Preference Shocks, International Frictions, and International Business Cycles

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Abstract

Replicating the degree of cross-country comovements of macroeconomic aggregates, dynamics

of prices and quantities of international trade, and the behavior of consumption and labor remains

an important challenge in international business cycle literature. This paper incorporates

preference shocks into a standard two-country model in which there exist international frictions,

such as costs of transportation and restrictions to international asset trade. Country-specific

preference shocks that generate fluctuations in each country's consumption and labor solve the

puzzles, except for the discrepancy between theory and data regarding international trade

variables. The presence or absence of international frictions plays a limited role in solving the

puzzles.

1. Introduction

Conventional international dynamic stochastic general equilibrium (IDSGE) models

embedded with complete markets and driven only by productivity shocks have failed to answer

some important puzzles in international macroeconomics (Obstfeld and Rogoff, 2001) although

they have succeeded in replicating the basic facts of business cycles in many respects (e.g.,

Backus et al., 1992, 1994; Baxter, 1995; Baxter and Crucini, 1995). The major puzzles that arise

from the standard workhorse models include counterfactually higher cross-country consumption

correlations than cross-country output correlations (the consumption correlation puzzle) and less

volatile terms of trade (the terms of trade [TOT] puzzle).[a] In addition, the two-country IDSGE

models typically generate much less volatile consumption and labor than the data (the

consumption-labor volatility puzzle), although this anomaly is not frequently mentioned.

Economists have subsequently tried to solve these puzzles. The consumption correlation

puzzle is, for instance, at least partly solved by a model with an inventory management decision

(Alessandria et al., 2013), a sticky price model with monetary policy shocks that affect aggregate

demand (Kollmann, 2001), a model with realistic level of increasing returns and multiple,

indeterminate convergent paths to the steady state (Xiao, 2004), a model with variable capital

utilization (Baxter and Farr, 2005), and a model with real wage rigidity (Yakhin, 2007). The

terms of trade puzzle is also solved to some extent by a model with oil imports (Backus and

Crucini, 2000), a model with imperfect competition and variable markups (Atkeson and Burstein,

2008), and a model with a low trade elasticity and non-contingent bonds (Corsetti et al., 2008).

About the consumption-labor volatility puzzle, introducing preferences that embed home

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[a] There are other important puzzles, such as the home bias puzzle, the savings-investment puzzle, and the purchasing parity power puzzle, but this paper focuses on the consumption correlation puzzle and the terms of trade puzzle.

production in a reduced form, Raffo (2008) shows the model economy can generate volatile consumption. Karabarbounis (2014) also demonstrates that non-separable preferences between consumption and labor due to home production are useful to increase consumption variability.

This paper tries to solve these puzzles simultaneously by introducing idiosyncratic demand characteristics in a general international business cycle model along with standard productivity shocks in the global economy with and without international frictions. The fact that the standard models generate lower consumption and labor volatilities and too high cross-country consumption comovements implies that the dynamics of the representative households' labor supply and consumption schedule are subject to country-specific idiosyncrasies. The model economies require the elements which add a substantial degree of consumption and investment volatility but do not lower the domestic comovements. The model economy also needs to have forces that generate the volatile trade-related variables and decrease cross-country consumption correlation. This paper, thus, introduces preferences with stochastic trade-off between consumption and leisure. Preference shocks can be thought of as, "more broadly as a demand shock" (Gali and Rabanal, 2005) and are expected to offer more variability in consumption, investment, and trade-related variables, and to give a relatively lower cross-country consumption correlation.

In addition to preference shocks, this paper considers the effects of international market frictions. The degree of international market frictions in this paper is measured by the degree of trade cost and the presence or absence of international frictions in international asset trade. For example, stronger financial linkages might generate higher cross-country comovements due to the spillover effect of preference shocks, while the direct impact of preference shocks on each country's expenditure would reduce cross-country comovements. The presence of international

trade cost might give rise to larger variations in the TOT, but a country hit by positive preference

shocks may not be able to fully import what she demands due to frictions in international trade

and the TOT might not become very volatile. In sum, quantitative impacts of the degree of

international market frictions on business cycle fluctuations are an empirical question.[b]

The remainder of this paper is presented as follows: In the next section, the stylized facts

of international business cycles are briefly reviewed and the robust empirical regularities are

identified; Section 3 presents the model economy; Section 4 discusses how each feature of the

calibrated two-symmetric-country models contributes to solving the puzzles of international

business cycles; Sensitivity analyses are conducted in Section 5; Finally, the paper is concluded.

2. Review of Stylized Facts

Table 1 reviews the stylized facts of business cycles for the benchmark period of 1980–

2002 (benchmark period) and for the similar period (1970-2002, BKK period) used in Backus et

al. (1993). This is due to the fact that isolating the effect of oil price shocks is better for

examining the role of preference shocks and international frictions in international business

cycles (Backus and Crucini, 2000, Hirata et al., 2013).[c] All data are quarterly, and all statistics are

based on logged data detrended by the HP filter with smoothing parameter 1600. Net exports are

defined as the ratio of (exports minus imports) to output in current prices, which is also detrended

by the HP filter. The sources of data are explained in Data Appendix.

There are similarities and discrepancies in business cycles within developed economies

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[b] Hirata et al. (2013) survey a number of empirical studies on the synchronization of business cycles across regions.
[c] Oil price shocks can be thought of as common shocks as they simultaneously and similarly affect a number of oil importing countries. The degree of cross-country comovements of macroeconomic variables has declined over time, at least partly due to the weakened effect of oil price shocks (Kose et al., 2003).

between the two periods. Overall, the volatilities and cross-country correlations have decreased over time; however, the basic business cycle properties emphasized in the business cycle literature such as Backus et al. (1993) hold. Consumption and labor are about 0.85 times as volatile as output, while investment is more volatile than output, with the average value being around 2.60. Output is highly correlated with investment (average correlation = 0.87) as well as with consumption (average correlation = 0.78). Given the fact that the standard IDSGE models driven only by productivity shocks generate lower variability (about half of the data) in consumption and labor (the consumption-labor volatility puzzle) and high output-consumption and output-investment comovements, the model economies require the elements which create a substantial degree of volatility in consumption and labor but do not lower the domestic comovements.

About the properties of the trade-related variables, the TOT are more volatile than output (the TOT puzzle); this is also the case with exports and imports. The variability of net exports is much smaller than that of exports, imports, the TOT, or output. The net exports are negatively correlated with output and the TOT. In terms of the cross-country comovements, the cross-country correlation coefficients of output display higher values than those of consumption (the consumption correlation puzzle). These observations imply that the model economy needs to be embedded with forces that generate the volatile trade-related variables and reduce cross-country consumption correlation.

3. Model Economy

The model economy is an extended version of Backus et al. (1994) with a couple of distinct features. First, the model economy is embedded not only with supply-side shocks but also

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with demand-side shocks. Second, international markets are possibly embedded with disturbances. The models assume two ultimate international financial markets: one is perfect financial mobility (complete markets, CM) and the other is zero international financial mobility (portfolio autarky, PA) across countries. Both CM and PA are at odds with reality; however, the "true" international capital mobility would lie between them. The models are also assumed to be associated with a certain level of international trade cost.

Two symmetric countries, countries 1 and 2, compose the world economy. The representative households of country i maximize the expected utility $E_0 \sum_{t=0}^{\infty} \beta^t u_{it} (c_{it}, n_{it})$ where $u_{it} = \left(c_{it}^{\mu A_{it}} (1 - n_{it})^{1 - \mu A_{it}} \right)^{1-\gamma} / (1 - \gamma)$, t is time, A_i denotes the exogenous preference shocks, c_i is consumption, n_i is the shares of time devoted in labor, $\beta \in (0,1)$ is the discount factor, $\mu \in (0,1)$ is the share parameter of consumption in utility, and $\gamma > 0$ is the relative risk aversion parameter.

