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and Risk Sharing: A Joint Test**

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# Trade Costs, Asset Market Frictions and Risk Sharing: A Joint Test\*

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## Abstract

This paper addresses the question of whether both goods and asset market frictions are necessary to explain the failure of consumption risk sharing across countries. I develop a test that uses bilateral import data to identify separately the role of trade costs and asset market frictions. I implement this test for a sample of 80 developed and developing countries, 1970-2000, and find that both frictions are necessary to explain the failure of perfect consumption risk sharing. At the same time, financial autarky is also rejected. Asset market frictions are relatively less important for developed than developing countries, and relatively less important in the second half of the sample period compared to the first half. Trade costs are found to be economically important, though declining in magnitude over time. The method I develop also provides estimates of the marginal utility of wealth, which is found to be more volatile in developing than developed countries.

Keywords: Risk sharing, trade costs, asset market frictions

## 1 Introduction

In a world where there are no frictions in goods markets, and a full set of contingent claims can be traded, consumption growth rates will be perfectly correlated across countries. This

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prediction is strongly rejected by the data [see Backus, Kehoe and Kydland (1992) and Lewis (1996) among others]. Considerable progress has been made to date in understanding how both goods and asset market frictions may help explain the failure of perfect consumption risk sharing. However the question of how to disentangle the two types of friction empirically has not yet been solved. This paper contributes to the literature by developing a way to identify separately the role of goods and asset market frictions in impeding risk sharing. Methodologically, this test bears some similarity to the tests of consumption insurance proposed by Cochrane (1991), Mace (1991), Townsend (1994) and Lewis (1996). However it applies to the case where in addition to the possibility of asset market frictions, agents (countries) specialize in the production of different goods which may be costly to exchange.

The test is derived from a multi-country DSGE model with Armington specialization, iceberg costs of shipping goods across countries and a very general asset market structure. In focusing on the role of trade costs in explaining failures of risk sharing, I follow Backus, Kehoe and Kydland (1992, 1995), Heathcote and Perri (2004a, b), Kose and Yi (2005), Mazzenga and Ravn (2004), and Obstfeld and Rogoff (2000) among others. But in contrast to much of the international macro literature, the modelling approach closely follows the structural gravity literature [most recently, Eaton and Kortum (2002) and Anderson and van Wincoop (2003, 2004)]. This gives the model a chance to match facts about intra-temporal trade as well as intertemporal trade, while simultaneously allowing for risk sharing through the terms of trade as described in Cole and Obstfeld (1991). The treatment of specialization and trade costs and the multi-country nature of the model are crucial in allowing for separate identification of the two frictions.

The asset market structure I assume is very general. It nests many of the cases considered in the literature on risk sharing: complete financial markets; financial autarky; an exogenously restricted set of assets; limited enforceability of intertemporal contracts. Because of the very general assumptions I make, I focus on the predictions of the model for equilibrium consumption allocations rather than the asset holdings necessary to support these allocations.

The frictionless version of the model makes the standard prediction of constant relative consumption. However trade costs and asset market frictions both lead to deviations from constant relative consumption across countries. Asset market frictions reduce countries' ability to insure themselves against future shocks in the standard manner. Trade costs

reduce the demand for consumption insurance by making it costly. In contrast to the case where there are only asset market frictions, it is not possible to identify separately the role of the two types of friction using data on aggregate consumption alone.<sup>1</sup> But if countries are sharing risk, it must show up in bilateral imports. The test for the two frictions is based on this insight.

More precisely, we know from the structural gravity literature that under the joint assumptions of specialization and homothetic preferences, the value of bilateral imports is inversely proportional to bilateral trade costs, and proportional to importer country expenditure, exporter country GDP, and time-varying “multilateral resistance” terms for importer and exporter. Anderson and van Wincoop (2003) show that these resistance terms capture countries’ aggregate resistance to trade at a particular point in time. The innovation of this paper is to show that they also have an interpretation in terms of the first order condition for aggregate consumption. In particular, the importer-year term is a function of the importer’s marginal utility of consumption and the inverse of its marginal utility of wealth. The exporter-year term is a complicated function of these variables for all countries. Since relative wealth differs according to the structure of asset markets, different asset markets place different restrictions on the evolution of the importer-year terms over time. This allows various hypotheses about the configuration of goods and asset market frictions to be tested in a gravity regression framework. Furthermore, the empirical approach yields as a by-product estimates of the evolution of bilateral trade costs and the marginal utility of wealth for each country.

I implement the test using bilateral import data for a sample of developed and developing countries from 1970-2000. I find that both trade costs and asset market imperfections are necessary in order to explain the failure of perfect consumption risk sharing. However the null of financial autarky is rejected. Applying the hypothesis tests to various subsamples of the data, asset market frictions appear to be relatively less important for developed than developing countries, and relatively less important in the second half of the sample period compared to the first half. In addition, I find that trade costs fall rapidly in the first half of the sample period, and are flat thereafter, though they remain large and economically important. Finally, my estimates of the marginal utility of wealth are more volatile for developing than for developed countries, consistent with developing countries being less able

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<sup>1</sup>This issue is discussed in a recent paper by Guibaud (2006).

to share risk than developed countries.

The first section of the paper describes the theoretical framework. The second section describes the empirical test for the role of frictions. The third section describes the data and results. The final section concludes.

## 2 Theoretical framework

I first lay out a general model with trade costs and asset market frictions, and develop its implications for international risk sharing through bilateral trade. I then focus on three special cases: complete markets and trade costs; financial autarky and trade costs; no trade costs. Throughout, the emphasis is on equilibrium allocations and the bilateral trade flows required to support those allocations. The predictions on bilateral trade flows form the basis for the empirical test.

### 2.1 Baseline model

#### Summary

There are  $N$  countries in the world, indexed  $i = 1, \dots, N$ . Each country produces a distinct intermediate good (also indexed  $i$ ) using capital and labor. Capital is accumulable, while labor is fixed in supply. Productivity in the intermediate goods sector differs across countries, and is stochastic. The intermediate goods are tradeable (at some cost). They are combined using a CES aggregator to produce a non-tradeable good used for consumption and investment. Asset markets are complete within countries, but need not be complete across countries. For simplicity of exposition, it is assumed that there is a common currency.

#### Uncertainty

The structure of uncertainty is as follows. In each period  $t$ , the economy experiences one event,  $s_t \in S$ . Denote by  $s^t$  the history of events from date 0 to date  $t$ . The probability of history  $s^t$  at date  $t$  is given by  $\pi(s^t)$ .

#### Utility and production

Across periods, utility is isoelatic. For simplicity, the problem is described as if country

$i$  had a single agent with expected utility given by:

$$U_i = \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t) L_{it} \frac{[C_i(s^t)/L_{it}]^{1-\rho}}{1-\rho} \quad (1)$$

where  $C_i(s^t)$  is aggregate consumption in country  $i$  at  $s^t$  and  $L_{it}$  is the population of country  $i$  at time  $t$  (assumed deterministic and equal to the labor force).<sup>2</sup>

Country  $i$  produces intermediate good  $i$  by combining capital and labor using a constant returns to scale production function with stochastic productivity:

$$Y_i(s^t) = F(A_i(s^t), K_i(s^{t-1}), L_{it}) \quad (2)$$

where  $A_i(s^t)$  is the realization of productivity, and  $K_i(s^{t-1})$  is the capital available for use in production in country  $i$  at time  $t$  (predetermined).

The production function for the aggregate non-traded good,  $X$ , used for consumption and investment is:

$$X_i(s^t) = \left( \sum_{k=1}^N Z_i(k, s^t)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \quad (3)$$

where  $Z_i(k, s^t)$  is absorption in country  $i$  of intermediate good  $k$  at  $s^t$ .<sup>3</sup> The aggregate good resource constraint is:

$$X_i(s^t) = C_i(s^t) + I_i(s^t) = C_i(s^t) + K_i(s^t) - K_i(s^{t-1}) \quad (4)$$

where  $I_i(s^t)$  is investment in country  $i$  at time  $t$  after history  $s^t$ . Investment need not be positive (capital can be eaten).

### Resource costs of trade

Intermediate goods trade may be costly: in order for one unit of  $j$ 's good to arrive in  $i$ ,  $\tau_{ij}(s^t)$  units must be shipped, with  $\tau_{ii}(s^t) = 1$ ,  $\tau_{ij}(s^t) \geq 1$  and  $\tau_{ij}(s^t) \tau_{jk}(s^t) \geq \tau_{ik}(s^t)$ . It is not required that  $\tau_{ij}(s^t) = \tau_{ji}(s^t)$ . The intermediate goods resource constraints must

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<sup>2</sup>The Appendix describes the case of endogenous labor supply with non-separable utility over consumption and leisure.

<sup>3</sup>The Appendix describes the case of non-traded as well as traded intermediate inputs into production of the final good.

take account of the resource cost of trade:<sup>4</sup>

$$Y_i(s^t) = \sum_{k=1}^N \tau_{ki}(s^t) Z_k(i, s^t) \quad (5)$$

### Goods markets

Producers of intermediate goods are assumed to be price takers. But due to trade costs, intermediate goods prices differ across countries:

$$Q_k(i, s^t) = \tau_{ki}(s^t) Q_i(i, s^t) \quad (6)$$

where  $Q_i(i, s^t)$  is the spot price of intermediate  $i$  in country  $i$  at  $s^t$  and  $Q_k(i, s^t)$  is its spot price in country  $k$ . In what follows,  $Q_i(i, s^t)$  will be abbreviated to  $Q(i, s^t)$ .

### Asset markets

At  $s^t$ , country  $i$  enters with a vector of asset holdings  $\mathbf{B}_i(s^{t-1})$  that pays dividends with value given by  $\mathbf{D}(s^t) \cdot \mathbf{B}_i(s^{t-1})$ . The vector of asset prices, taken as given by each country, is  $\mathbf{R}(s^t)$ . The value of asset holdings is given by  $\mathbf{R}(s^t) \cdot \mathbf{B}_i(s^{t-1})$ . The country can choose to re-optimize its holdings by purchasing a new vector  $\mathbf{R}(s^t) \cdot \mathbf{B}_i(s^t)$ , with  $\mathbf{B}_i(s^t) \in \mathcal{B}_i(s^t, \mathbf{K}(s^{t-1}))$ . Assets are distinguished by their dividend vectors, while the asset market structure determines  $\mathcal{B}_i(s^t, \mathbf{K}(s^{t-1}))$ , the set of assets available to country  $i$  at  $s^t$ . Assets are defined such that they are in zero net supply:

$$\sum_{i=1}^N \mathbf{B}_i(s^t) = 0 \quad (7)$$

This setup is general enough to encompass frictionless asset markets, financial autarky, and a variety of different types of market incompleteness that allow for partial risk sharing through asset markets. In this, there are many similarities with the approach of Choi (2005), who looks at the effect of non-traded goods and general asset market frictions on the relationship between real exchange rates and relative consumption.

