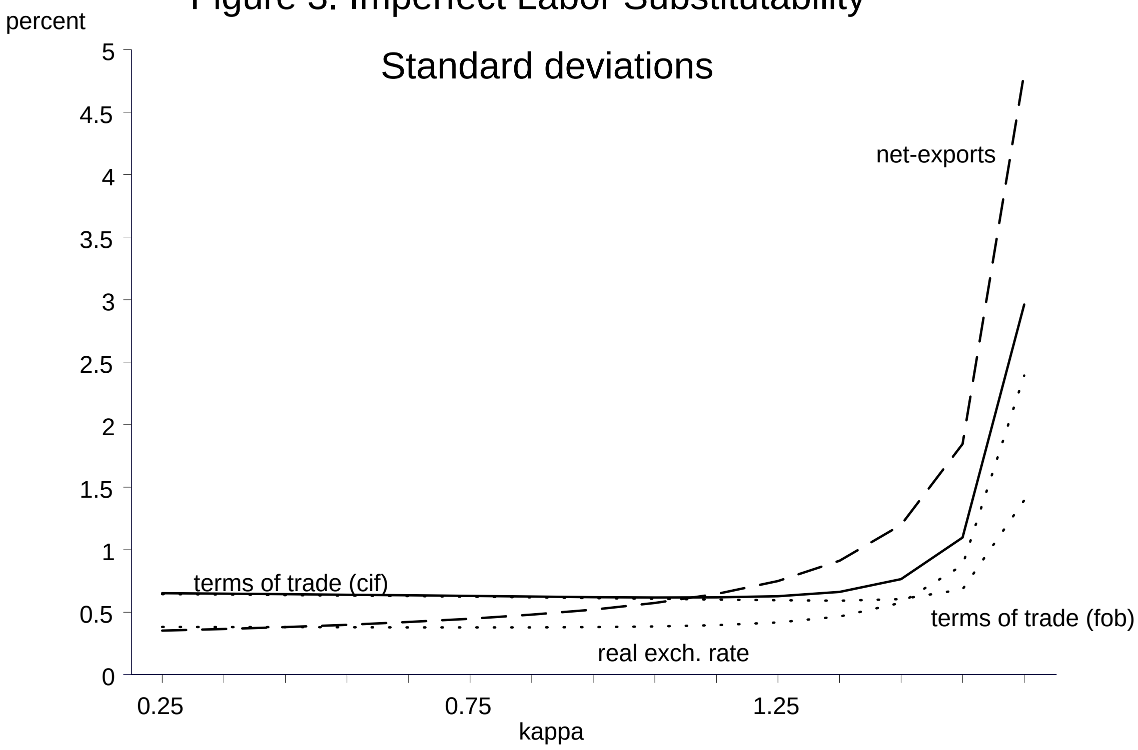

Table 1. Business Cycle Moments

variable	Standard deviations (%)	1'st order autocorrelation	Correlation with output	Correlation with terms of trade	Cross-country correlations
output	1.41 [0.91;2.41]	0.80 [0.33;0.94]	-	-	0.33 [0.15;0.41]
consumption	1.34 [0.57;2.01]	0.78 [0.55;0.94]	0.69 [0.36;0.87]	-	0.22 [0.04;0.34]
gov. spending	1.17 [0.70;2.88]	0.66 [0.00;0.92]	0.02 [-0.39;0.58]	-	-
investment	4.23 [2.95;6.62]	0.83 [0.48;0.96]	0.74 [0.55;0.94]	-	0.30 [0.13;0.44]
exports	3.27 [2.13;4.41]	0.67 [0.34;0.91]	0.44 [0.06;0.78]	-	-
imports	4.29 [2.62;6.51]	0.79 [0.51;0.94]	0.67 [0.63;0.88]	-	-
net exports	0.96 [0.45;1.64]	0.73 [0.42;0.93]	-0.27 [-0.61;0.06]	0.035 [-0.30;0.51]	-
employment	1.21 [0.58;2.48]	0.73 [0.20;0.96]	0.48 [-0.01;0.86]	-	0.20 [-0.09;0.35]
terms of trade	3.19 [1.17;5.30]	0.88 [0.70;0.94]	-0.08 [-0.36;0.20]	-	-
real exch. rate	4.03 [1.48;7.93]	0.80 [0.75;0.88]	0.07 [-0.55;0.44]	0.39 [-0.07;0.75]	-