In each country, the household supplies labor and rents capital to the domestic intermediate good producing firms under perfect competition. It produces a differentiated, imperfectly substitutable, and tradable intermediate good which is both domestically used and exported. The intermediate goods producing firms have the following technology: $y_{it} = F(z_{it}, k_{it}, n_{it}) = z_{it} k_{it}^{\theta} n_{it}^{1-\theta}$, where y_i denotes (per capita) intermediate good production, z_i is the exogenous technology shock, k_i is the capital stock, and $\theta \in (0,1)$ is the share of capital.

Production of the intermediate goods is subject to the constraints: $y_{1t} = a_{1t} + a_{2t}$ and $y_{2t} = b_{1t} + b_{2t}$ where a and b are the differentiated intermediate goods produced in countries 1 and 2, respectively. Subscripts indicate the locations of the intermediate goods used, i.e., b_1 is the intermediate goods produced in country 2 and used in country 1.

Final goods producing firms that produce non-traded final goods f_i domestically

consumed or invested: $f_{it} = c_{it} + x_{it}$ where x_i denotes investment. The representative household

in each country sells her intermediate goods to the domestic final good producing firm that has a

technology: $f_{it} = Q(a_{it}, b_{it})$ where $f_{it} = (\omega_{i1} a_{it}^{1-\alpha} + \omega_{i2} b_{it}^{1-\alpha})^{1/(1-\alpha)}$ is the Armington

aggregator (Armington, 1969), ω is the share parameter of each good, and α^{-1} is the elasticity of

substitution between the intermediate goods.

Following Baxter and Crucini (1993), capital formation with adjustment costs $\phi(x_{it}/$

$k_{it}) = \phi_{it}$ and with the properties $\phi_{it} > 0, \phi_{it}' > 0$, and $\phi_{it}'' < 0$ follows $k_{it+1} = (1 - \delta_i)k_{it} +$

$\phi_{it} k_{it}$ where $\phi_i' = 1$ implies that the adjustment costs do not affect the steady state conditions.

The elasticity of marginal adjustment cost is $\eta_i = -(\phi_i' k_i)/(\phi_i'' x_i)$.

3.1. Frictions in International Financial Markets

To evaluate the role of international frictions in international financial markets, two

extreme cases for world financial markets, i.e., CM and PA, are considered.[d] In the CM economy

where Arrow-Debreu securities are available, people can have full access to contingent claims

that insure themselves from unforeseen shocks. Under CM, the model can be solved as a social

planner model. The following problem is solved: $\max \sum_{t=0}^{\infty} \beta^t [\sum_{i=1}^{2} u_{it}]$ subject to the resource

and budget constraints.

In the portfolio autarky economy where no financial assets are traded internationally,

international risk-sharing does not exist. The representative household in each country can only

trade the intermediate goods through spot markets. The households barter their home

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[d] Baxter and Crucini (1995) employ a model with a risk-free bond market driven by stationary productivity shocks. Heathcote and Perri (2002) deal with all three markets (CM, bond, and PA). They show that models with a bond market setting generate similar results to those in a complete markets setting and the results of bond markets essentially lie between those of CM and those of PA. Kose and Yi (2006) employ three-country models embedded with CM and PA and with trade cost. To my knowledge, no previous paper has included CM and PA, trade cost, and productivity and preference shocks all together.

intermediate good for the foreign intermediate good, so each country is subject to the budget

constraints: $p_{1at}y_{1t} = p_{1t}f_{1t}$ and $p_{2bt}y_{2t} = p_{2t}f_{2t}$ where p_i is the price of the final good, and p_{ij}

is the price of the intermediate good j in country i.

3.2. Frictions in International Trade

The model economy is also associated with international trade cost that includes not only

shipping costs but also tariffs and non-tariff barriers. Obstfeld and Rogoff (2001) theoretically

show that trade cost is helpful to solve the puzzles explained above, as trade cost not only

restricts international trade but also international financial mobility as a result.

Following Samuelson (1954), an iceberg cost specification is adopted. The iceberg cost

model assumes that part of a good melts during its transportation, or $m_{vit} = j_{vt} - tc(j_{vt})$ where

country v receives m_{vi} amount of the intermediate good j, produced in and shipped from country

i. Part of j, $tc(j_{vt}) = g_{vi}j_{vt}^s \in [0, j_{vt}]$, where $g_{vi} \geq 0$ and $s \geq 1$. $tc(j_{vt})$ is lost during

international transportation. For example, imports of country 1 from country 2 are $m_{12t} = b_{1t} -$

$g_{12}b_{1t}^2$. A special case, $g_{vi} = 0$, is the same as the simple costless transportation case. The final

good firm's technology is now $f_{it} = [\omega_{i1}j_{it}^{1-\alpha} + \omega_{i2}m_{ivt}^{1-\alpha}]^{1/(1-\alpha)}$ where

$(i, j, v) = (1, a, 2)$ and $(2, b, 1)$, respectively. The presence of trade cost leads to a difference

between the TOT in fob (free on borad; F-TOT) and the TOT in cif (cost, insurance, and freight;

C-TOT). Roughly speaking, cif and fob prices include and do not include trade cost, respectively,

and the C-TOT and F-TOT for country 1 are $p_{12ct} = (\partial f_{1t}/\partial m_{12t})/(\partial f_{1t}/\partial a_{1t})$ and $p_{12ft} =$

$(\partial f_{1t}/\partial b_{1t})/(\partial f_{1t}/\partial a_{1t})$, respectively.[e] The (rate of) trade cost τ_{iv} is defined as $p_{ivc}/p_{ivf} -$

$1 = g_{12}sb_1^{s-1}(1 - g_{12}sb_1^{s-1})^{-1}$, if $(i, v) = (1, 2)$. When 30 percent quadratic trade cost is

[e] A country's transporter is assumed to only carry its own imports.

assumed, g_{12} is chosen to satisfy $(\tau_{12}, s) = (30\%, 2)$. In the Backus et al. (1994) model economy

without trade cost ($g = 0$), the C-TOT equal F-TOT are they fluctuate much less than the data.

With a positive trade cost, the F-TOT are now subject to the extra variability from the trade cost

τ_{iv}. In addition, the F-TOT are consistent with the TOT data computed from implicit export and

import deflators of national accounts (the log of the ratio of the import deflator to the export

deflator). Henceforth, the F-TOT are used as the theoretical TOT.

3.3. Driving Forces and Solution

The economy is subject to two types of exogenous shocks, i.e., preference and

productivity shocks. Modern business cycle studies recognize the pivotal role of disturbances to

preferences. Ireland and Schuh (2008) document that preference shocks stand as a proxy for "a

wide variety of non-technological disturbances that potentially play a role in driving aggregate

fluctuations at short, medium, and long horizons."[f] Chang et al. (2007) give demographic

changes, tax reforms, shifts in the marginal rate of substitution between leisure and consumption,

or (non-neutral) technological changes in household production technology as examples of

preference shocks.[g] Bencivenga (1992) shows that preference shocks that shift the labor supply

curve through the preference's trade-off between leisure and consumption can improve the

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[f] The shocks on preference are generally unobservable and an interpretation might be difficult (Hess and Shin, 1997; Raffo, 2010; Karabarbounis, 2014), and thus intuitive explanation is needed. For example, the Great East Japan Earthquake and Tsunami in 2011 would cause not only shocks on productivity of firms but also shocks on preferences of people. After the shock, people would put more weight on consumption and less weight on leisure, since rebuilding their lives would be needed. Chugh (forthcoming) also discusses that the events of September 11, 2001, would lead to a decrease in present consumption demand and an increase in savings for the future that would promote more investment.