### Competitive equilibrium

At each point in time, country  $i$  chooses  $C_i(s^t)$ ,  $\mathbf{Z}_i(s^t)$ ,  $K_i(s^t)$  and  $\mathbf{B}_i(s^t)$  to maximize

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<sup>4</sup>The Appendix describes the implications of including tariffs.

expected utility (1) subject to the consolidated aggregate good resource constraint:

$$\left( \sum_{k=1}^N Z_i(k, s^t)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} = C_i(s^t) + K_i(s^t) - K_i(s^{t-1}) \quad (8)$$

and the (nominal) budget constraint:

$$\begin{aligned} & \sum_{k=1}^N \tau_{ik}(s^t) Q(k, s^t) Z_i(k, s^t) - Q(i, s^t) Y_i(s^t) \\ &= [\mathbf{D}(s^t) + \mathbf{R}(s^t)] \cdot \mathbf{B}_i(s^{t-1}) - \mathbf{R}(s^t) \cdot \mathbf{B}_i(s^t) \end{aligned} \quad (9)$$

where  $\mathbf{R}(s^t)$ ,  $\mathbf{D}(s^t)$  and  $\mathbf{Q}(s^t)$ , are taken as given, and  $\mathbf{B}_i(s^t) \in \mathcal{B}_i(s^t, \mathbf{K}(s^{t-1}))$ .

**Definition:** A *competitive equilibrium* is a vector of prices ( $\mathbf{Q}^*$ ,  $\mathbf{R}^*$ ) and a vector of quantities for each country ( $\mathbf{C}_i^*$ ,  $\mathbf{Z}_i^*$ ,  $\mathbf{K}_i^*$ ,  $\mathbf{B}_i^*$ ) such that each country solves the above problem at every realized state  $s^t$  and (8), (5) and (7) hold for all realized  $s^t$  (i.e. all markets clear).

### First order conditions

Assume the existence of a competitive equilibrium. Then for any  $s^t$  and for given  $\mathbf{K}^*$  and  $\mathbf{B}^*$ , the following first order conditions are necessary and sufficient (the problem of country  $i$  at  $s^t$  is convex). Let the multipliers on the budget constraints (9) be given by:

$$\zeta_i(s^t) = \beta^t \pi(s^t) H_i(s^t) \quad (10)$$

where  $H_i(s^t)$  is the marginal utility of current nominal wealth for country  $i$  evaluated at  $s^t$ . Let the multipliers on the aggregate good resource constraints (8) be given by:

$$\nu_i(s^t) = \beta^t \pi(s^t) G_i(s^t) \quad (11)$$

where  $G_i(s^t)$  is the price in terms of utility of an extra unit of of the aggregate good in  $i$  at  $s^t$ . We can convert this to the same units as nominal wealth by dividing by the marginal utility of nominal wealth to get  $P_i(s^t)$ :

$$P_i(s^t) = G_i(s^t) / H_i(s^t) \quad (12)$$



For convenience, write:

$$M_i(s^t) = 1/H_i(s^t) \quad (13)$$

Without loss of generality, the unit of account in each period is chosen such that  $\sum_{i=1}^N M_i(s^t) =$

1. The first order condition with respect to  $C_i(s^t)$  can then be written:<sup>5</sup>

$$M_i(s^t) (C_i(s^t) / L_{it})^{-\rho} = P_i(s^t) \quad (14)$$

while the first order condition with respect to  $Z_i(k, s^t)$  is:

$$P_i(s^t) X_i(s^t)^{\frac{1}{\eta}} Z_i(k, s^t)^{-\frac{1}{\eta}} = \tau_{ik}(s^t) Q(k, s^t) \quad (15)$$

Note that different asset market structures imply different sets of  $M_i(s^t)$ . That is, they imply different distributions of nominal wealth across countries and hence different distributions of the marginal utility of nominal wealth. It is not in general possible to solve out explicitly for the  $M_i(s^t)$  as functions of the other variables, though in some cases, their behavior can be partially characterized.<sup>6</sup>

### Relative consumption

For the purpose of comparison with standard tests of consumption insurance, it is useful to consider the implications of the model for relative consumption. Using (3), the production function for the aggregate good  $X$  and (15), the first order conditions with respect to absorption of individual intermediate goods, the date- $t$  state- $s^t$  aggregate price level in country  $i$  can be written:

$$P_i(s^t) = \left[ \sum_{k=1}^N (\tau_{ik}(s^t) Q(k, s^t))^{1-\eta} \right]^{\frac{1}{1-\eta}} \quad (16)$$

Purchasing power parity fails ( $P_i(s^t) \neq P_j(s^t)$ ) due to the existence of trade costs.

The first order condition for consumption implies a relationship between the real exchange

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<sup>5</sup>The Appendix describes how the  $M_i(s^t)$  can be mapped into state-contingent Pareto weights for a series of intratemporal planning problems.

<sup>6</sup>See the subsection on complete financial markets. The Appendix also presents an interpretation of the  $M_i(s^t)$  in the case of limited enforcement.

rate and relative consumption given by:

$$RER_{ij}(s^t) = \frac{P_j(s^t)}{P_i(s^t)} = \frac{M_j(s^t)}{M_i(s^t)} \left[ \frac{C_i(s^t)/L_{it}}{C_j(s^t)/L_{jt}} \right]^\rho \quad (17)$$

where  $M_i(s^t)$  is as defined above. In general, the ratio  $M_j(s^t)/M_i(s^t)$  depends on the consumption allocation, so the relationship between the real exchange rate and relative per capita consumption need not be monotonic. Inverting this relationship, relative per capita consumption can be written:

$$\frac{C_i(s^t)/L_{it}}{C_j(s^t)/L_{jt}} = \left[ \frac{M_i(s^t)}{M_j(s^t)} \right]^{1/\rho} \left[ \frac{\sum_{k=1}^N \frac{(\tau_{ik}(s^t))^{1-\eta}}{\phi_k(s^t)} Y_k(s^t)^{\frac{\eta-1}{\eta}}}{\sum_{k=1}^N \frac{(\tau_{jk}(s^t))^{1-\eta}}{\phi_k(s^t)} Y_k(s^t)^{\frac{\eta-1}{\eta}}} \right]^{\frac{1}{(\eta-1)\rho}} \quad (18)$$

with

$$\phi_k(s^t) = \left[ \sum_{h=1}^N M_h(s^t)^\eta (C_h(s^t)/L_{ht})^{-\rho\eta} X_h(s^t) \tau_{hk}(s^t)^{1-\eta} \right]^{\frac{\eta-1}{\eta}} \quad (19)$$

Clearly, relative consumption can vary for two reasons. First, in the presence of asset market frictions  $M_i(s^t)/M_j(s^t)$  need not be constant. Second, in order for consumption risk sharing to take place, goods must be shipped internationally, and since it is costly to do so, agents will optimally choose not to smooth consumption perfectly. This effect is captured by the second term in (18). The numerator can be seen as world output from the perspective of country  $i$ , the denominator as world output from the perspective of country  $j$ . This second term differs from 1 in general, because in a world with trade costs, “world” consumption and “world” output are different depending on where they are measured. Standard tests of consumption insurance (which test for variation in consumption growth rates across countries) cannot distinguish between these two possible sources of failure in consumption risk sharing.

### **Bilateral imports**

Since goods must be shipped for the value of a country’s expenditure to exceed the value of its output, any cross-country risk sharing that takes place must be reflected in bilateral trade flows. The first order conditions for intermediate goods absorption, (15) can be combined with the resource constraints (5) and (8) to yield the following familiar expression for the

value of country  $i$ 's imports from  $k$  in period  $t$  following history  $s^t$ :

$$\tau_{ik}(s^t) Q(k, s^t) Z_i(k, s^t) = [P_i(s^t) X_i(s^t)] [Q(k, s^t) Y_k(s^t)] \left( \frac{P_i(s^t) \Pi_k(s^t)}{\tau_{ik}(s^t)} \right)^{\eta-1} \quad (20)$$

with

$$\Pi_k(s^t)^{1-\eta} = \sum_{j=1}^N \left( \frac{\tau_{jk}(s^t)}{P_j(s^t)} \right)^{1-\eta} P_j(s^t) X_j(s^t) \quad (21)$$

This is the standard gravity relationship in the presence of trade costs. The value of bilateral imports is inversely proportional to bilateral trade costs, and proportional to the expenditure of the importer, the GDP of the exporter, and to time-varying importer and exporter “multilateral resistance” terms [see Anderson and van Wincoop (2003), 2004].

Now, it is possible to make use of the first order condition with respect to consumption, (14), to place some restrictions on the importer-year and exporter-year terms. The value of country  $i$ 's imports from  $k$  in period  $t$  following history  $s^t$  can be written:

$$\begin{aligned} & \tau_{ik}(s^t) Q(k, s^t) Z_i(k, s^t) \\ = & \frac{[P_i(s^t) X_i(s^t)] [Q(k, s^t) Y_k(s^t)]}{\tau_{ik}(s^t)^{\eta-1}} \frac{M_i(s^t)^{\eta-1} (C_i(s^t)/L_{it})^{\rho(1-\eta)}}{\sum_{j=1}^N M_j(s^t)^\eta (C_j(s^t)/L_{jt})^{-\rho\eta} X_j(s^t) \tau_{jk}(s^t)^{1-\eta}} \end{aligned} \quad (22)$$

This expression makes it possible to use panel data on bilateral imports to test separately for the role of asset market frictions and trade costs in impeding risk sharing. The next subsections develop this approach by deriving the appropriate restrictions on (22) in the case of frictionless financial markets and financial autarky, as well as zero trade costs.

## 2.2 Frictionless financial markets

When financial markets are complete, the competitive equilibrium described in the previous sub-section is Pareto optimal. Following the Negishi-Mantel algorithm, the competitive equilibrium allocation can be recovered as the solution to a planning problem, where the planner chooses vectors  $\mathbf{C}$ ,  $\mathbf{Z}$  and  $\mathbf{K}$  to maximize the ex-ante weighted sum of expected utilities:

$$\sum_{i=1}^N \lambda_i U_i = \sum_{i=1}^N \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t) \lambda_i L_{it} u(C_i(s^t)/L_{it}) \quad (23)$$

subject to (for all  $i$  and  $s^t$ ) the resource constraints (5) and (8), and  $\sum_{i=1}^N \lambda_i = 1$ . The first order conditions with respect to aggregate consumption and absorption of intermediates take the form:

$$\lambda_i (C_i(s^t) / L_{it})^{-\rho} = P_i(s^t) \quad (24)$$

and

$$P_i(s^t) X_i(s^t)^{1/\eta} Z_i(k, s^t)^{-1/\eta} = \tau_{ik}(s^t) Q(k, s^t) \quad (25)$$

where  $P_i(s^t)$  is the appropriately normalized multiplier on the aggregate good constraint for country  $i$  at state  $s^t$  and  $Q(k, s^t)$  is the appropriately normalized multiplier on the intermediate good constraint for good  $k$  at state  $s^t$ . The  $\lambda_i$  can be interpreted as Pareto weights, or as the constant *relative* marginal utility of nominal wealth (i.e. relative to agents in other countries). I now outline the implications for relative consumption and bilateral trade of the complete markets assumption.