Notes: All data were taken from the OECD national accounts. The sample period is 1970.1-2000.4 and the data are quarterly. The terms of trade are computed as the implicit imports deflator divided by the implicit exports deflator. Net exports are computed as exports minus imports divided by output, all in current prices. The real exchange rate is measured by the real effective exchange rate. Output components and employment are measured in per capita terms. All data except net-exports are in logs and are detrended using the Hodrick-Prescott filter using a value of 1600 for the smoothing parameter. The ratio of net exports to output was also Hodrick-Prescott filtered.

Numbers in brackets are the minimum and the maximum of the moments across the 14 countries in the sample.

Table 2. Estimates of Costs of Transportation

	Transportation cost measure (percent)		
	Mean weighted	Mean unweighted	Modal
1974	6.31	14.42	9.15
1979	5.25	13.70	8.77
1984	4.81	14.32	8.26
1989	3.83	10.68	7.17
1994	3.49	10.08	6.33

Note: Source of data: Feenstra (1996). Transport costs are measured as US imports in c.i.f. prices divided by US imports in f.o.b. prices less one calculated at the 4 digit level. "Mean weighted" is the mean transportation cost weighted goods by their share of total imports. "Mean unweighted" is the unweighted mean of the transportation costs at the 4 digit level. "Modal" is the model value of the transportation costs at the 4 digit level.

Table 3. Calibration of Baseline Model

parameter	value	remarks
N/T	0.30	Steady-state share of time used for market activities
s_x	0.20	Steady-state export share
s_g	0.20	Steady-state government spending share
s_c	0.543	Steady-state consumption share. Computed as residual
s_i	0.257	Steady-state investment share. Computed as $\delta K/V$
s_{tr}	0.035	Steady-state share of transport sector value added, $s_{tr} = y^{tr}/\left(y^{tr}+y\right)$
K/V	10.29	Steady-state capital-output ratio. Computed as $K/V = \frac{\beta\alpha\left(1+\left(p^{tr}-1/\pi_1\right)\alpha/\gamma\pi_1 s_x\right)}{(1-\beta(1-\delta))(1-s_x+p^{tr}\pi_1 s_x)}$
p^{tr}	1.20	Steady-state ratio of c.i.f. import prices to f.o.b. import prices
θ	0.267	Preference parameter. Computed as
		$\theta = \frac{s_c N/T/(1-N/T)}{(s_c N/T/(1-N/T))+\alpha(1+(p^{tr}-1/\pi_1)\alpha/\gamma\pi_1 s_x))(1-s_x+p^{tr}\pi_1 s_x)}$
$1/\sigma$	1/2	Intertemporal elasticity of substitution
β	$(1.04)^{0.25}$	Subjective discount factor
α	0.64	Labor income share in output sector
π_1	0.984	Transportation technology parameter. Computed as $\pi_1 = \left(s_{tr}s_x/\left(1-s_{tr}\right)+1\right)/p^{tr}$
π_2	5.186	Transportation technology parameter. Computed as $\pi_2 = \pi_1 s_x y/\left(\left(k^{tr}\right)^{1-\gamma}\left(n^{tr}\right)^{\gamma}\right)$
γ	0.64	Labor income share in transportation sector
δ	0.025	Rate of depreciation
$1/\rho$	1.5	Elasticity of subst. between domestic goods and imports
ω_1	0.842	Share parameter in Armington aggregator. Computed as
		$\omega_1 = \left[\left(1-s_x\right)/\left(1-s_x+p^{tr}s_x\pi_1\right)\right]^{\rho}$
ω_2	0.397	Share parameter in Armington aggregator. Computed as $\omega_2 = \omega_1\left[s_x\left(p^{tr}\right)^{1/\rho}\pi_1/\left(1-s_x\right)\right]^{\rho}$