[g] Karabarbounis (2014) explains the role of preference shocks by using home production. Assuming that home production and market production sectors are substitutes, he shows that when domestic market consumption is low, households use more non-market time to home production and the marginal utility of market consumption rises less than the case without home production due to the substitutability. Canova and Ubide (1998) similarly demonstrate that the disturbances to household technologies fill the role of preference shocks.

productivity shock driven closed economy models thanks to a sufficiently high labor variation. Hall (1997), Rotemberg and Woodford (1997), and Gali and Rabanal (2005) also emphasize that preference shocks that propagate through atemporal channels account for most of the business cycle fluctuations in the U.S.[h] Baxter and King (1991) and Farmer and Guo (1994) find that the closed economy model driven by preference shocks alone behaves well, provided that preference shocks are associated with (1) market failures or (2) a time-varying capacity-utilization rate.

Even in IDSGE models, preference shocks are powerful driving forces that can be used to solve several discrepancies between the theory and the data.[i] Obstfeld (1995) documents that preference shocks are, "not inherently implausible, but until they are modeled more fully."[j] Stockman and Tesar (1995) introduce preference shocks in the trade-off between traded and non-traded consumption and show that preference shocks contribute slightly to solving the cross-country consumption correlation puzzle, although productivity shocks explain the majority of basic business cycle characteristics. Wen (2007) finds that a one-good, two-country model driven only by preference shocks associated with habit formation can solve some puzzles in international macroeconomics. He claims the key to solving the puzzles are not frictions (including market incompleteness and sticky prices), but preference shocks. Heathcote and Perri (2013) and Corsetti et al. (2008) introduce preference shocks, showing that they, to some degree,

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[h] Holland and Scott (1998) discover that preference shocks are complementary to productivity shocks for explaining the U.K. business cycles. They find the predictability of preference shocks via oil prices, the terms of trade, money, and prices. Gali, Gertler, and Lopez-Salido (2002) demonstrate similar results. Gali, Gertler, and Lopez-Salido (2002) also show that Hall's (1997) preference shock can be thought of as a variation in counter-cyclical mark-ups.

[i] Blankenau, Kose, and Yi (2001) and Chadha, Janssen, and Nolan (2001) examine preference shocks in small open economy models.

[j] Raffo (2010) constructs a model with investment-specific technology shocks that generate fluctuations in domestic absorption but do not have a direct impact on the aggregate production function. He shows that playing a similar role to preference shocks, investment-specific technology shocks solve the disconnection between real exchange rate movements and consumption movements (the Backus and Smith puzzle). Mandelman et al. (2011) estimate VECM of the investment-specific technology shocks of OECD economies and simulate a model a la Raffo (2010) by using the VECM estimates of the shocks.

solve the Backus and Smith puzzle and the terms of the trade puzzle.

In this paper, following the specification of Hall (1997) and Holland and Scott (1998),

preference shocks are computed from the first order condition: $\frac{1-\mu A_{it}}{\mu A_{it}}\frac{c_{it}}{1-n_{it}} = \frac{(1-\theta)y_{it}}{n_{it}}$. The

innovations of A_{it} are assumed to be country-specific and uncorrelated between countries.

Productivity shocks z_{it} are measured by the Solow residuals (TFP), which are the

residuals of the estimated Cobb-Douglas production function. The innovations of z_{it} are assumed

to be correlated between countries, as is standard in the IDSGE literature.

As this dynamic rational expectations model cannot be solved analytically, the system of

equations characterizing the solution of the model around the steady state is log-linearized

following the standard IDGE literature. In the case of CM, the model is converted into the

equivalent social planner's problem. In the case of PA, the optimization problems of each agent in

each country are solved along with the equilibrium conditions. The approximate solution of the

dynamics in response to exogenous shocks is found, using Sims (2002) that is a generalized

version of Blanchard and Khan (1980). All statistics reported later are based on 1,000

simulations.

4. Calibration

Table 2 presents the parameter values and the given steady states. The parameters are

mainly quoted from Backus et al. (1994). There are some original parameters and steady state

values based on the data. The elasticity of marginal adjustment cost (η) is the same as Baxter and

Crucini (1995) and Baxter and Farr (2005). Trade cost is the average of trade costs among Japan,

the U.S., and the EU, which are taken from Harrigan (1993). Table 2 also reports some properties

of the stochastic shock processes. For productivity shocks, three-country VAR is run and the

average of the results is symmetrized. It is assumed that preference shocks are stochastic, time-varying, and independent across countries. They are assumed to follow the simple AR(1) process: $\ln A_{it} = \rho_{Ai} \ln A_{it-1} + \varepsilon_{Ait}$ where ρ_{Ai} is the AR(1) coefficient, and $\varepsilon_{Ait} \sim N(0, \sigma_{Ait}^2)$ is the exogenous variation in preference. The average of these shocks over Japan, the U.S., and the EU is used.

4.1. Benchmark Results

Table 3 shows the benchmark simulation results. Both CM and PA economies predict cross-country correlations in consumption that are nearly the same as those in output, and they substantially solve the consumption correlation puzzle. Both CM and PA economies generate plausible volatility in the domestic variables. They predict the fact that volatility in output is higher than those in consumption and labor and is lower than that in investment. Moreover, they succeed in solving the consumption-labor volatility puzzle, but not at the expense of the data-consistent prediction of the standard models where output is very highly correlated with investment and consumption.[k]

About the trade-related variables, both the CM and PA economies fail in reproducing the observed variability, but the CM economy succeeds in replicating the negative correlation coefficients between net exports and output and that between net exports and the TOT.[l] Both the CM and PA economies still generate counter-factually low volatility in quantities and the TOT, although the CM economy predicts higher volatility in exports and imports, and the PA economy predicts higher variability in the TOT. With regard to the behavior of net exports in the PA

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[k] Introducing preference shocks generates more data-consistent domestic comovements.
[l] Raffo (2008) uses the standard model with the GHH preference and shows that the model can reproduce countercyclical trade balance through generating countercyclical fluctuations of goods.

economy, they never fluctuate and have no correlations with any variables.

4.2. The Role of Frictions in International Financial Markets and Preference Shocks

Since all features are concurrently included in the benchmark model, each will be examined in turn to better understand their respective contributions.

To begin with, the influence of international diversification opportunities on the economy is examined. There are three distinctions in potential benefit between the frictionless and frictional cases of international financial markets. The first difference is within international consumption risk-sharing. The CM economy provides a full diversification of the idiosyncratic risks by pooling them using state-contingent claims, thereby ensuring consumption across all states of nature. The PA economy, on the other hand, provides no diversification of the idiosyncratic country-specific risks, thereby exposing the economy to all types of country-specific shocks. The second difference is in intertemporal trade, i.e., consumption smoothing. The full availability of international financial assets under CM enables people to smooth out consumption over time. However, consumption smoothing is impossible unless there is at least one internationally-traded bond. The third difference is within the possibility of current account imbalance. Countries in the CM economy can run a temporary current account imbalance thanks to the existence of international financial markets, while those in the PA economy cannot run a trade deficit or surplus because of the non-existence of international financial markets. The PA economy therefore requires period-by-period balanced trade, i.e., trade balance is always zero.