### Relative consumption

Purchasing power parity fails because of trade costs, exactly as in (16). As a result, marginal utilities are not equalized across countries. But under complete markets, there is a monotonic relationship between the real exchange rate and relative consumption, given by:

$$RER_{ij}(s^t) = \frac{P_j(s^t)}{P_i(s^t)} = \frac{\lambda_j}{\lambda_i} \left[ \frac{C_i(s^t) / L_{it}}{C_j(s^t) / L_{jt}} \right]^\rho \quad (26)$$

Since price levels differ across countries in a way that varies over time, relative consumption also varies over time. Relative consumption can be written:

$$\frac{C_i(s^t) / L_{it}}{C_j(s^t) / L_{jt}} = \left[ \frac{\lambda_i}{\lambda_j} \right]^{1/\rho} \left[ \frac{\sum_{k=1}^N \frac{\tau_{ik}(s^t)^{1-\eta}}{\phi_k(s^t)} Y_k(s^t)^{\frac{\eta-1}{\eta}}}{\sum_{k=1}^N \frac{\tau_{jk}(s^t)^{1-\eta}}{\phi_k(s^t)} Y_k(s^t)^{\frac{\eta-1}{\eta}}} \right]^{\frac{1}{(\eta-1)\rho}} \quad (27)$$

with

$$\phi_k(s^t) = \left[ \sum_{h=1}^N \lambda_h^\eta (C_h(s^t) / L_{ht})^{-\rho\eta} X_h(s^t) \tau_{hk}(s^t)^{1-\eta} \right]^{\frac{\eta-1}{\eta}} \quad (28)$$

Because of the resource costs of trade, agents optimally choose not to smooth their consumption perfectly.

### Bilateral imports

The risk sharing that takes place across countries must be reflected in trade flows. The value of country  $i$ 's imports from  $k$  at  $s^t$  is given by the expression:

$$\begin{aligned} & \tau_{ik}(s^t) Q(k, s^t) Z_i(k, s^t) \\ = & \frac{[P_i(s^t) X_i(s^t)] [Q(k, s^t) Y_k(s^t)]}{\tau_{ik}(s^t)^{\eta-1}} \frac{\lambda_i^{\eta-1} (C_i(s^t) / L_{it})^{\rho(1-\eta)}}{\sum_{j=1}^N \lambda_j^\eta (C_j(s^t) / L_{jt})^{-\rho\eta} X_j(s^t) \tau_{jk}(s^t)^{1-\eta}} \end{aligned} \quad (29)$$

Expression (29) differs from (22) in that  $\lambda_i$  is independent of the state  $s^t$ . This restriction is the basis for the empirical test of the null of complete asset markets against the alternative of financial frictions.

### 2.3 Financial autarky

Under financial autarky, the value of expenditure must be equal to the value of output in all periods and states of the world. The budget constraint (9) reduces to:

$$\sum_{k=1}^N \tau_{ik}(s^t) Q(k, s^t) Z_i(k, s^t) - Q(i, s^t) Y_i(s^t) = 0 \quad (30)$$

If in addition, it is assumed that trade costs are symmetric ( $\tau_{ij}(s^t) = \tau_{ji}(s^t)$ ) the expression for bilateral imports can be rewritten in a way that is familiar from the literature on structural gravity equations:<sup>7</sup>

$$\begin{aligned} & \tau_{ik}(s^t) Q(k, s^t) Z_i(k, s^t) \\ = & \frac{[P_i(s^t) X_i(s^t)] [Q(k, s^t) Y_k(s^t)]}{\tau_{ik}(s^t)^{\eta-1}} \left( M_i(s^t) (C_i(s^t) / L_{it})^{-\rho} M_k(s^t) (C_k(s^t) / L_{kt})^{-\rho} \right)^{\eta-1} \end{aligned} \quad (31)$$

This is analogous to equation 13 in Anderson and van Wincoop (2003). The prediction of symmetry is the basis for a test of the null of financial autarky, joint with symmetric trade costs against the alternative of some risk sharing through asset trade.

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<sup>7</sup>The predictions for PPP, real exchange rates and relative consumption are all as in the general case

## 2.4 No trade costs

When trade is costless ( $\tau_{ik}(s^t) = 1 \forall i, k$ ), we obtain results that are familiar from Lucas (1982).

### Relative consumption

In the absence of trade costs, purchasing power parity always holds

$$P_i(s^t) = \left[ \sum_{k=1}^N Q(k, s^t)^{1-\eta} \right]^{\frac{1}{1-\eta}} \quad (32)$$

The relationship between the real exchange rate and relative consumption is:

$$REER_{ij}(s^t) = \frac{P_j(s^t)}{P_i(s^t)} = \frac{M_j(s^t)}{M_i(s^t)} \left[ \frac{C_i(s^t)/L_{it}}{C_j(s^t)/L_{jt}} \right]^\rho \quad (33)$$

Since the real exchange rate between any pair of countries is always equal to 1, this implies that relative consumption is given by:

$$\frac{C_i(s^t)/L_{it}}{C_j(s^t)/L_{jt}} = \left[ \frac{M_i(s^t)}{M_j(s^t)} \right]^{1/\rho} \quad (34)$$

This is the expression from which standard tests of consumption risk sharing are derived. If financial markets are complete,  $M_i(s^t)/M_j(s^t) = \lambda_i/\lambda_j$  and relative consumption is constant.

### Bilateral imports

The value of country  $i$ 's absorption of  $k$ 's output in period  $t$  following history  $s^t$  is given by:

$$\begin{aligned} & Q(k, s^t) Z_i(k, s^t) \\ = & [P_i(s^t) X_i(s^t)] [Q(k, s^t) Y_k(s^t)] \frac{1}{\sum_{j=1}^N P_j(s^t) X_j(s^t)} \end{aligned} \quad (35)$$

Financial frictions (if present) shift the distribution of total expenditure across states and over time, but in the absence of trade costs, the composition of expenditure is always identical across countries.

### 3 A test for the role of frictions

Classic tests of international risk sharing typically focus on predictions with respect to consumption aggregates and overwhelmingly reject the perfect risk sharing hypothesis. But as equation (18) makes clear, in the presence of trade costs, aggregate consumption data alone are not sufficient to identify cleanly *which* frictions are necessary to account for the failure of risk sharing. In contrast, it is possible to do so using data on bilateral imports.

The predictions of the model with respect to the relationship between bilateral imports, output, consumption and trade costs can be conveniently summarized as follows. Let  $IM_{ikt}$  denote the value of country  $i$ 's imports from country  $k$  in period  $t$ . Let  $EXP_{it}$  denote the value of  $i$ 's absorption (i.e.  $P_{it}C_{it} + P_{it}I_{it}$ ) in period  $t$ . Let  $GDP_{kt}$  denote the value of  $k$ 's output in period  $t$ . Then:

$$\frac{IM_{ikt}}{EXP_{it}GDP_{kt}} = \Theta_{it}\Phi_{kt}\tau_{ikt}^{1-\eta} \quad (36)$$

Assumptions about the configuration of frictions imply the following restrictions on  $\Theta_{it}$ ,  $\Phi_{kt}$  and  $\tau_{ikt}^{1-\eta}$ :

| Assumption                                      | $\Theta_{it}$  | $\Phi_{kt}$   | $\tau_{ikt}^{1-\eta}$ |
|---|--|---|-----------------------|
| (1) General asset markets, trade costs          | $M_{it}^{\eta-1} (C_{it}/L_{it})^{-\rho(\eta-1)}$    | $1/\sum_{j=1}^N \Theta_{jt}EXP_{jt}\tau_{kjt}^{1-\eta}$ | $\tau_{ikt}^{1-\eta}$ |
| (2) Financial autarky, trade costs <sup>8</sup> | $M_{it}^{\eta-1} (C_{it}/L_{it})^{-\rho(\eta-1)}$    | $M_{kt}^{\eta-1} (C_{kt}/L_{kt})^{-\rho(\eta-1)}$       | $\tau_{ikt}^{1-\eta}$ |
| (3) Complete markets, trade costs               | $\lambda_i^{\eta-1} (C_{it}/L_{it})^{-\rho(\eta-1)}$ | $1/\sum_{j=1}^N \Theta_{jt}EXP_{jt}\tau_{kjt}^{1-\eta}$ | $\tau_{ikt}^{1-\eta}$ |
| (4) No trade costs                              | 1  | $1/\sum_{j=1}^N EXP_{jt}$                               | 1                     |

The general asset markets, trade cost model nests the other possible configurations of frictions. Given data on bilateral imports, GDP, expenditure and real consumption, and some assumptions about bilateral trade costs, it is possible to estimate the different models, and use likelihood ratio tests to test the restrictions in (2), (3) and (4) against the unrestricted model, (1).

I now describe the estimation procedure I adopt. The standard assumption in the em-

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<sup>8</sup>Symmetric trade costs must also be assumed.

pirical gravity literature about the form of bilateral trade costs is:<sup>9</sup>

$$\tau_{ikt}^{1-\eta} = \prod_{n=1}^J (Z_{ik}^n)^{\gamma_t^n}, \quad Z_{ik}^n = 1 \text{ if } i = k, \quad z_{ik}^n \geq 1 \text{ otherwise} \quad (37)$$

In general, the number of “gravity” variables,  $J \ll (N - 1)^2$ , where  $(N - 1)^2$  is the number of bilateral pairs usually included in the regressions (data on trade with self is not available from the same source as other bilateral trade flows). Commonly used gravity variables include bilateral distance, dummies for common language, colonial heritage and legal origins. Ideally, bilateral barriers due to trade policy should also be controlled for (see the treatment of tariffs in the Appendix). Unfortunately, constructing the required data is a huge undertaking, and beyond the scope of this paper.

Substituting in the expression for trade costs and taking logs yields four linear models corresponding to the four cases summarized above. Let  $w_{ikt} = \ln(IM_{ikt}/EXP_{it}GDP_{kt})$ ,  $c_{it} = \ln C_{it}/L_{it}$  and  $z_{ikt}^n = \ln Z_{ikt}^n$ . Let  $\theta_{it}$  be an importer-year fixed effect,  $\phi_{kt}$  an exporter-year fixed effect,  $\theta_i$  an importer fixed effect and  $\phi_t$  a year fixed effect. Then we have the following four empirical models:<sup>10</sup>

| Assumption                             | Estimating equation  |
|--|--|
| (1) General asset markets, trade costs | $w_{ikt} = \theta_{it} + \phi_{kt} + \sum_{n=1}^J \gamma_t^n z_{ik}^n + \varepsilon_{ikt}$               |
| (2) Financial autarky, trade costs     | $w_{ikt} = \theta_{it} + \theta_{kt} + \sum_{n=1}^J \gamma_t^n z_{ik}^n + \varepsilon_{ikt}$             |
| (3) Complete markets, trade costs      | $w_{ikt} = \theta_i + \phi_{kt} + \beta_c c_{it} + \sum_{n=1}^J \gamma_t^n z_{ik}^n + \varepsilon_{ikt}$ |
| (4) No trade costs                     | $w_{ikt} = \phi_t + \varepsilon_{ikt}$   |

All of the above models take the form of structural gravity equations with particular restrictions. Financial autarky requires that the importer-year fixed effect for a particular country be equal to its exporter-year fixed effect. Complete markets requires that the importer-year fixed effect be equal to a constant plus a function of per capita real consumption. No trade costs requires zero coefficients on gravity variables and importer-year/exporter-year fixed effects the same for all countries.