Table 4. Steady State Effects on Trade and Welfare

	Elasticity of substitution					
	$1/\rho = 0.5$		$1/\rho = 1.5$		$1/\rho = 6$	
p^{tr}	trade share	τ	trade share	τ	trade share	τ
1.1	20.71	-2.93	22.17	-3.20	29.65	-3.73
1.15	20.34	-1.52	21.04	-1.54	24.40	-1.66
1.20	20.00	-	20.00	-	20.00	-
1.25	19.68	1.46	19.04	1.43	16.37	1.33
1.30	19.37	2.85	18.15	2.77	13.39	2.41

Note: τ is the welfare measure and a negative sign denotes an increase in welfare. Trade share is the induced steady-state trade share and p^{tr} is the steady-state transport cost measured by imports at c.i.f. prices divided by imports at f.o.b. prices. All other parameters than transportation costs and the elasticity of substitution are calibrated using the baseline model parameter values.

Table 5. Business Cycle Moments

model variable	(1) No frictions[1]	(2) Base-line model	(3) High cap. intensity[2]	(4) Large trade share[3]	(5) Low elasticity[4]	(6) High elasticity[5]	(7) No spill-overs[6]
Standard Deviation (%)							
output	1.30	1.29	1.29	1.24	1.23	1.36	1.44
consumption	0.84	0.82	0.81	0.80	0.84	0.81	0.60
investment	4.81	4.13	3.87	4.69	3.99	4.57	4.45
exports	1.50	1.08	0.93	1.18	1.19	1.07	1.08
net exports	0.47	0.32	0.27	0.78	0.44	0.37	0.27
employment	0.52	0.49	0.48	0.35	0.42	0.62	0.58
terms of trade	0.60	0.66	0.68	0.88	1.10	0.25	1.00
real exchange rate	0.36	0.39	0.40	0.16	0.63	0.17	0.58
Autocorrelation							
output	0.67	0.67	0.66	0.67	0.67	0.67	0.70
terms of trade	0.81	0.78	0.76	0.74	0.74	0.87	0.78
real exchange rate	0.81	0.79	0.79	0.81	0.75	0.84	0.78
Correlation with output							
consumption	0.80	0.80	0.80	0.78	0.84	0.75	0.86
investment	0.88	0.89	0.90	0.81	0.88	0.89	0.95
exports	0.07	0.13	0.18	0.30	0.09	-0.09	0.44
imports	0.95	0.76	0.75	0.70	0.94	0.38	0.56
net-exports	-0.58	-0.59	-0.60	-0.50	-0.65	-0.30	-0.61
terms of trade	0.46	0.47	0.48	0.62	0.46	0.27	0.54
real exchange rate	0.46	0.41	0.38	0.56	0.42	0.07	0.58
Correlation with the terms of trade							
net-exports	-0.10	-0.20	-0.26	-0.55	-0.69	0.68	-0.27
real exchange rate	1	0.99	0.98	0.97	0.99	0.96	0.99

Notes: Results based on simulating the model 500 times for a time horizon of 120 quarters.

1) This assumes that $\pi_1 = 1$, $\pi_2 \to \infty$. 2) This assumes that $\gamma = 0.4269$. 3) This assumes that the steady state trade share is equal to 40%. 4) This assumes that $1/\rho = 0.5$. 5) This assumes that $1/\rho = 6$. 6) This assumes that $\kappa_1 = \kappa_4 = 0.95$, $\kappa_2 = \kappa_3 = 0$, $E(\epsilon_1 \epsilon_2) = 0$

Table 6. International Comovements

Model	Cross-Country Correlation of Output	Consumption	Investment
(1)	-0.01	0.86	-0.68
(2)	0.03	0.86	-0.60
(3)	0.04	0.85	-0.55
(4)	0.12	0.95	-0.69
(5)	0.13	0.79	-0.57
(6)	-0.09	0.92	-0.66
(7)	-0.02	0.49	-0.21

Notes: See notes to Table 5 for details on calibration.