Table 4 compares the quantitative impact of each shock under CM and PA. In Case 1, both economies are solely driven by productivity shocks. The consumption correlation puzzle is involved in both economies, while the PA economy generates higher cross-country output

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correlation and lower cross-country consumption correlation (but the difference in correlation coefficients is statistically insignificant). Both economies generate plausible volatility in output and replicate the fact that volatility in output is higher than those in consumption and labor and lower than that in investment. However, they fail in solving the consumption-labor volatility puzzle and generate the counter-factually high output-consumption and output-investment correlation coefficients. Although exports, imports, and net exports fluctuate more in the CM economy than in the PA economy and the TOT fluctuate less in the CM economy than in the PA economy, their variability is far below the data.[m]

The difference between Case 1 and Case 2 shows that adding preference shocks helps solve many discrepancies between the data and the model driven solely by productivity shocks, although this still cannot solve the TOT puzzle. The volatility of consumption and labor nearly doubles thanks to the wedge between the marginal product of labor and the marginal rate of substitution, while the volatility of output increases just slightly. And then, the wedge reduces the cross-country consumption correlation to the close level of the cross-country output correlation. But the variability in the TOT remains almost unchanged in the CM economy. This implies that preference shocks do not give sufficient variability in international trade quantities through the demand-side channel, albeit they give it in domestic variables. The TOT moves more in the PA economy than in the CM economy although the contribution is quantitatively small and statistically insignificant.

To understand the role of preference shocks in the model economy, Figure 1 displays the

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[m] Heathcote and Perri (2002) discover that the TOT moves more within the PA economy, because the lack of international financial markets requires a larger change in the TOT for clearing markets when productivity rises. They find a larger difference in the TOT than the model economies examined here mainly because of the larger investment variability. This is examined in the sensitivity analysis of the adjustment cost of capital formation.

impulse responses of a rise in preference shocks in country 1. The representative household in

country 1 desires more consumption and less leisure, as the marginal utilities from consumption

and leisure increase and decrease, respectively. In other words, preference shocks shift the labor

supply curve through the trade-off between leisure and consumption.[n] The demand driven boom

also stimulates investment and output.

Under CM, the increase (decrease) in domestic (foreign) investment reflects the deficit

of net exports. To meet the need for more consumption, country 1 exports less and imports more,

while the TOT rises. The household in country 2 feels a relatively smaller urge with regard to

current consumption than does the household in country 1. International consumption risk-

sharing implies that consumption is transferred from country 2 to country 1.[o] The demand for

more intermediate good b (=imports) from country 1 leads to a small rise in country 2's output.

Under PA, country 1 must export more for more imports in order to balance trade. The

greater effect on the TOT under PA, in turn, stems from the relative scarcity of intermediate good

b (to a) in country 1. In country 2, labor and output are almost unchanged, despite the fact that

the household is willing to raise its consumption to take advantage of the relative price

advantage. Under PA, the household in country 1 consumes less than it can do under CM because

of the lack of international asset trade. In addition, the differences in investment behavior under

CM and PA are attributed to the presence and absence of the resource shifting channel.

In sum, two reasons give rise to the fact that the consumption correlation puzzle is

significantly solved by preference shocks under both CM and PA. First, preference shocks alter

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[n] Productivity shocks affect labor by shifting labor demand curve.

[o] Since final goods are non-tradable, consumption is not transferable across countries, per se. However, the technology of final goods production in this model is just binding two intermediate goods together (the easiness of binding is governed by the elasticity parameter), and thus, transfer is eventually done through trading intermediate goods across countries.

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the consumption behavior in each country, as Wen (2007) explains. However, this reason is insufficient to explain why preference shocks are more effective in the CM economy. The second reason is the availability of international financial flows in the CM economy. After country 1 receives favorable preference shocks, consumption is transferred from country 2 to country 1 and as a result, the cross-country consumption correlation decreases.

4.3. The Role of Frictions in International Trade and Preference Shocks

Table 4 also displays the responses of the model economy when the trade cost is 0% and 35%. The inclusion of trade cost does not affect the domestic variables very much. Instead, it influences the trade variables and international comovements to a limited extent. These results reject the theoretical predictions by Obstfeld and Rogoff (2001) that claim that trade cost is essential to explain the TOT variability and international comovements.

International trade becomes more costly and less smooth after the rise in trade cost, resulting in more volatility in the TOT (= F-TOT) than that within the C-TOT. The trade cost, at the same time, reduces fluctuations in exports, imports, and net exports, and thus, the variability in the TOT also decreases. Which effect is more dominant is an empirical question.

When the economy is solely driven by productivity shocks, the TOT puzzle is not solved both under CM and PA. This is consistent with Ravn and Mazzenga (2004) who show that the standard productivity shock driven model associated with trade cost predicts the low TOT variability.

Once preference shocks are embedded within the model economy, shocks from the demand-side give more variability in trade quantities and the TOT. The variability, however, is quantitatively far less than that in the data. This result indicates that the effect of trade cost on

reducing the variations in trade quantities cancels out the effect of trade cost on increasing the variations in the TOT, even in the case with both productivity and preference shocks.

The frictions have a minor impact on international comovements as well, but the interesting finding is that an increase in cost generates higher consumption comovements under CM rather than under PA. This is because trade cost indirectly lowers the effect of international risk-sharing through reducing international trade. Barter-only international trade in the PA economy is already restricted and accordingly, the effect from trade cost is relatively smaller.

5. Sensitivity Analysis

Now the robustness check of our main findings considering a variety of sensitivity analyses is conducted. Table 5 displays the results of various cases of shock properties. The effects of varying productivity shocks' persistence with no spillovers (Case (a)) are similar for both financial market structures. Higher productivity persistence lowers volatility in the majority of variables except consumption. Regarding cross-country comovements, high persistence worsens the consumption correlation puzzle, i.e., it lowers the output comovements and raises the consumption comovements under CM. This is because greater productivity persistence makes the behavior of each country's output depend more upon shocks to her country. Cross-country comovements remain relatively stable with respect to the different degree of productivity persistence under PA.[P]

The difference in the spillover coefficients of productivity shocks (Case (b)) does not

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[P] Baxter and Crucini (1994) demonstrate that one-good, two-country random walk productivity shock driven models associate with restricted international asset markets substantially solve the consumption correlation puzzle. However, Heathcote and Perri (2002) find that that is not necessarily the case because of the relatively larger influences of the substitutability between intermediate goods on international comovements in the case of two-country, two-good models.

affect volatility very much but have a certain influence on the cross-country comovements. In both markets, higher spillover coefficients lead to lower output comovements. This is because a favorable shock in country 1 immediately let her produce more, while country 2 does so with lag due to the gradual propagation of the shock (and thus works less and invests less today). At the same time, thanks to the increase in wealth in both countries, higher spillover coefficients generate higher consumption comovements under both CM and PA.

The higher correlation of productivity shocks (Case (c)) produces higher cross-country comovements, as explained in Backus et al. (1992, 1993). When the correlation is very high (= 0.5), the output comovements exceed the consumption comovements.

Changes in the preference persistence (Case (d)) alter the quantitative results slightly, but the quantitative findings remain intact. Moreover, the results of varying risk aversion (Case (e)) and varying the elasticity of marginal capital adjustment costs (Case (f)) point to similar conclusions from the benchmark experiments both under CM and PA.

Varying the elasticity of substitution between the intermediate goods (Case (g)) has a major effect on both the behavior of trade variables and the TOT, as is well known in the literature. In terms of changes in the cross-country correlations, provided that the elasticity of substitution is low (= higher complementarity), the output comovements rise and the consumption comovements fall under CM, while both comovements rise under PA. [q] A greater complementarity implies that substituting intermediate goods a and b becomes more costly, so the relative price of imports (= the TOT) becomes more sensitive to shocks. Under PA, the TOT puzzle can be solved with a higher complementarity, but the quantitative results are sensitive to the choice of the elasticity value.

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[q] Pakko (2002) explains how this lower elasticity weakens the negative cross-correlation between net exports and the TOT.

When countries import more each other in the steady state (Case (h)), the cross-country business cycle transmission channels become broader and the cross-country output correlation coefficients become larger (and consumption comovements remain almost unchanged).

6. Conclusion

This paper incorporates preference shocks into a standard two-good, two-country IDSGE model. Adding preference shocks solves many discrepancies between the data and the model driven solely by productivity shocks. The volatility of consumption and labor nearly doubles, while the volatility of output increases just slightly. The most striking change is shown in the substantial improvement in simulated cross-country consumption correlation. However, the shortcoming is that preference shocks do not give sufficient variability in international trade quantities and the TOT.