The data used to estimate these models is described in the next section. For roughly 1/3

<sup>9</sup>See Anderson and van Wincoop (2004).

<sup>10</sup>Because of data availability constraints, the restrictions on the relationships between  $\phi_{kt}$  and the other variables in models (1), (2), and (3) are not imposed (data on the full universe of bilateral pairs would be required).



of the bilateral pairs in the sample, bilateral imports are recorded as zero. In order to avoid dropping these observations,  $w_{ikt}$  is constructed as  $\ln[(1 + IM_{ikt}) / EXP_{it}GDP_{kt}]$ . The three models with trade costs are estimated using two-way fixed effects, as the number of dummy variables would otherwise be very large. Bilateral trade costs are allowed to vary over time by letting the coefficients on the gravity variables vary over time.

Given values for  $\eta$  and  $\rho$ , it is possible to use the estimates of the unrestricted model to recover implied bilateral trade costs, and time-series of the implied inverse marginal utility of wealth. Under the assumptions of zero internal trade costs ( $\tau_{iit} = 1 \forall i$ ), and no home bias (see Appendix) bilateral trade costs are recovered by calculating:

$$\hat{\tau}_{ikt} = \left[ \exp \left( \sum_{n=1}^J \hat{\gamma}_t^n z_{ikt}^n \right) \right]^{\frac{1}{1-\eta}} \quad (38)$$

As regards the marginal utility of wealth, what is of interest is the behavior of this variable for one country relative to others. The Appendix notes the correspondence between the following object and the dynamic weight of each country in an appropriately specified series of planning problems:

$$\frac{\hat{M}_{it}L_{it}}{\sum_{h=1}^N \hat{M}_{ht}L_{ht}} = \frac{\left[ \exp \left( \hat{\theta}_{it} \right) \right]^{\frac{1}{\eta-1}} (C_{it}/L_{it})^\rho L_{it}}{\sum_{h=1}^N \left[ \exp \left( \hat{\theta}_{ht} \right) \right]^{\frac{1}{\eta-1}} (C_{ht}/L_{ht})^\rho L_{ht}} \quad (39)$$

## 4 Data and results

Annual bilateral merchandise imports in current dollars from 1970 to 2000 are taken from the *NBER-United Nations Trade Data* prepared by Feenstra and Lipsey. The current dollar value of GDP, the current dollar value of total expenditure and the current dollar value of total imports are taken from the World Bank's *World Development Indicators* (WDI). The dependent variable is constructed using this data as follows:

$$\frac{IM_{ikt}}{EXP_{it}GDP_{kt}} = \left[ IM_{ikt}^{UN} \cdot \frac{IM_{it}^{WDI}}{\sum_{h=1}^N IM_{iht}^{UN}} \right] \left[ \frac{1}{[GDP_{it}^{WDI} - EX_{it}^{WDI} + IM_{it}^{WDI}] \cdot [GDP_{kt}^{WDI}]} \right]$$

where  $IM_{it}$  and  $EX_{it}$  denote the value of  $i$ 's total imports and exports in period  $t$ , and the subscripts  $UN$  and  $WDI$  indicate the source of the data. Population is also taken from the

WDI.

Private consumption per capita and government consumption per capita measured in constant international dollars are taken from the *Penn World Tables*, version 6.1. The baseline measure of real consumption is the sum of both private and government consumption per capita. The employment rate from the *Penn World Tables* is used to test robustness of the results to relaxing the assumption of consumption-leisure separability.

For the purposes of estimating the gravity equations, data on variables that are correlated with trade costs are required. Bilateral distance in miles is calculated using the great circle distance algorithm provided by Gray (2001). Dummy variables indicating common language, contiguity, a colonial relationship post-1945 and a common colonizer post-1945 are constructed based on the *CIA World Factbook*. A dummy variable indicating common legal origin (British, French, German, Scandinavian or Socialist) is constructed based on the categorization provided by la Porta et al (1999).

One issue in mapping the model into the data is that data on bilateral service trade are not available. It is implicitly assumed that bilateral service flows follow the same pattern as bilateral merchandise flows.

The largest possible sample given the requirement that all of the above variables be available for all years 1970-2000 consists of 80 developed and developing countries. The list of countries is in the Appendix.

## 4.1 Results

### Baseline results

Table 1 reports the results from estimating the four models described above using all bilateral pairs in the 80-country sample. The coefficients on the gravity variables are allowed to vary by 5-year period. Standard errors are clustered by country-pair. The estimated coefficients on the gravity variables in the models with trade costs are fairly standard and relatively stable across specifications. They suggest that trade costs are falling over time, most rapidly in the first half of the sample period.<sup>11</sup>

Table 2 reports the likelihood ratio test statistics and p-values for the three hypothesis tests, taking the trade cost-enforcement friction model as the alternative hypothesis in each

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<sup>11</sup>The rejection of the null of complete financial markets means that the estimated coefficient on log consumption in the complete markets regression should not be over-interpreted.

case. The null of no frictions in asset markets is rejected at all significance levels. The null of financial autarky is rejected at all significance levels. The null of no trade costs is also rejected at all significance levels.

The estimated coefficients on the gravity variables from the unrestricted model (column 1) can be used to construct fitted values of bilateral trade costs between all country pairs for the 6 five-year intervals covered by the sample. This requires a value for the elasticity of substitution,  $\eta$ . Following Anderson and van Wincoop (2004), a baseline elasticity of 6 is used. Table 3 reports summary statistics of the implied trade costs. Using this elasticity, and under the joint assumption of zero internal trade costs and no home bias, the predicted trade costs are very high, much higher than measured costs of trade for goods that are actually traded. This is typical of the trade costs estimated using gravity models of this type. Apart from the possible failure of the identifying assumptions, one explanation for this discrepancy is that there are both fixed and per unit costs of trade. The failure of the empirical model used here to take account of fixed costs may lead to upward-biased estimates of per unit trade costs [see Helpman, Melitz and Rubinstein (2004)]. At any rate, the evidence strongly suggests a much greater macroeconomic role for trade costs than usually presumed in the international real business cycle literature.

The estimated coefficients from the unrestricted model are used to recover the implied relative marginal utility of wealth given values of  $\eta = 6$  and  $\rho = 1$ . At these values, the time-series average of the implied weight of the US in the planner's problem (32%) matches the time-series average of its share in within-sample world GDP (also 32%).<sup>12</sup> This is illustrated in Figure 1 which shows the time-series of the implied US weight along with the average share of the US in in-sample GDP for the period. Meanwhile, the cross-sectional correlation of these two averages for the full sample of 80 countries is 0.97. The time-series properties of the weights are explored by dividing the sample into 21 developed countries and the 59 remaining countries. The predicted planning weights for developing countries are much more volatile than those for developed countries, consistent with a greater degree of risk sharing among developed countries. Table 4 reports summary statistics for the coefficient of variation of the implied weights for these two groups (i.e. the standard deviation divided by the mean). The corresponding statistics for the coefficient of variation of shares in within-sample world

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<sup>12</sup>Higher values for  $\rho$  produce a much more skewed distribution of planning weights, with the weight on the US being much higher and that on all other countries much lower.

GDP are also reported. Figures 2, 3 and 4 illustrate this further by showing time-series of the estimated planning weights (with mean normalized to 1) for a select subset of countries.

### **Results by level of development**

It is possible that while financial markets are incomplete from the perspective of developing countries, within developed countries risk can be pooled in so far as trade costs allow. This hypothesis can be tested by estimating the same four empirical models on a subsample of the data containing only observations on bilateral imports between 21 developed countries. The estimation results are reported in Table 5. The magnitude of the coefficients on the gravity variables in the models with trade costs are different from those in the full sample, and the implied trade costs are substantially smaller (see Table 7). Overall, the models with trade costs explain a good deal more of the variation within this subsample than they do in the full sample of 80 countries.

Table 6 reports the likelihood ratio test statistics and associated p-values for the 21-country subsample. The null of no asset market frictions and costly trade is rejected against the alternative of frictions in both goods and asset markets at all conventional levels of significance. However in contrast to the full sample results, the p-value is less than 1 (i.e. 0.89). The null of financial autarky is rejected in favor of some degree of risk sharing through intertemporal trade at all levels of significance. The null of no trade costs is rejected against the alternative of frictions in both goods and asset markets at all levels of significance. In a weak sense, these results suggest that the developed country subsample is closer to complete risk sharing than the full sample.

### **Results by period**

The same four models are estimated separately on the first half of the time-period (1970-1984) and the second half of the time period (1985-2000), and the likelihood ratio tests performed. Tables 8 and 9 report the likelihood ratio test statistics and associated p-values for the two samples. In both the earlier period and the later period, the null of no asset market frictions but costly trade is rejected against the alternative of frictions in both goods and asset markets, though the likelihood ratio statistic is much lower in the later period. Similarly, the null of financial autarky is rejected in favor of the alternative of some risk sharing through financial markets, and the null of no trade costs is strongly rejected in both periods. These results are suggestive of some weakening in asset market frictions over time.

## 4.2 Robustness

The results of the previous subsection are robust along a number of different dimensions.

### **Non-separability of utility over consumption and leisure**

It is simple to modify the tests presented here to allow for non-separability of consumption and leisure. As the Appendix describes, all that is necessary is to respecify the marginal utility of consumption in the complete markets regression. As in Lewis (1996), it is assumed as an approximation that log marginal utility of consumption is linear in the log of consumption and the log of employment per capita. Allowing for this does not affect the results of the hypothesis tests - in each of the three cases, the null is rejected in favor of the alternative at all levels of significance.

### **Government vs private consumption**

The model presented here does not include government consumption. In the empirical implementation, it is implicitly assumed that the consumption that is being smoothed is the sum of government and private consumption. This assumption can easily be relaxed, analogous to the case of non-separability over consumption and leisure, by controlling separately for private and public consumption in the complete markets regression. Doing this does not affect the results of the hypothesis tests.

### **Time variation in trade costs**

The baseline specification allows trade costs to vary over time by 5-year period. The likelihood ratio test results are unchanged if the full 31 year interactions with trade costs are allowed for. The estimated evolution of trade costs (high and falling over 1970-1984, relatively constant thereafter) is also similar when the full 31 year interactions are allowed for. The results are also robust to the elimination of time variation in trade costs.