Table 7. Extensions

model variable	(1) Foreign Transports	(2) Altern. preferences ξ low	(3) Altern. preferences ξ high	(4) As (3) . with high adj. costs	(5) Imports pre-determ.	(6) Imports pre-determ., no spill-over	(7) As (6) with low elasticity
Standard Deviation (%)							
output	1.28	1.30	1.58	1.28	1.30	1.44	1.32
consumption	0.82	0.82	0.84	0.84	0.83	0.64	0.76
investment	4.71	4.36	13.8	4.18	3.84	4.40	3.54
exports	1.25	1.28	7.51	1.77	0.99	1.02	1.01
net exports	0.51	0.39	2.61	0.53	0.28	0.29	0.50
employment	0.48	0.50	0.71	0.44	0.48	0.57	0.44
terms of trade	0.58	0.65	1.57	0.64	0.79	1.18	2.20
real exchange rate	0.37	0.38	1.27	0.38	0.55	0.80	1.46
Autocorrelation							
output	0.67	0.67	0.68	0.67	0.66	0.69	0.65
terms of trade	0.77	0.80	0.67	0.75	0.65	0.67	0.57
real exchange rate	0.81	0.82	0.64	0.79	0.59	0.58	0.49
Correlation with output							
consumption	0.82	0.80	0.80	0.82	0.80	0.84	0.77
investment	0.87	0.89	0.74	0.87	0.87	0.93	0.89
exports	0.01	0.09	-0.46	0.23	0.14	0.28	0.28
imports	0.78	0.76	0.64	0.66	0.54	0.43	0.58
net-exports	-0.56	-0.57	-0.58	-0.41	-0.51	-0.54	-0.54
terms of trade	0.73	0.46	-0.22	0.57	0.45	0.57	0.49
real exchange rate	0.48	0.37	-0.33	0.48	0.32	0.51	0.45
Correlation with the terms of trade							
net-exports	-0.25	-0.30	0.47	-0.32	-0.28	-0.42	-0.91
RER	0.94	0.99	0.99	0.98	0.96	0.99	0.99
Cross-country correlations							
output	0.05	0.02	-0.28	0.04	0.05	0.01	0.31
consumption	0.86	0.86	0.73	0.86	0.79	0.26	-0.14
investments	-0.69	-0.63	-0.96	-0.65	-0.56	-0.24	0.08

Notes: In Column (the import production function is given by equation (23) In columns (2)-(4) preferences are given by equation (24). Column (2) assumes that $\xi = 0.5$, (3) and (4) that $\xi = 1.6$. In column (4) the capital adjustment cost parameters are increased to match the observed volatility of investments. In columns (5)-(7) imports are predetermined. Column (5) applies the calibration of the baseline model. Column (6) assumes that $\kappa_1 = \kappa_4 = 0.95$, $\kappa_2 = \kappa_3 = 0$, $E(\epsilon_1 \epsilon_2) = 0$. Column (7) assumes that $1/\rho = 0.5$.

8 Appendix: Data Documentation:

The data on GDP and its components were obtained from the National Accounts section of SourceOECD. Exchange rates were taken from the OECD Main Economic Indicators section of Source OECD. Population numbers were obtained from IMF's International Financial Statistics. National accounts data were seasonally adjusted from the source. We converted the annual population data into quarterly data by linear interpolations. Output is measured as GDP in constant prices divided by population. Consumption is measured by private final consumption expenditure in constant prices divided by population. Investment is gross fixed capital formation in constant prices divided by population. Government expenditure is measured by government final consumption in constant prices divided by population. Exports are measured as exports of goods and services in constant prices divided by population. Imports are imports of goods and services in constant prices divided by population. Net exports are defined as nominal exports less nominal imports divided by current price GDP. The terms of trade are defined as the implicit import deflator divided by the implicit export price deflator. The real exchange rate is defined as the real effective CPI -based trade-weighted exchange rate.