The model economy driven by both productivity and preference shocks is also embedded with international frictions, such as costs of international transportation and restrictions to international asset trade. Obstfeld and Rogoff (2001) show that trade cost can help explain the puzzles in international macroeconomics, such as the consumption correlation puzzle and the TOT puzzle. Heathcote and Perri (2002) claim that thinking about the extent of international borrowing and lending opportunities cannot be bypassed for solving the puzzles. In a more comprehensive framework, this paper finds that costs of international transportation and restrictions to international asset trade can qualitatively help solve the puzzles, but their quantitative contribution is limited. This result might be considered to be consistent with the fact that the empirical regularities of international business cycles emphasized in the business cycle literature such as Backus et al. (1993) have held over time. In other words, the reduction in

international market frictions would have had a limited impact on the nature of international

business cycles that is discussed in Section 2.

There are interesting research questions to be explored in future studies. One of the most

important topics is the growing importance of Asian countries as trading partners for developed

economies.[r] The vast majority of IDSGE studies have assumed the U. S. and the EU (+Japan) as

the potential two large economies. But given the fact that the shares of GDP of Asia (excluding

Japan), Asia (including Japan), and the U.S. in the world GDP are 25%, 33%, and 21%,

respectively, the models are expected to be extended to three-country models associated with

asymmetric international frictions and the oil importing structure.[s]

Data Appendix
If the data are already seasonally adjusted, those are used; otherwise, they are seasonally adjusted
by the Census X11 procedure. The EU data refer to the EU 15 countries: Aggregate EU data are
used when available; otherwise all data are simply aggregated over the member countries. All
series but prices and population are on a per capita basis.

Population
Total population data for the U.S. and the EU are taken from IMF, *International Financial
Statistics*. If these are annual, they are interpolated assuming the population grew at a constant
rate within each year. Total population for Japan is taken from Statistics Bureau & Statistics
Center, Ministry of Public Management, Home Affairs, Posts and Telecommunications, *Monthly
Report on Current Population Estimates*.

National accounts
All data are taken from OECD, *Quarterly National Accounts*. All data except nominal net exports
(divided by nominal output) are in real terms at constant 1995 prices. Since capital accumulation
data used for estimating TFP are unavailable, the accumulated investment data since 1961 are
constructed, assuming 2.5% quarterly depreciation rate for the U.S. and the EU. For Japan, the
published capital accumulation data taken from ESRI, *Gross Capital Stock of Private Enterprises*

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[r] Otsu and Hirata (2011) construct a two-country business cycle accounting model for Japan and the Asian
Tigers. They find that Asian Tiger's production efficiency has had a strongly positive effect on Japanese
economic growth for the last 30 years.
[s] For example, the import share from Asian countries is now more than half of Japanese imports. Japan's
imports from and exports to China, for the first time since WWII, exceeded those from and to the U.S. in 2002
and 2007, respectively.

are used. The TOT are calculated by the implicit import price deflator divided by the implicit export price deflator. Both deflators are taken from OECD, *Quarterly National Accounts*.

Labor

Labor force of each country is defined as Labor hours worked times Number of employees. If only annual data are available, the annual data are used as the corresponding years' quarterly data, assuming the quarterly changes are the same within each year. If quarterly data are available for some limited period, annual data are used to fill in the gaps. The data sources are OECD, *Main Economic Indicators* for hours of work in total industry, ILO, *LABORSTA* for hours of work in manufacturing industry, OECD, *Labour Market Statistics* for average actual annual hours worked per person in employment, *OECD Key Indicators of the Labour Market* for annual hours worked per person in total industry, and MHLW, *Monthly Report on the Labour Force Survey* for the Japanese average weekly hours of work. Note that due to the data availability, labor statistics for the BKK period are computed from the data used in Heathcote and Perri (2003).

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Table 1. Business Cycle Facts[*]

(1) Volatility

	y_i	c_i	x_i	n_i	p_{ivf}	nx_i	ex_i	im_i
Japan	1.31	0.99	3.25	0.74	4.87	0.56	3.74	5.86
	[1.53]	[1.38]	[3.63]	[1.01]	[6.63]	[0.71]	[4.30]	[6.22]
U.S.	1.36	1.06	3.52	0.95	1.48	0.40	3.21	4.01
	[1.65]	[1.37]	[4.48]	[1.31]	[2.80]	[0.45]	[4.30]	[5.20]
EU	0.76	0.82	2.08	0.96	1.22	0.36	1.96	2.12
	[1.00]	[0.90]	[2.38]	[1.07]	[1.87]	[0.45]	[2.25]	[2.76]

(2) Domestic comovements / (3) International comovements

	(y_i,c_i)	(y_i,x_i)	(y_i,p_{ivf})	(y_i,nx_{if})	(nx_i,p_{ivf})		y	c
Japan	0.71	0.91	0.43	-0.51	-0.38	Japan - U.S.	-0.04	-0.05
	[0.81]	[0.93]	[-0.06]	[-0.41]	[-0.44]		[0.39]	[0.35]
U.S.	0.84	0.93	-0.02	-0.34	-0.22	Japan - EU	0.14	0.05
	[0.87]	[0.94]	[-0.23]	[-0.32]	[0.04]		[0.46]	[0.44]
EU	0.79	0.76	-0.28	-0.13	-0.19	U.S. - EU	0.29	0.12
	[0.83]	[0.81]	[-0.15]	[-0.15]	[-0.40]		[0.57]	[0.41]

[*] y = output, c = consumption, x = investment, n = labor, p_f = the terms of trade (fob), nx = net exports, ex = imports, and im = imports. i = Japan, the U.S., and the EU Statistics are based on logged and HP detrended quarterly data (seasonally adjusted) with smoothing parameter 1600. Net exports refer to the HP detrended ratio of (exports–imports) to output. All variables are expressed in terms of domestic prices, except net exports, which are nominal. "Volatility" is the standard deviation (%). "Domestic comovements" denote the contemporaneous cross-correlation coefficients of domestic variables. "International comovements" are the contemporaneous cross-correlation coefficients of each variable across countries. See Data Appendix for details of the data sources and definitions. The sample period for statistics (in square brackets) is the benchmark (BKK) period.

Table 2. Benchmark Parameters, Steady States, and Driving Forces[*]

Preference				Production		
β	Discount factor	0.99		$1/\alpha$	Elasticity of substitution between intermediate goods	1.50
γ	Relative risk aversion	2.00				
μ	Consumption share	0.34		θ	Capital share	0.36
				δ	Capital depreciation rate	0.025
Trade				η	Elasticity of marginal adjustment cost	15.00
$\tau_{iv}=\tau_{vi}$	Trade cost	20%		ϖ_{ii}	Share of home good	$(1-ms)^{\alpha}$
s	Trade cost power term	2.00		ϖ_{ik}	Share of foreign good	ms^{α}
ms	Import share	0.15				

Productivity shocks

$$\rho_z = \begin{pmatrix} 0.916 & 0.020 \\ 0.020 & 0.916 \end{pmatrix} \qquad \sigma^2_z = \begin{pmatrix} 0.007^2 & 0.0025^2 \\ 0.0025^2 & 0.007^2 \end{pmatrix} \qquad \rho(\varepsilon_z) = 0.13$$

Preference shocks

$$\rho_A = \begin{pmatrix} 0.910 & 0.000 \\ 0.000 & 0.910 \end{pmatrix} \qquad \sigma^2_A = \begin{pmatrix} 0.007^2 & 0.000^2 \\ 0.000^2 & 0.007^2 \end{pmatrix}$$

Table 3. Benchmark Results[*]