### **5-year aggregation of the data**

The model does not specify what is the length of a period. It is customary to use annual data to estimate gravity equations, but there is no reason why longer frequencies should not be used (shorter frequencies exacerbate the problem of zeros in the dependent variable). When the data is aggregated over 5-year periods, deflating nominal variables by the US consumer price index (from WDI), the results are very similar to the baseline. The only difference is that the implied trade costs are considerably more reasonable. This may be attributed partly to the attenuation of the problem of the zeros.

### **Inclusion of estimates of trade with self**

The model presented above suggests that domestic absorption of domestic output can be treated exactly like absorption of foreign output. In principle, one would like to include observations on absorption of domestic output in the sample, but data on this variable is not available. It is possible to construct an estimate along the lines described in Fitzgerald (2005). This estimate assumes that the ratio of gross output to value added is constant, and equal to 2. Domestic absorption of domestic output is then given by:

$$IM_{it} = 2.GDP_{it} - EX_{it}$$

To be consistent, total expenditure is calculated as

$$EXP_{it} = 2.GDP_{it} - EX_{it} + IM_{it}$$

The results of the likelihood ratio tests estimated using the modified data set are unchanged from the baseline, though the estimated trade costs are larger than in the baseline case.

## 5 Conclusion

This paper presents a multi-country model with trade costs and a generalized asset market structure. Based on the model, an empirical test for the presence of each of the two types of friction is developed. I implement this test using a sample of developed and developing countries. The results suggest that both trade costs and asset market imperfections are necessary in order to explain the failure of perfect consumption risk sharing across countries. However I find that there is some risk sharing through intertemporal trade, since the null of financial autarky is rejected. In addition, asset market frictions appear to be less important for developed than for developing countries. I find that trade costs, though falling over time, are of much greater economic importance than is usually assumed in the international real business cycle literature.

The methodology presented here does not specify the particular form of asset market frictions other than in the polar cases of frictionless markets and financial autarky. But it has the advantage that estimates of the marginal utility of wealth are produced as a by-product of the test. Future research may exploit this to say more about the nature of international asset market imperfections.

## A Planner's problem

It is convenient to note the correspondence between the competitive equilibrium consumption allocation and the allocation that would be obtained as the solution to a series of intratemporal social planning problems.

**Claim:** Let  $(\mathbf{C}^*(s^t), \mathbf{Z}^*(s^t), \mathbf{K}^*(s^t))$  denote a competitive equilibrium allocation for state  $s^t$ . Then there exists a vector  $\tilde{\mathbf{M}}(s^t)$  with  $\sum_{i=1}^N \tilde{M}_i(s^t) = 1$  such that:

$$\begin{aligned} (\mathbf{C}^*(s^t), \mathbf{Z}^*(s^t)) &= \arg \max_{\mathbf{C}, \mathbf{Z}} \sum_{i=1}^N \tilde{M}_i(s^t) L_{it} u(C_i(s^t) / L_{it}) \\ \text{s.t. } \sum_{k=1}^N \tau_{ki}(s^t) Z_k(i, s^t) &= F(A_i(s^t), K_i^*(s^{t-1}), L_{it}) \\ \left( \sum_{k=1}^N Z_i(k, s^t)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} &= C_i(s^t) + K_i^*(s^t) - K_i^*(s^{t-1}) \end{aligned}$$

That is at state  $s^t$ , for any competitive equilibrium, there exists a vector  $\tilde{\mathbf{M}}(s^t)$  such that  $(\mathbf{C}^*(s^t), \mathbf{Z}^*(s^t))$  is a solution to the above planning problem where  $\tilde{M}_i(s^t)$  is the weight of the aggregate utility of country  $i$  in the planner's objective function ( $\tilde{M}_i(s^t) L_{it}$  is the weight of the utility of the representative agent from country  $i$  in the planner's objective). The  $M_i(s^t) L_{it}$  in the competitive equilibrium can thus be interpreted as (state-contingent) weights in the planner's objective function.

## B Endogenous labor supply and nonseparable utility

Assume everything is as in section 2.1, except that utility of the representative agent is given by:

$$U_i = \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi(s^t) N_{it} u\left(\frac{C_i(s^t)}{N_{it}}, \frac{L_i(s^t)}{N_{it}}\right) \quad (40)$$

where  $N_{it}$  is population in country  $i$  at time  $t$ , and  $L_i(s^t)$  is aggregate labor supply. Labor supply rather than population enters into the intermediate goods production function (2). Optimization is over the sequence of aggregate labor supplies as well as consumption, intermediate goods absorption, capital and asset holdings. The first order condition for country

$i$ 's problem with respect to consumption is:

$$M_i(s^t) u_C \left( \frac{C_i(s^t)}{N_{it}}, \frac{L_{it}}{N_{it}} \right) = P_i(s^t) \quad (41)$$

The first order condition with respect to absorption of the intermediate good is unchanged. Combining these with the resource constraints yields the following expression for normalized bilateral imports, analogous to (22):

$$\frac{\tau_{ik}(s^t) Q(k, s^t) Z_i(k, s^t)}{[P_i(s^t) X_i(s^t)] [Q(k, s^t) Y_k(s^t)]} = \left( \frac{P_i(s^t) \Pi_k(s^t)}{\tau_{ik}(s^t)} \right)^{\eta-1} \quad (42)$$

with

$$\Pi_k(s^t)^{1-\eta} = \sum_{j=1}^N P_j(s^t) X_j(s^t) (\tau_{kj}(s^t) / P_j(s^t))^{1-\eta} \quad (43)$$

and

$$P_i(s^t) = M_i(s^t) u_{C,i}(s^t) \quad (44)$$

The only modification to the results in section 2.1 is that now the marginal utility of consumption depends on leisure as well as consumption.

## C Non-traded inputs

Assume everything is as in section 2.1, except that each country produces two types of intermediates, traded (superscript  $T$ ) and non-traded (superscript  $N$ ). As before, country  $i$  specializes in the production of traded intermediate  $i$ . The production function for traded intermediates is:

$$Y_i^T(i, s^t) = F^T(A_i^T(s^t), K_i^T(s^{t-1}), L_{it}^T) \quad (45)$$

An aggregate intermediate good  $X^T$  is produced by combining all traded intermediates using a CES production function:

$$X_i^T(s^t) = \left( \sum_{k=1}^N Z_i^T(k, s^t)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \quad (46)$$



Final output is produced by combining  $X^T$  and non-traded intermediate  $X^N$  using a constant returns to scale production function:

$$X_i(s^t) = F(X_i^T(s^t), X_i^N(s^t)) \quad (47)$$

As in the baseline case, this aggregate good is used for consumption and investment.

The first order condition with respect to  $C_i(s^t)$  is unchanged. The first order condition with respect to  $Z_i^T(k, s^t)$  is:

$$P_i(s^t) F_T(X_i^T(s^t), X_i^N(s^t)) X_i^T(s^t)^{\frac{1}{\eta}} Z_i^T(k, s^t)^{-\frac{1}{\eta}} = \tau_{ik}(s^t) Q^T(k, s^t) \quad (48)$$

where  $P_i(s^t)$  is the price of the aggregate good,  $F_T$  is the partial derivative of  $F$  with respect to  $X^T$  and  $Q^T(k, s^t)$  is the price of traded intermediate  $k$  in country  $k$ . Under the assumption of perfect competition at all stages of production, the price of  $X_i^T(s^t)$  is given by:

$$P_i^T(s^t) = P_i(s^t) F_T(X_i^T(s^t), X_i^N(s^t)) \quad (49)$$

These first order conditions can be combined with the resource constraints to obtain the following expression for normalized bilateral imports, analogous to (22):

$$\frac{\tau_{ik}(s^t) Q^T(k, s^t) Z_i^T(k, s^t)}{[P_i^T(s^t) X_i^T(s^t)] [Q^T(k, s^t) Y_k^T(s^t)]} = \left( \frac{P_i^T(s^t) \Pi_k^T(s^t)}{\tau_{ik}(s^t)} \right)^{\eta-1} \quad (50)$$

with

$$\Pi_k^T(s^t)^{1-\eta} = \sum_{j=1}^N P_j^T(s^t) X_j^T(s^t) (\tau_{kj}(s^t) / P_j^T(s^t))^{1-\eta} \quad (51)$$

and

$$P_{it}^T = M_{it} (C_i(s^t) / L_{it})^{-\rho} F_{T,it} \quad (52)$$

Hence, a test that allows for the presence of non-tradeables would require time-series data on the value of output of tradeables and non-tradeables, and both current and constant international price data on absorption of tradeables and nontradeables. In the absence of such data for a wide cross-sample of countries, it is not possible to implement this test.

## D Tariffs

Suppose that each country can impose a vector of per unit tariffs on imported intermediates, with revenues rebated in lump sum form. Let  $\omega_{ik}(s^t)$  be the fraction of each dollar spent in  $i$  on  $k$ 's good that arrives as payment to a seller in  $k$ . The gross tariff (one plus the tariff rate) is then given by  $\varphi_{ik}(s^t) = 1/\omega_{ik}(s^t)$ . Remember that  $\varphi_{ii}(s^t) = 1 \forall i$ . The relationship between the price of good  $k$  in country  $i$  and the price received in country  $k$  is given by:

$$Q_i(k, s^t) = \varphi_{ik}(s^t) \tau_{ik}(s^t) Q_k(k, s^t) \quad (53)$$

Because of tariffs, we have to distinguish between the value of imports before tariffs and after tariffs. The data is presented in pre-tariff form, so we have the following expression for normalized bilateral imports, analogous to (22):

$$\frac{\tau_{ik}(s^t) Q(k, s^t) Z_i(k, s^t)}{[P_i(s^t) X_i(s^t)] [Q(k, s^t) Y_k(s^t)]} = \left( \frac{P_i(s^t) \Pi_k(s^t)}{\tau_{ik}(s^t)} \right)^{\eta-1} (\varphi_{ik}(s^t))^{-\eta} \quad (54)$$

with

$$\Pi_k(s^t)^{1-\eta} = \sum_{j=1}^N \left( \frac{\tau_{jk}(s^t)}{P_j(s^t)} \right)^{1-\eta} (\varphi_{jk}(s^t))^{-\eta} P_j(s^t) X_j(s^t) \quad (55)$$

and

$$M_i(s^t) (C_i(s^t) / L_{it})^{-\rho} = P_i(s^t) \quad (56)$$

## E Home bias

Suppose the production function for the aggregate non-traded good,  $X$ , used for consumption and investment is:

$$X_i(s^t) = \left( \sum_{k=1}^N [\sigma_{ik} Z_i(k, s^t)]^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \quad (57)$$

where  $\sigma_{ik}$  is a parameter indicating the strength of country  $i$ 's "preference" for intermediate good  $k$ . If  $\sigma_{ik} = 1 \forall i \neq k$  and  $\sigma_{ii} > 1$  for some  $i$ , those countries for which  $\sigma_{ii} > 1$  exhibit home bias. In this case, we have the following expression for normalized bilateral imports,

analogous to (22):

$$\frac{\tau_{ik}(s^t) Q(k, s^t) Z_i(k, s^t)}{[P_i(s^t) X_i(s^t)] [Q(k, s^t) Y_k(s^t)]} = \left( \frac{P_i(s^t) \Pi_k(s^t)}{\tau_{ik}(s^t) / \sigma_{ik}} \right)^{\eta-1} \quad (58)$$

with

$$\Pi_k(s^t)^{1-\eta} = \sum_{j=1}^N \left( \frac{\tau_{kj}(s^t) / \sigma_{kj}}{P_j(s^t)} \right)^{1-\eta} P_j(s^t) X_j(s^t) \quad (59)$$

and

$$M_i(s^t) (C_i(s^t) / L_{it})^{-\rho} = P_i(s^t) \quad (60)$$

## F Limited enforcement

Limited enforcement is a particular case of asset market frictions where there is a clear interpretation of the  $M(s^t)_i$ . Assume that countries have access to a full set of contingent claims, but cannot commit ex-ante to make payments that are not ex-post optimal, as in Kehoe and Perri (2002). Intertemporal and interstate trade is feasible only to the extent to which payment can be enforced by the threat of exclusion from future trade. There are many possible equilibria of this game. The degree of risk sharing that can be sustained depends on the discount factor and the severity of the punishment. Assume that parameters are such that there exists a subgame perfect equilibrium where a country that defaults on its obligations to another country is excluded from participating in all future markets by all countries, forever. ‘‘Cheat the cheater’’ punishments are necessary to sustain this SPE when  $N > 2$  [see Kletzer and Wright (2000)].