The longest sample periods are 1970 q.1 - 2000 q.4. All data for Australia, Canada, France, Italy, Japan, the UK, and the US are for the full sample. The real exchange rate is available for the full sample for all countries as well. For the other variables and countries, sample periods are: Austria: 1976 q.1 - 1999 q.2; Denmark: 1977 q.1 - 1999 q.2. The Netherlands: 1982 q.2 - 2000 q.4. New Zealand: 1982 q.2 - 1999 q.2. Spain: 1970 q.1 - 1998 q.4. Sweden: 1980 q.1 - 1998 q.4. Switzerland: 1980 q.1 - 2000 q.4.

8.1 Proof of the Risk Sharing Condition

We assume that there is a complete set of asset markets and that all agents behave competitively.. Hence, the competitive equilibrium can be derived from the social planners problem. This problem can be formulated as:

$$\max \Psi_1 E_t \sum_{s=t}^{\infty} \beta^{s-t} u\left(c_{1s}, L_{1s}\right) + \Psi_2 E_t \sum_{s=t}^{\infty} \beta^{s-t} u\left(c_{2s}, L_{2s}\right) \tag{25}$$

subject to the sequence of resource constraints for the output sector, the final goods sector (the Armington aggregators), the import production functions, the capital accumulation equations, and the constraints on the use of time. Furthermore, the expectations are conditional on the state at date t and the processes specified for the exogenous shocks to the economy. Ψ_1 and Ψ_2 denote social welfare weights. Without any loss of generality we will assume that $\Psi_1 = \Psi_2 = 1$.

Focusing on the static conditions, we obtain the following set of first-order conditions:

$$u_c(1) = \lambda_1 \tag{26}$$

$$u_c(2) = \lambda_2 \tag{27}$$

$$\lambda_1 \omega_1 d_1^{-\rho} \left[\omega_1 d_1^{1-\rho} + \omega_2 m_1^{1-\rho}\right]^{\rho/(1-\rho)} = \mu_1 \tag{28}$$

$$\lambda_2 \omega_1 d_2^{-\rho} \left[\omega_1 d_2^{1-\rho} + \omega_2 m_2^{1-\rho}\right]^{\rho/(1-\rho)} = \mu_2 \tag{29}$$

$$\lambda_1 \omega_2 m_1^{-\rho} \left[\omega_1 d_1^{1-\rho} + \omega_2 m_1^{1-\rho}\right]^{\rho/(1-\rho)} = \mu_2/\pi_1 + \varphi_1 \tag{30}$$

$$\lambda_2 \omega_2 m_2^{-\rho} \left[\omega_1 d_2^{1-\rho} + \omega_2 m_2^{1-\rho}\right]^{\rho/(1-\rho)} = \mu_1/\pi_1 + \varphi_2 \tag{31}$$

$$u_L(1) = \mu_1 \alpha y_1 / n_1^y \tag{32}$$

$$u_L(2) = \mu_2 \alpha y_2 / n_2^y \tag{33}$$

$$u_L(1) = \varphi_1 \gamma m_1 / n_1^t \tag{34}$$

$$u_L(2) = \varphi_2 \gamma m_2 / n_2^t \tag{35}$$

where u_c denotes the marginal utility of consumption, u_L the marginal utility of leisure, λ_i is the multiplier on the final goods resource constraint for country i, μ_i is the multiplier on the output good resource constraints, and φ_i is the multiplier on the import resource constraint. The first two conditions are the conditions for the optimal choice of c_1 and c_2. The second and third equations are the conditions for the optimal choices of d_1 and d_2. The fifth and sixth conditions are for the optimal choices of m_1 and m_2. The last for equations are the conditions for the optimal choices of n_1^y, n_2^y, n_1^{tr}, and n_2^{tr}.