(1) Volatility

	y_i	c_i	x_i	n_i	p_{ivf}	nx_i	ex_i	im_i
CM	1.20	0.92	3.36	0.79	0.74	0.14	0.94	1.24
PA	1.19	0.89	3.16	0.80	0.88 *	0.00	0.85	0.84 **
Data	1.31	0.99	3.25	0.74	4.87	0.56	3.74	5.86

(2) Domestic comovements

	(y_i,c_i)	(y_i,x_i)	(y_i,p_{ivf})	(y_i,nx_{if})	(nx_i,p_{ivf})
CM	0.83	0.94	0.90	-0.47	-0.27
PA	0.86	0.91	0.67 **	0.00	0.00
Data	0.71	0.91	0.43	-0.51	-0.38

(3) International comovements

	y	c
CM	0.09	0.11
PA	0.11 **	0.18 **
Data	0.13	0.04

[*]Statistics are based on logged and HP detrended simulated data with smoothing parameter 1600. Net exports refer to the HP detrended ratio of (exports - imports) to output. All moments of models (CM and PA) are averages over the 1,000 simulations of the model. All variables are expressed in terms of domestic prices, except net exports, which are nominal. "Volatility" is the standard deviation (%). "Domestic comovements" denote the contemporaneous cross-correlation coefficients of domestic variables. "International comovements" are the contemporaneous cross-correlation coefficients of each variable across countries. For volatility, the F-test is applied for testing the difference of the PA case from the CM case. Subscripts ** and * indicate volatility under CM is statistically different from the volatility under PA at the 5% and 10% level, respectively. For correlation, the Fischer's z-test statistic is used for testing the difference of the PA case from the CM case. Subscripts ** and * indicate the correlation coefficient under CM is statistically different from the correlation coefficient under PA at the 5% and 10% level, respectively. Since net exports never move under PA, statistical tests for the volatility of net exports, for the correlation between output and net exports, and for the correlation between the TOT and net exports are not displayed. Data (Japan) are taken from Table 1. International comovements are averages of the Japan-U.S. and Japan-EU comovements.

Table 4. International Frictions and Business Cycles[*]

(1) Volatility

	y_i		c_i		x_i		n_i		p_{ivf}		nx_i		ex_i		im_i	
Benchmark (t_{iv}=t_{vi}=20%)																
CM	1.20		0.92		3.36		0.79		0.74		0.14		0.94		1.24	
PA	1.19		0.89		3.16		0.80		0.88		0.00		0.85		0.84	
t_{iv}=t_{vi}	0%	35%	0%	35%	0%	35%	0%	35%	0%	35%	0%	35%	0%	35%	0%	35%
Case 1 (productivity)																
CM	1.12	1.11	0.54	0.54	3.38	3.33	0.37	0.35	0.76	0.74	0.05	0.06 *	0.91	0.70 **	0.95	1.09
PA	1.10	1.09	0.55	0.55	3.14	3.17	0.34	0.33	0.77	0.82	0.00	0.00	0.91	0.70 **	0.89	0.69 **
Case 2 (productivity + preference)																
CM	1.21	1.20	0.93	0.92	3.41	3.34	0.80	0.79	0.77	0.78	0.15	0.13 *	1.09	0.84 **	1.11	1.31 *
PA	1.19	1.19	0.89	0.90	3.14	3.17	0.80	0.80	0.84	0.91	0.00	0.00	0.99	0.76 **	0.97	0.75 **

(2) Domestic comovements

	(y_i,c_i)		(y_i,x_i)		(y_i,p_{ivf})		(y_i,nx_{if})		(nx_i,p_{ivf})	
Benchmark (t_{iv}=t_{vi}=20%)										
CM	0.83		0.94		0.90		-0.47		-0.27	
PA	0.86		0.91		0.67		0.00		0.00	
t_{iv}=t_{vi}	0%	35%	0%	35%	0%	35%	0%	35%	0%	35%
Case 1 (productivity)										
CM	0.96	0.97	0.99	0.99	0.67	0.98 **	-0.26	-0.61 **	-0.24	-0.48 *
PA	0.97	0.98	1.00	1.00	0.66	0.67	0.00	0.00	0.00	0.00
Case 2 (productivity + preference)										
CM	0.82	0.83	0.95	0.93	0.61	0.98 **	-0.31	-0.54 *	-0.04	-0.45 **
PA	0.86	0.86	0.91	0.90	0.66	0.67	0.00	0.00	0.00	0.00

(3) International comovements

	y		c	
Benchmark (t_{iv}=t_{vi}=20%)				
CM	0.09		0.11	
PA	0.11		0.18	
t_{iv}=t_{vi}	0%	35%	0%	35%
Case 1 (productivity)				
CM	0.09	0.09	0.53	0.43
PA	0.14	0.12	0.43	0.36
Case 2 (productivity + preference)				
CM	0.10	0.09	0.11	0.11
PA	0.12	0.10	0.21	0.16

*See Table 3. For volatility, the F-test is applied for testing the difference of the 35% cost case from the no-cost case in each financial market. Subscripts ** and * indicate volatility in the case of the 35% cost is statistically different from the volatility in the case of the 0% cost at the 5% and 10% level, respectively. For correlation, the Fischer's z-test statistic is used for testing the difference of the 35% cost case from the no-cost case in each financial market. Subscripts ** and * indicate the correlation coefficient in the case of the 35% cost is statistically different from the correlation coefficient in the case of 0% cost at the 5% and 10% level, respectively.

Table 5. Sensitivity Analyses[*]

(1)

	y_i		c_i		x_i		n_i		p_{ivf}		nx_i		ex_i		im_i	
	CM	PA	CM	PA	CM	PA	CM	PA	CM	PA	CM	PA	CM	PA	CM	PA
Benchmark	1.20	1.19	0.92	0.89	3.36	3.16	0.79	0.80	0.74	0.88	0.14	0.00	0.94	0.85	1.24	0.84
(a) Varying productivity persistence without spillovers																
=0.80	1.19	1.09	0.86	0.43 **	3.72	3.52	0.83	0.42 **	0.69	0.78	0.14	0.00	0.91	0.79	1.27	0.77
=0.95	1.19	1.07	0.94	0.60 **	3.07	2.88	0.78	0.28 **	0.77	0.78	0.14	0.00	0.98	0.77	1.20	0.76
=0.99	1.08	0.93 **	1.00	0.74 *	2.11 **	1.86 **	0.73	0.09 **	0.78	0.69 **	0.15	0.00	1.03	0.67 **	1.06	0.66 **
(b) Varying spillover term of productivity shocks																
=-0.04	1.20	1.18	0.90	0.88	3.37	3.21	0.80	0.81	0.77	0.85	0.14	0.00	1.01	0.85	1.22	0.85
=0.00	1.20	1.19	0.91	0.88	3.39	3.21	0.80	0.80	0.74	0.87	0.14	0.00	0.96	0.85	1.24	0.85
=0.04	1.17	1.16	0.94	0.91	3.20	2.99	0.78	0.79	0.72	0.88	0.14	0.00	0.91	0.83	1.21	0.82
(c) Varying productivity shock's correlation																
=-0.50	1.32	1.30	0.92	0.90	3.77	3.45	0.82	0.82	0.94 **	1.10 **	0.14	0.00	0.92	0.83	1.14	0.66 **
=0.00	1.20	1.19	0.92	0.89	3.36	3.13	0.80	0.81	0.77	0.94	0.14	0.00	0.92	0.83	1.21	0.82
=0.50	1.31	1.30	0.97	0.95	3.67	3.50	0.81	0.82	0.70	0.74 *	0.14	0.00	1.03	0.96	1.38	0.82
(d) Varying preference persistence																
=0.80	1.18	1.17	0.91	0.90	3.32	3.14	0.74	0.73	0.73	0.86	0.12	0.00	0.88	0.83	1.19	0.82
=0.99	1.22	1.22	0.87	0.80	3.43	3.20	0.88	0.93	0.74	0.92	0.18 **	0.00	1.05	0.87	1.32	0.86