The planner maximizes the weighted sum of expected utilities (23) subject to the aggregate and intermediate good resource constraints, and the incentive compatibility constraints:

$$\sum_{r=t}^{\infty} \sum_{s^r} \beta^{r-t} \pi(s^r | s^t) L_{ir} u(C_i(s^r) / L_{ir}) \geq V_i(K_i(s^{t-1}), s^t) \quad (61)$$

where:<sup>13</sup>

$$V_i(K_i(s^{t-1}), s^t) = \max \sum_{r=t}^{\infty} \sum_{s^r} \beta^{r-t} \pi(s^r | s^t) L_{ir} u(C_i(s^r) / L_{ir}) \quad (62)$$

---

<sup>13</sup>The assumption that the punishment is autarky (rather than financial autarky) means that  $V$  does not depend on the capital stock of all countries.

The Lagrange multipliers on the aggregate good resource constraints are:

$$\sigma_i (s^t) = \beta^t \pi (s^t) P_i (s^t) \quad (63)$$

The Lagrange multipliers on the intermediate good resource constraints are:

$$\mu (k, s^t) = \beta^t \pi (s^t) Q (k, s^t) \quad (64)$$

The Lagrange multipliers on the IC constraints are:

$$\gamma_i (s^t) = \beta^t \pi (s^t) \delta_i (s^t) \quad (65)$$

Following Marcet and Marimon (1998), solutions to the following problem (if they exist) are also solutions to the planner's problem:

$$\mathcal{L} = \sum_{i=1}^N \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi (s^t) \left[ \begin{array}{l} M_i (s^{t-1}) L_{it} u (C_i (s^t) / L_{it}) + \delta_i (s^t) [L_{it} u (C_i (s^t) / L_{it}) - V_i (K_i (s^{t-1}), s^t)] + \\ Q (i, s^t) \left[ Y_i (s^t) - \sum_{k=1}^N \tau_{ki} (s^t) Z_k (i, s^t) \right] + \\ P_i (s^t) \left[ \left( \sum_{j=1}^N Z_i (j, s^t)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} - C_i (s^t) - K_i (s^t) + K_i (s^{t-1}) \right] \end{array} \right]$$

with:

$$M_i (s^t) = M_i (s^{t-1}) + \delta_i (s^t) \quad (66)$$

and  $M_i (s^{-1}) = \lambda_i$ . Notice that  $M_i (s^t) / \sum_{k=1}^N M_k (s^t)$  is country  $i$ 's dynamic weight in the planner's welfare. The evolution of this weight depends on the cross-country pattern of binding incentive compatibility constraints. Countries whose IC constraints bind gain (in terms of their dynamic weight in the planner's utility) relative to those whose constraints remain slack. The likelihood that an IC constraint binds depends on the difference between the value of autarky and the value of remaining in the market, which in turn depends on the size of trade costs [see Guibaud (2006)]. This illustrates that it may not be possible to allocate numerical shares to the role of asset market frictions vs trade costs in explaining the failure of risk sharing.

## Countries in the sample

### Developed countries

|           |             |             |
|-----------|-------------|-------------|
| Australia | Germany     | Norway      |
| Austria   | Greece      | Portugal    |
| Belgium   | Ireland     | Spain       |
| Canada    | Italy       | Sweden      |
| Denmark   | Japan       | Switzerland |
| Finland   | Netherlands | UK          |
| France    | New Zealand | USA         |

### Developing countries

|                    |            |                     |
|--------------------|------------|---------------------|
| Algeria            | Gabon      | Niger               |
| Argentina          | Gambia     | Nigeria             |
| Barbados           | Ghana      | Pakistan            |
| Benin              | Guatemala  | Paraguay            |
| Bolivia            | Honduras   | Peru                |
| Brazil             | Hong Kong  | Philippines         |
| Burkina Faso       | Hungary    | Rwanda              |
| Burundi            | Iceland    | Senegal             |
| Cameroon           | Indonesia  | South Africa        |
| Chad               | Israel     | Sri Lanka           |
| Chile              | Jamaica    | Syria               |
| China              | Kenya      | Thailand            |
| Colombia           | Korea      | Togo                |
| Congo              | Madagascar | Trinidad and Tobago |
| Costa Rica         | Malawi     | Tunisia             |
| Cote d'Ivoire      | Malaysia   | Turkey              |
| Dominican Republic | Mali       | Uruguay             |
| Ecuador            | Mexico     | Venezuela           |
| Egypt              | Morocco    | Zambia              |
| El Salvador        | Nepal      |                     |

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Table 1: Regression results for full sample of 80 countries, 1970-2000

|                              |             | (1)         |         | (2)         |         | (3)         |         | (4)            |      |
|------------------------------|-------------|-------------|---------|-------------|---------|-------------|---------|----------------|------|
| Asset market                 |             | Enforcement |         | Autarky     |         | No friction |         |                |      |
| Goods market                 |             | Trade costs |         | Trade costs |         | Trade costs |         | No trade costs |      |
| variable                     | interaction | coeff.      | s.e.    | coeff.      | s.e.    | coeff.      | s.e.    | coeff.         | s.e. |
| ln(consumption)              | none        | .           | .       | .           | .       | 0.00        | 0.00    | .              | .    |
| ln(1+dist)                   | 1970-1974   | -1.69       | 0.09 ** | -1.69       | 0.09 ** | -1.68       | 0.09 ** | .              | .    |
| ln(1+dist)                   | 1975-1979   | -1.50       | 0.08 ** | -1.50       | 0.08 ** | -1.54       | 0.08 ** | .              | .    |
| ln(1+dist)                   | 1980-1984   | -1.08       | 0.08 ** | -1.08       | 0.08 ** | -1.26       | 0.08 ** | .              | .    |
| ln(1+dist)                   | 1985-1989   | -0.81       | 0.10 ** | -0.81       | 0.10 ** | -0.98       | 0.09 ** | .              | .    |
| ln(1+dist)                   | 1990-1994   | -0.88       | 0.09 ** | -0.88       | 0.09 ** | -0.78       | 0.09 ** | .              | .    |
| ln(1+dist)                   | 1995-2000   | -0.89       | 0.09 ** | -0.89       | 0.09 ** | -0.67       | 0.09 ** | .              | .    |
| not contiguous               | 1970-1974   | -0.22       | 0.44    | -0.22       | 0.44    | -0.11       | 0.48    | .              | .    |
| not contiguous               | 1975-1979   | 0.55        | 0.42    | 0.55        | 0.42    | 0.80        | 0.43 *  | .              | .    |
| not contiguous               | 1980-1984   | 0.41        | 0.36    | 0.41        | 0.36    | 0.80        | 0.35 ** | .              | .    |
| not contiguous               | 1985-1989   | 0.25        | 0.41    | 0.25        | 0.41    | 0.43        | 0.41    | .              | .    |
| not contiguous               | 1990-1994   | 0.58        | 0.39    | 0.58        | 0.38    | 0.29        | 0.40    | .              | .    |
| not contiguous               | 1995-2000   | 0.67        | 0.38 *  | 0.67        | 0.38 *  | 0.16        | 0.40    | .              | .    |
| no common lang.              | 1970-1974   | -2.22       | 0.15 ** | -2.22       | 0.16 ** | -2.70       | 0.16 ** | .              | .    |
| no common lang.              | 1975-1979   | -1.66       | 0.15 ** | -1.66       | 0.15 ** | -1.87       | 0.15 ** | .              | .    |
| no common lang.              | 1980-1984   | -1.48       | 0.15 ** | -1.48       | 0.16 ** | -1.36       | 0.15 ** | .              | .    |
| no common lang.              | 1985-1989   | -1.38       | 0.19 ** | -1.38       | 0.20 ** | -1.09       | 0.19 ** | .              | .    |
| no common lang.              | 1990-1994   | -1.67       | 0.19 ** | -1.67       | 0.20 ** | -1.52       | 0.19 ** | .              | .    |
| no common lang.              | 1995-2000   | -1.69       | 0.18 ** | -1.69       | 0.19 ** | -1.59       | 0.19 ** | .              | .    |
| no colonial rel.             | 1970-1974   | -2.56       | 0.31 ** | -2.56       | 0.29 ** | -1.86       | 0.32 ** | .              | .    |
| no colonial rel.             | 1975-1979   | -2.71       | 0.34 ** | -2.71       | 0.33 ** | -2.53       | 0.33 ** | .              | .    |
| no colonial rel.             | 1980-1984   | -2.93       | 0.34 ** | -2.93       | 0.33 ** | -3.27       | 0.34 ** | .              | .    |
| no colonial rel.             | 1985-1989   | -2.98       | 0.38 ** | -2.98       | 0.37 ** | -3.52       | 0.37 ** | .              | .    |
| no colonial rel.             | 1990-1994   | -2.70       | 0.38 ** | -2.70       | 0.38 ** | -2.88       | 0.36 ** | .              | .    |
| no colonial rel.             | 1995-2000   | -2.48       | 0.39 ** | -2.48       | 0.38 ** | -2.32       | 0.36 ** | .              | .    |
| no com. col. rel.            | 1970-1974   | -2.56       | 0.23 ** | -2.56       | 0.24 ** | -2.43       | 0.21 ** | .              | .    |
| no com. col. rel.            | 1975-1979   | -1.77       | 0.23 ** | -1.77       | 0.23 ** | -1.88       | 0.21 ** | .              | .    |
| no com. col. rel.            | 1980-1984   | -0.56       | 0.21 ** | -0.56       | 0.21 ** | -0.67       | 0.20 ** | .              | .    |
| no com. col. rel.            | 1985-1989   | 0.33        | 0.27    | 0.33        | 0.28    | 0.46        | 0.25 *  | .              | .    |
| no com. col. rel.            | 1990-1994   | 0.41        | 0.26    | 0.41        | 0.27    | 0.35        | 0.25    | .              | .    |
| no com. col. rel.            | 1995-2000   | 0.48        | 0.26 *  | 0.48        | 0.27 *  | 0.51        | 0.24 ** | .              | .    |
| no com. legal hist.          | 1970-1974   | 0.31        | 0.12 ** | 0.31        | 0.13 ** | 0.11        | 0.12    | .              | .    |
| no com. legal hist.          | 1975-1979   | 0.14        | 0.12    | 0.14        | 0.12    | 0.13        | 0.12    | .              | .    |
| no com. legal hist.          | 1980-1984   | -0.06       | 0.12    | -0.06       | 0.12    | 0.02        | 0.12    | .              | .    |
| no com. legal hist.          | 1985-1989   | -0.44       | 0.14 ** | -0.44       | 0.15 ** | -0.31       | 0.14 ** | .              | .    |
| no com. legal hist.          | 1990-1994   | -0.18       | 0.14    | -0.18       | 0.14    | -0.12       | 0.14    | .              | .    |
| no com. legal hist.          | 1995-2000   | -0.08       | 0.13    | -0.08       | 0.14    | -0.13       | 0.13    | .              | .    |
| importer fixed effects       |             | no          |         | no          |         | yes         |         | no             |      |
| importer-year fixed effects  |             | yes         |         | no          |         | no          |         | no             |      |
| exporter-year fixed effects  |             | yes         |         | no          |         | yes         |         | no             |      |
| symmetric-year fixed effects |             | no          |         | yes         |         | no          |         | no             |      |
| year fixed effects           |             | no          |         | no          |         | no          |         | yes            |      |
| R <sup>2</sup>               |             | 0.54        |         | 0.51        |         | 0.51        |         | 0.03           |      |
| N                            |             | 195920      |         | 195920      |         | 195920      |         | 195920         |      |