From the first two conditions we get that:

$$\frac{u_c(1)}{u_c(2)} = \frac{\lambda_1}{\lambda_2} \tag{36}$$

and it follows from the third and fourth condition that:

$$\begin{aligned} \frac{\lambda_1}{\lambda_2} &= \frac{\mu_1}{\mu_2} \frac{\omega_1 d_2^{-\rho} \left[\omega_1 d_2^{1-\rho} + \omega_2 m_2^{1-\rho}\right]^{\rho/(1-\rho)}}{\omega_1 d_1^{-\rho} \left[\omega_1 d_1^{1-\rho} + \omega_2 m_1^{1-\rho}\right]^{\rho/(1-\rho)}} \\ &= \frac{\mu_1}{\mu_2} \frac{\left[\omega_1^{1/\rho} + \omega_2 \omega_1^{(1-\rho)/\rho} (m_2/d_2)^{1-\rho}\right]^{\rho/(1-\rho)}}{\left[\omega_1^{1/\rho} + \omega_2 \omega_1^{(1-\rho)/\rho} (m_1/d_1)^{1-\rho}\right]^{\rho/(1-\rho)}} \end{aligned}$$

where it will have to be the case that:

$$\frac{\mu_2}{\mu_1} = p_1^{fob} \tag{37}$$

$$\frac{\omega_2}{\omega_1}(m_i/d_i)^{-\rho} = p_1^{cif} \tag{38}$$

Using these we get that:

$$\frac{\lambda_1}{\lambda_2} = \frac{1}{p_1^{fob}} \frac{\left[\omega_1^{1/\rho} + \omega_2^{1/\rho}\left(p_1^{cif}\right)^{(\rho-1)/\rho}\right]^{\rho/(\rho-1)}}{\left[\omega_1^{1/\rho} + \omega_2^{1/\rho}\left(p_2^{cif}\right)^{(\rho-1)/\rho}\right]^{\rho/(\rho-1)}} = 1/q_1$$

Hence, as we wanted to show, we have that:

$$\frac{u_c(2)}{u_c(1)} = q_1 \tag{39}$$

8.2 Calibration

Table . Labor Income Share Estimates

Country	Labor shares of income			Transport sector output share	
	Manufacturing	Transports	Sample	percent	sample
Australia	54.8[1]	51.3[1]	1989-99	6.6[3]	1969-85
Austria	65.3[1]	61.7[1]	1989-99	-	-
Canada	67.4[1]	62.6[1]	1970-97	8.4[3]	1961-85
Denmark	72.3[1]	63.3[1]	1970-2000	8.5[3]	1966-85
France	62.7[1]	52.9[1]	1992-99	-	-
Italy	58.0[1]	59.7[1]	1970-99	-	-
Japan	53.3[1]	58.3[1]	1990-99	6.4[3]	1970-86
Netherlands	59.4[1]	63.3[1]	1995-99	-	-
Spain	62.9[1]	52.9[1]	1995-98	-	-
Sweden	61.6[1]	46.6[1]	1995-96	6.3[3]	1970-86
UK	75.6[1]	72.0[1]	1970-2000	6.9[3]	1973-86
US[2]	64.9[2]	64.7[2]	1987-1999	5.8[3]	1960-86
Average	63.2	59.5	-	7.0	-

Notes: 1) Source: OECD, National Income Surveys. Labor share is estimated as compensation to employees divided by GDP. The transport sector includes transports, storage, and communications.

2) Source: Bureau of Economic Analysis. Labor share is estimated as compensation to employees divided by GDP. The transport sector includes transports only.

3) Source: OECD Intersectorial Data Base (the ISDB).