(2)

	(y_i,c_i)		(y_i,x_i)		(y_i,p_{ivf})		(y_i,nx_{if})		(nx_i,p_{ivf})		(3)	y		c	
	CM	PA	CM	PA	CM	PA	CM	PA	CM	PA		CM	PA	CM	PA
Benchmark	0.83	0.86	0.94	0.91	0.90	0.67	-0.47	0.00	-0.27	0.00		0.09	0.11	0.11	0.18
(a) Varying productivity persistence without spillovers															
=0.80	0.77	0.97	0.94	0.99	0.91	0.65	-0.57 *	0.00	-0.43 **	0.00		0.13 **	0.16 **	0.02 **	0.30 **
=0.95	0.84	0.99	0.94	0.99	0.88	0.66	-0.32 **	0.00	-0.04 **	0.00		0.08	0.14 **	0.11	0.29 **
=0.99	0.89	1.00	0.94	1.00	0.87	0.66	-0.07 **	0.00	0.28	0.00		0.02 **	0.12	0.21 **	0.28 **
(b) Varying spillover term of productivity shocks															
=-0.04	0.81	0.86	0.94	0.90	0.88	0.64	-0.31 **	0.00	-0.03 **	0.00		0.13 **	0.18 **	0.03 **	0.06 **
=0.00	0.82	0.86	0.94	0.90	0.89	0.65	-0.42	0.00	-0.20 **	0.00		0.11 **	0.14 **	0.08 **	0.14 **
=0.04	0.84	0.87	0.94	0.90	0.90	0.67	-0.50	0.00	-0.30	0.00		0.07 **	0.08 **	0.14 **	0.22 **
(c) Varying productivity shock's correlation															
=-0.50	0.81	0.85	0.95	0.92	0.95	0.86 **	-0.38 **	0.00	-0.21 **	0.00		-0.39 **	-0.37 **	-0.08 **	-0.03 **
=0.00	0.82	0.86	0.94	0.90	0.90	0.70	-0.46	0.00	-0.24	0.00		-0.01 **	0.01 **	0.07 **	0.14 **
=0.50	0.85	0.88	0.95	0.92	0.93	0.68	-0.51	0.00	-0.36 **	0.00		0.36 **	0.37 **	0.20 **	0.28 **
(d) Varying preference persistence															
=0.80	0.82	0.84	0.93	0.89	0.90	0.67	-0.49	0.00	-0.30	0.00		0.09	0.11	0.13 *	0.17
=0.99	0.86	0.92	0.97	0.96	0.88	0.67	-0.44	0.00	-0.19 **	0.00		0.10	0.10	0.06 **	0.24 **

(1)

	y_i		c_i		x_i		n_i		p_{ivf}		nx_i		ex_i		im_i	
	CM	PA	CM	PA	CM	PA	CM	PA	CM	PA	CM	PA	CM	PA	CM	PA
Benchmark	1.21	1.21	0.93	0.89	3.47	3.28	0.79	0.81	0.72	0.89	0.14	0.00	0.94	0.86	1.27	0.85
(e) Varying risk aversion parameter																
=1	1.21	1.21	0.93	0.89	3.47	3.28	0.79	0.81	0.72	0.89	0.14	0.00	0.94	0.86	1.27	0.85
=10	1.20	1.18	0.90	0.89	3.26	3.06	0.81	0.79	0.78	0.88	0.13	0.00	0.96	0.84	1.19	0.83
(f) Varying elasticity of marginal adjustment cost parameter																
=5	1.12	1.11	0.98	0.96	2.36 **	2.41 **	0.73	0.75	0.79	0.82	0.14	0.00	1.04	0.79	1.09	0.78
=50	1.26	1.24	0.89	0.86	4.02 *	3.56	0.84	0.83	0.71	0.91	0.17 **	0.00	0.95	0.88	1.37	0.87
(g) Varying elasticity of substitution parameter																
=0.5	1.13	0.92 **	0.92	0.81	3.16	5.09 **	0.75	0.78	1.32 **	9.11 **	0.34 **	0.00	0.99	5.01 **	1.94 **	4.97 **
=0.9	1.17	1.16	0.93	0.85	3.30	2.86	0.77	0.76	1.00 **	1.82 **	0.19 **	0.00	0.94	1.18 **	1.54 **	1.15 **
=2.0	1.22	1.20	0.92	0.91	3.38	3.24	0.81	0.81	0.60 **	0.63 **	0.14	0.00	0.96	0.75	1.12	0.75
(h) Varying import share																
=0.45	1.27	1.28	0.81	0.67 **	2.68 **	2.26 **	0.87	0.89	0.71	1.27 **	0.46 **	0.00	1.02	2.50 **	1.39	0.96

(2)

	(y_i,c_i)		(y_i,x_i)		(y_i,p_{ivf})		(y_i,nx_{if})		(nx_i,p_{ivf})		(3)	y		c	
	CM	PA	CM	PA	CM	PA	CM	PA	CM	PA		CM	PA	CM	PA
Benchmark	0.82	0.85	0.94	0.91	0.90	0.67	-0.50	0.00	-0.32 *	0.00		0.11 *	0.11	0.07 **	0.18
(e) Varying risk aversion parameter															
=1	0.82	0.85	0.94	0.91	0.90	0.67	-0.50	0.00	-0.32 *	0.00		0.11 *	0.11	0.07 **	0.18
=10	0.84	0.87	0.94	0.91	0.89	0.67	-0.35 **	0.00	-0.09 **	0.00		0.06 **	0.10	0.17 **	0.18
(f) Varying elasticity of marginal adjustment cost parameter															
=5	0.88	0.92	0.93	0.89	0.87	0.67	-0.06 **	0.00	0.29	0.00		0.09	0.10	0.14 **	0.19
=50	0.79	0.82	0.94	0.91	0.91	0.67	-0.63 **	0.00	-0.52 **	0.00		0.08	0.11	0.10	0.17
(g) Varying elasticity of substitution parameter															
=0.5	0.85	0.57 **	0.93	0.13 **	0.77	0.32 **	-0.85 **	0.00	-0.90 **	0.00		0.23 **	0.82 **	0.08 **	0.35 **
=0.9	0.84	0.84	0.94	0.87	0.84	0.65	-0.79 **	0.00	-0.73 **	0.00		0.14 **	0.16 **	0.09 *	0.30 **
=2.0	0.82	0.87	0.94	0.91	0.93	0.67	-0.17 **	0.00	0.05 **	0.00		0.06 **	0.10	0.12	0.15 *
(h) Varying import share															
=0.45	0.75	0.60 **	0.92	0.67 **	0.90	0.92 **	-0.86 **	0.00	-0.65 **	0.00		0.14 **	0.17 **	0.05 **	-0.09 **

See Tables 3 and 4. (1), (2), and (3) refer to volatility, domestic comovements, and international comovements, respectively. The statistical difference of each case from the benchmark case is reported. Subscripts ** and * indicate in each case is statistically different from the benchmark case at the 5% and 10% level, respectively. Parameters are as in Table 2, except the following: (a) $diag(\rho_z)$ without productivity spillovers; (b) productivity shocks' spillovers; (c) $\rho(\varepsilon_z)$; (d) $diag(\rho_A)$; (e) γ; (f) η; (g) $1/\alpha$; (h) ms.