Dependent variable is  $\log(1+IM_{ij}/EXP_iGDP_j)$ . \* significant at 10%; \*\* significant at 5%



**Table 2: Likelihood ratio test results for full sample of 80 countries, 1970-2000**

| Null                                  | Alternative           | LR     | d.f. | N      | p-value |
|---------------------------------------|-----------------------|--------|------|--------|---------|
| Trade costs, no asset market friction | trade, asset friction | 13625  | 2399 | 195920 | 1       |
| Trade costs, financial autarky        | trade, asset friction | 12898  | 2480 | 195920 | 1       |
| No trade costs                        | trade, asset friction | 145273 | 4965 | 195920 | 1       |

LR test statistic is asymptotically distributed as chi-squared with d.f. as given

A p-value greater than 0.05 indicates rejection of the null at the 5% significance level

**Table 3: Fitted trade costs for full sample of 80 countries  
Allowing trade costs to vary every 5 years**

| Period    | elasticity of substitution = 6 |     |       | elasticity of substitution = 9 |     |      |
|-----------|--------------------------------|-----|-------|--------------------------------|-----|------|
|           | Mean                           | Min | Max   | Mean                           | Min | Max  |
| 1970-1974 | 6615                           | 706 | 10859 | 1266                           | 269 | 1783 |
| 1975-1979 | 3316                           | 594 | 5043  | 799                            | 236 | 1074 |
| 1980-1984 | 1350                           | 393 | 1841  | 429                            | 171 | 538  |
| 1985-1989 | 737                            | 205 | 974   | 276                            | 101 | 341  |
| 1990-1994 | 739                            | 213 | 1001  | 276                            | 104 | 348  |
| 1995-2000 | 685                            | 207 | 960   | 261                            | 102 | 337  |

Trade costs are expressed as a percentage of the home country price

**Table 4: Summary statistics of coefficient of variation  
of implied planning weights and shares in world GDP**

|                  | OECD countries |      |      | Non-OECD countries |      |      |
|------------------|----------------|------|------|--------------------|------|------|
|                  | Mean           | Min  | Max  | Mean               | Min  | Max  |
| Planning weights | 0.17           | 0.06 | 0.38 | 0.36               | 0.15 | 0.79 |
| GDP shares       | 0.13           | 0.08 | 0.25 | 0.29               | 0.13 | 0.65 |

Planning weights are calculated as described in the text

GDP shares are calculated relative to total in-sample GDP

The coefficient of variation is  $sd/mean$  over period 1970-2000

**Table 5: Regression results for 21 developed countries only, 1970-2000**

|                              |             | (1)              | (2)     | (3)         | (4)            |
|------------------------------|-------------|------------------|---------|-------------|----------------|
| Asset market                 |             | General friction | Autarky | No friction | .              |
| Goods market                 |             | Trade costs      |         | Trade costs | No trade costs |
| variable                     | interaction | coeff.           | s.e.    | coeff.      | s.e.           |
| ln(consumption)              | none        | .                | .       | 0.00        | 0.00           |
| ln(1+dist)                   | 1970-1974   | -0.90            | 0.08 ** | -0.90       | 0.08 **        |
| ln(1+dist)                   | 1975-1979   | -0.98            | 0.08 ** | -0.98       | 0.07 **        |
| ln(1+dist)                   | 1980-1984   | -1.06            | 0.07 ** | -1.06       | 0.07 **        |
| ln(1+dist)                   | 1985-1989   | -1.02            | 0.07 ** | -1.02       | 0.06 **        |
| ln(1+dist)                   | 1990-1994   | -1.06            | 0.07 ** | -1.06       | 0.06 **        |
| ln(1+dist)                   | 1995-2000   | -1.04            | 0.07 ** | -1.04       | 0.06 **        |
| not contiguous               | 1970-1974   | -0.06            | 0.13    | -0.06       | 0.13           |
| not contiguous               | 1975-1979   | -0.02            | 0.12    | -0.02       | 0.12           |
| not contiguous               | 1980-1984   | 0.10             | 0.10    | 0.10        | 0.10           |
| not contiguous               | 1985-1989   | 0.10             | 0.10    | 0.10        | 0.10           |
| not contiguous               | 1990-1994   | 0.16             | 0.11    | 0.16        | 0.10           |
| not contiguous               | 1995-2000   | 0.16             | 0.11    | 0.16        | 0.11           |
| no common lang.              | 1970-1974   | -0.28            | 0.13 ** | -0.28       | 0.12 *         |
| no common lang.              | 1975-1979   | -0.21            | 0.12 *  | -0.21       | 0.12 **        |
| no common lang.              | 1980-1984   | -0.16            | 0.10    | -0.16       | 0.10           |
| no common lang.              | 1985-1989   | -0.13            | 0.09    | -0.13       | 0.09           |
| no common lang.              | 1990-1994   | -0.06            | 0.09    | -0.06       | 0.09           |
| no common lang.              | 1995-2000   | -0.04            | 0.10    | -0.04       | 0.11           |
| no com. legal hist.          | 1970-1974   | -0.39            | 0.08 ** | -0.39       | 0.08 **        |
| no com. legal hist.          | 1975-1979   | -0.34            | 0.07 ** | -0.34       | 0.08 **        |
| no com. legal hist.          | 1980-1984   | -0.36            | 0.07 ** | -0.36       | 0.08 **        |
| no com. legal hist.          | 1985-1989   | -0.40            | 0.06 ** | -0.40       | 0.07 **        |
| no com. legal hist.          | 1990-1994   | -0.46            | 0.06 ** | -0.46       | 0.06 **        |
| no com. legal hist.          | 1995-2000   | -0.48            | 0.06 ** | -0.48       | 0.07 **        |
| importer fixed effects       | no          |                  |         | yes         | no             |
| importer-year fixed effects  | yes         |                  |         | no          | no             |
| exporter-year fixed effects  | yes         |                  |         | yes         | no             |
| symmetric-year fixed effects | no          |                  |         | no          | no             |
| year fixed effects           | no          |                  |         | no          | yes            |
| R <sup>2</sup>               |             | 0.89             |         | 0.86        | 0.88           |
| N                            |             | 13020            |         | 13020       | 13020          |

Dependent variable is  $\log(1+IM_{ij}/EXP_iGDP_j)$ . \* significant at 10%; \*\* significant at 5%

**Table 6: Likelihood ratio test results for 21 developed countries, 1970-2000**

| Null                                  | Alternative           | LR    | d.f. | N     | p-value |
|---------------------------------------|-----------------------|-------|------|-------|---------|
| Trade costs, no asset market friction | trade, asset friction | 672   | 629  | 13020 | 0.89    |
| Trade costs, financial autarky        | trade, asset friction | 3388  | 651  | 13020 | 1       |
| No trade costs                        | trade, asset friction | 26109 | 1295 | 13020 | 1       |

LR test statistic is asymptotically distributed as chi-squared with d.f. as given

A p-value greater than 0.05 indicates rejection of the null at the 5% significance level

**Table 7: Fitted trade costs for 21 developed countries**

**Allowing trade costs to vary every 5 years**

|           | elasticity of substitution = 6 |     |     | elasticity of substitution = 9 |     |     |
|-----------|--------------------------------|-----|-----|--------------------------------|-----|-----|
|           | Mean                           | Min | Max | Mean                           | Min | Max |
| 1970-1974 | 349                            | 143 | 532 | 154                            | 74  | 216 |
| 1975-1979 | 395                            | 163 | 611 | 170                            | 83  | 241 |
| 1980-1984 | 444                            | 184 | 700 | 186                            | 92  | 267 |
| 1985-1989 | 411                            | 173 | 642 | 175                            | 87  | 250 |
| 1990-1994 | 439                            | 185 | 694 | 184                            | 92  | 265 |
| 1995-2000 | 421                            | 179 | 663 | 179                            | 90  | 256 |

Trade costs are expressed as a percentage of the home country price

**Table 8: Likelihood ratio test results for full sample of countries, 1970-1984**

| Null                                  | Alternative           | LR    | d.f. | N     | p-value |
|---------------------------------------|-----------------------|-------|------|-------|---------|
| Trade costs, no asset market friction | trade, asset friction | 6249  | 1119 | 94800 | 1       |
| Trade costs, financial autarky        | trade, asset friction | 7149  | 1200 | 94800 | 1       |
| No trade costs                        | trade, asset friction | 69926 | 2403 | 94800 | 1       |

LR test statistic is asymptotically distributed as chi-squared with d.f. as given

A p-value greater than 0.05 indicates rejection of the null at the 5% significance level