Figure 1. Impulse Responses for 1% Preference Shocks in Country 1[*]

n_1

n_2

ex_1

im_1

p_{1f}

nx_1
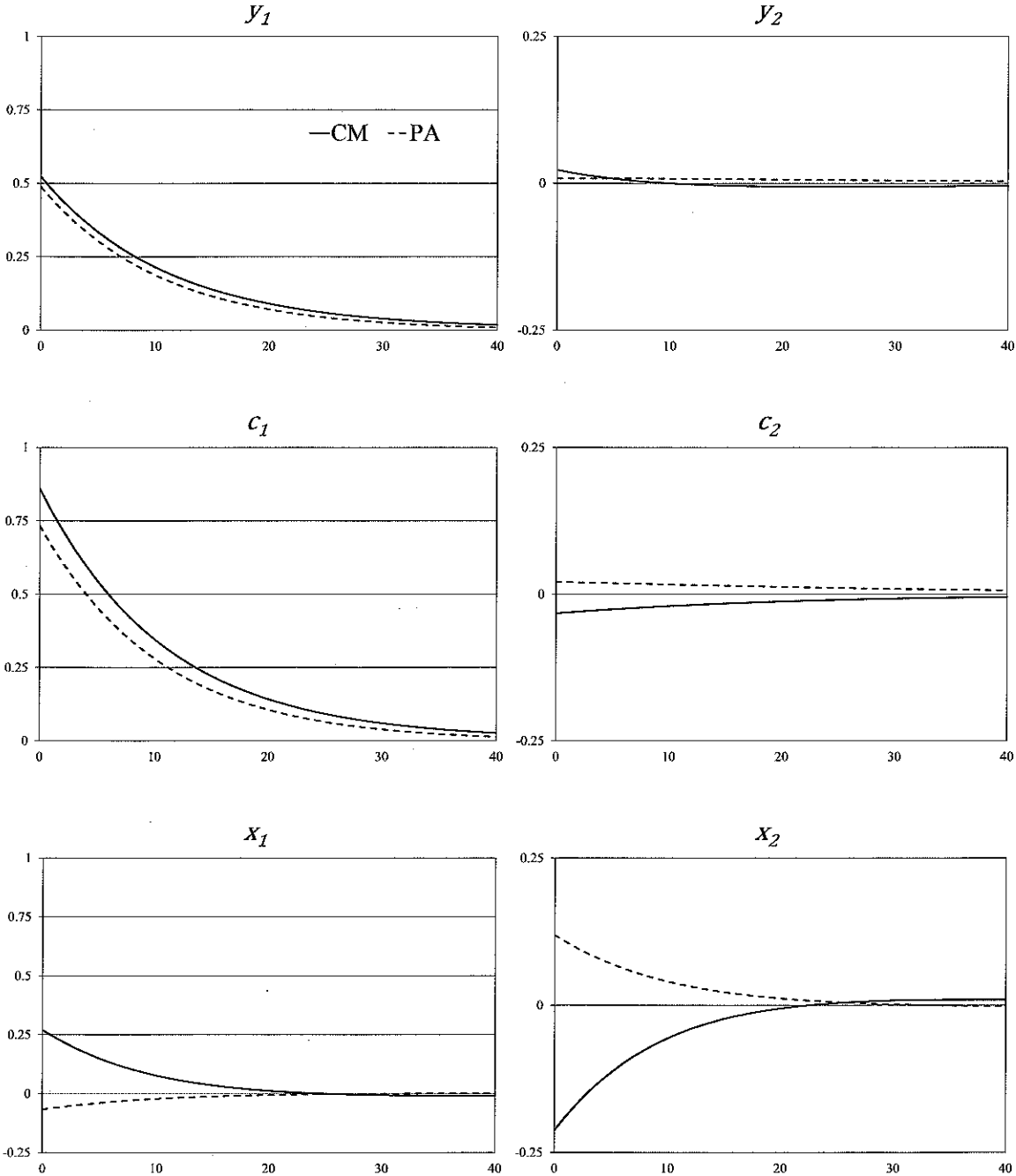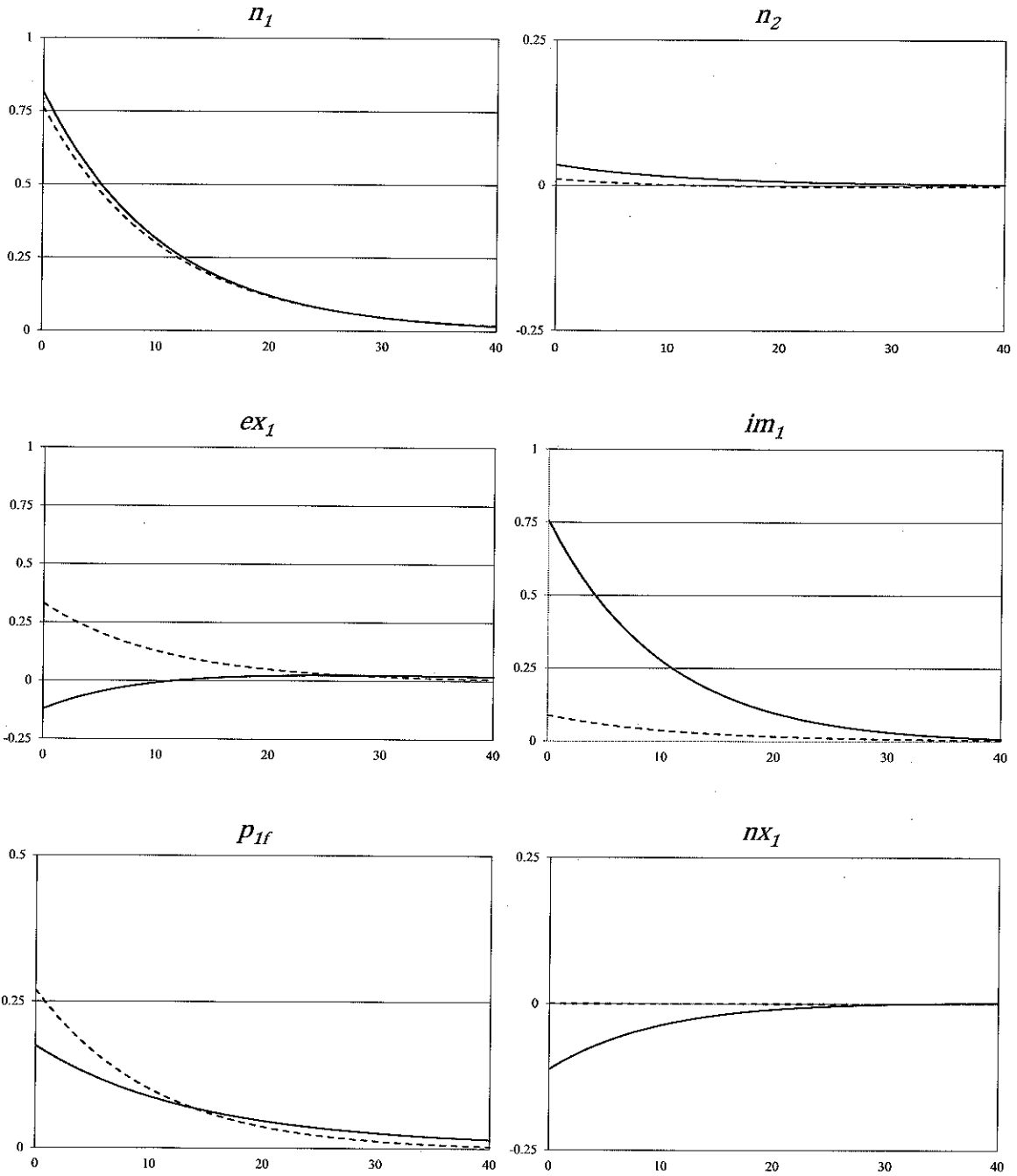
* X- and Y-axes denote time and % deviation from the steady states, respectively. The solid and dotted lines display the impulse responses under CM and PA, respectively.

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