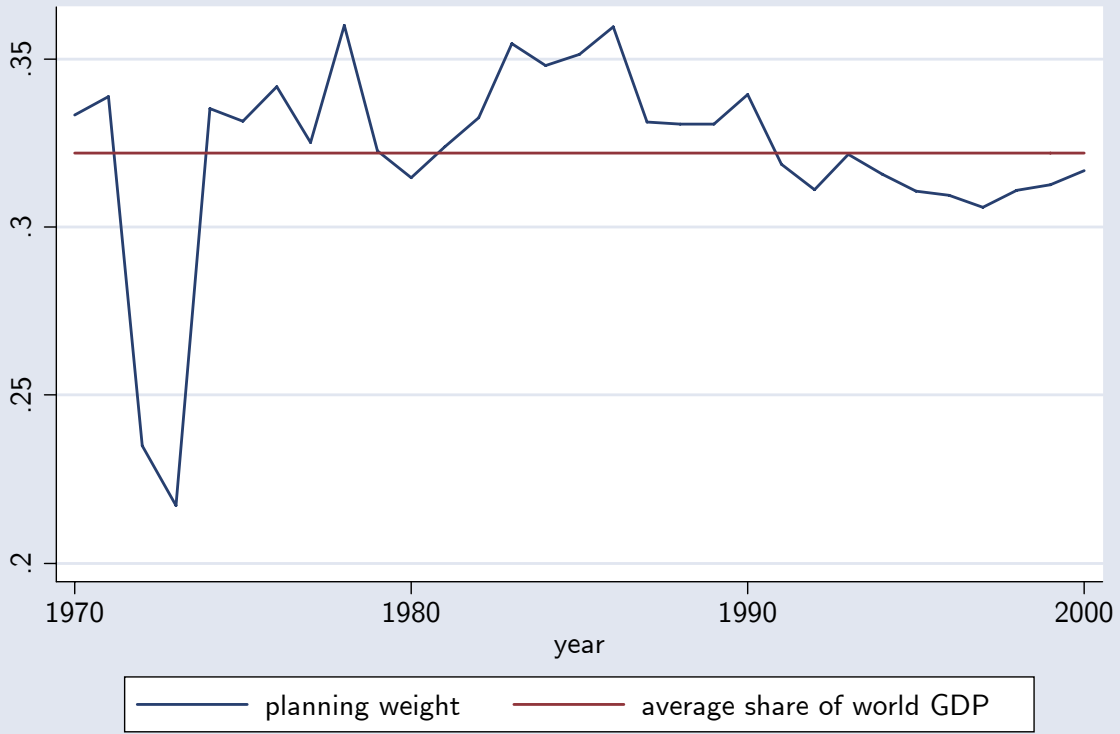
**Table 9: Likelihood ratio test results for full sample of countries, 1985-2000**

| Null                                  | Alternative           | LR    | d.f. | N      | p-value |
|---------------------------------------|-----------------------|-------|------|--------|---------|
| Trade costs, no asset market friction | trade, asset friction | 1676  | 1199 | 101120 | 1       |
| Trade costs, financial autarky        | trade, asset friction | 5888  | 1280 | 101120 | 1       |
| No trade costs                        | trade, asset friction | 75287 | 2562 | 101120 | 1       |

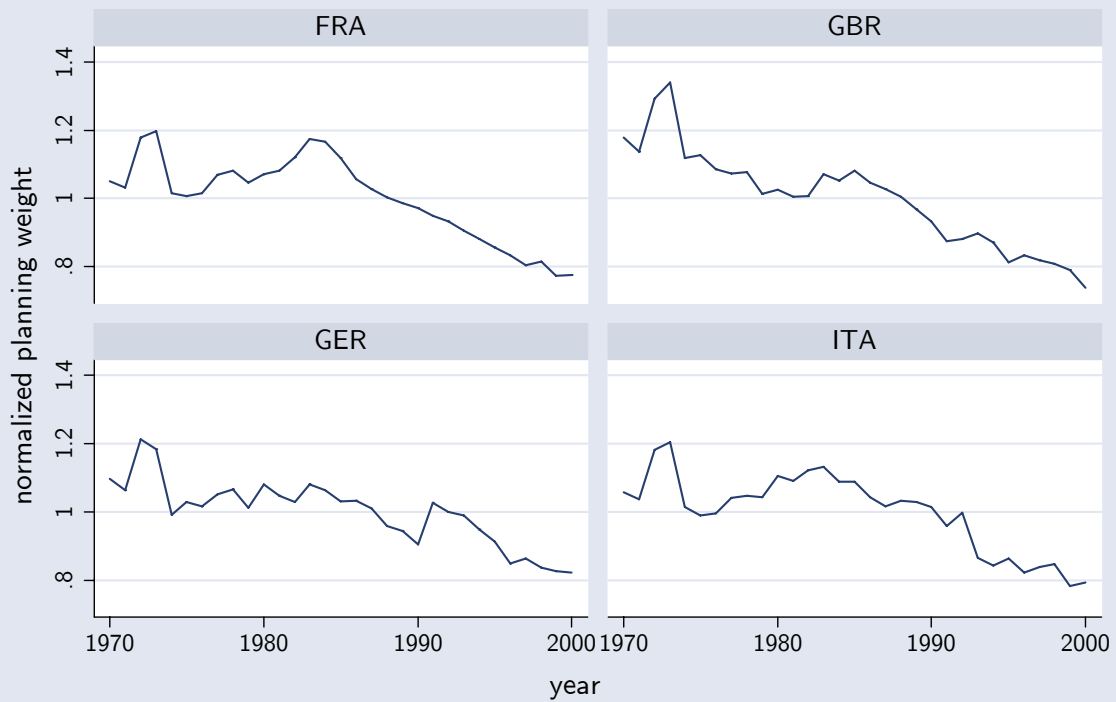
LR test statistic is asymptotically distributed as chi-squared with d.f. as given

A p-value greater than 0.05 indicates rejection of the null at the 5% significance level

Planning weight and average GDP share for USA

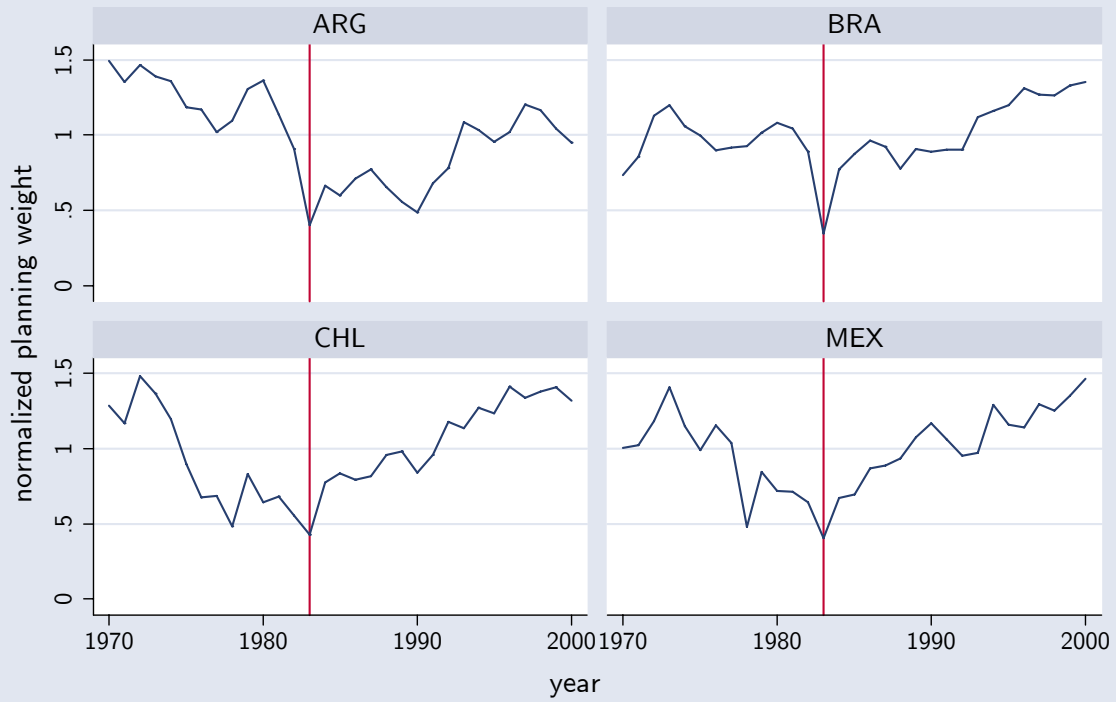


Normalized planning weight for 4 European countries



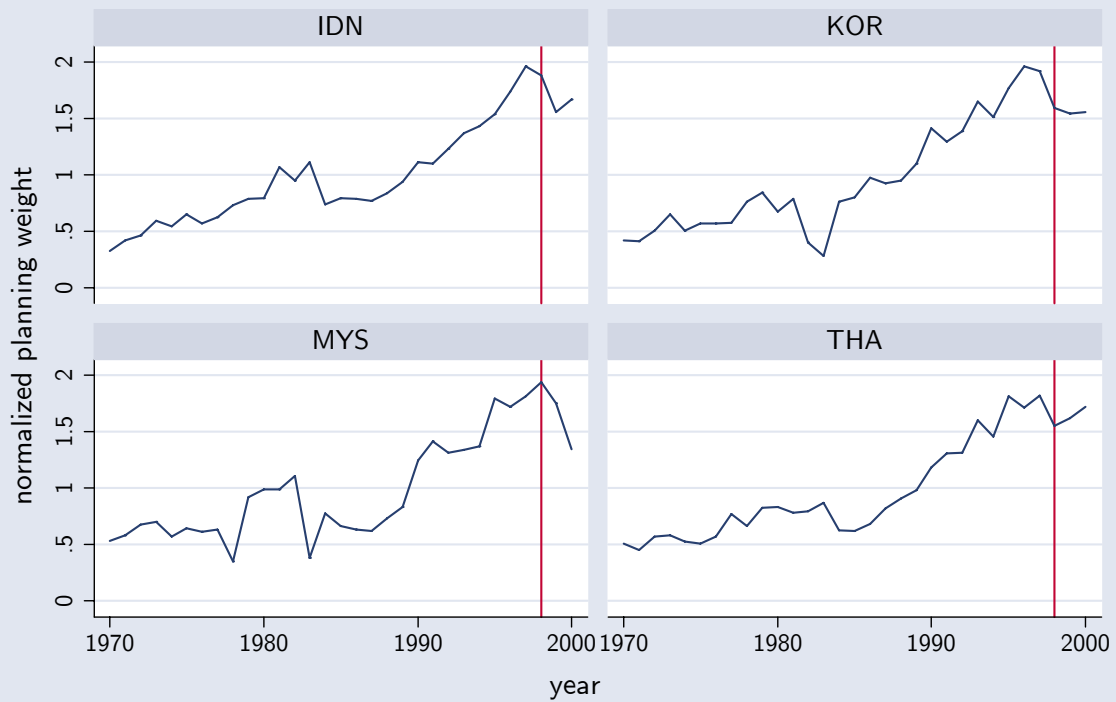
Graphs by code for home country

### Normalized planning weight for 4 Latin American countries



Graphs by code for home country

### Normalized planning weight for 4 East Asian countries



Graphs by code for home country