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How much can Standard Theory Account for?**

MORTEN OVERGAARD RAVN

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International Business Cycles: How much can Standard Theory Account for?

by

Morten Overgaard Ravn

European University Institute, Department of Economics,
via dei Roccettini, 9, I-50016 San Domenico di Fiesole (FI), Italy
and
Institute of Economics, University of Aarhus, Building 350,
DK-8000 Aarhus C., Denmark
Telephone: +45 86 130111, Fax: +45 86 136334,
EMAIL: ECORAVN@ECOSTAT.AAU.DK

Abstract:
In this paper I first provide some empirical facts of international business cycles. I then investigate whether standard international real business cycle models can account for these moments of the data. I find that the standard theories seem unable to account for key-features of the data. For some variables (like consumption levels) theory predicts too high international comovements while it has the opposite implication for other variables (e.g. investment and output). Simple extensions do not improve the performance by much and stochastic shocks to government spending seem to have only minor effects in open-economy real business cycle models.

Key words: stochastic growth models; international and national business cycles; investment and trade dynamics; stochastic government spending shocks.

JEL classification: E32, E62, F21

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1 Introduction

In this paper I will argue that our understanding of the international transmission of business cycles may not very advanced. Standard quantitative open-economy models have implications for national business cycles and international comovements that are counterfactual and in some circumstances so much at odds with the data that one is led to conclude that these can not account for the transmission of macroeconomic fluctuations across countries. Since most economies depend heavily on their access to trade in international goods and financial markets, it seems important to try to gain further insight into this key element of modern economies.

The research into quantitative open economy models of business cycles has developed rapidly within recent years. This research has been concerned with understanding both individual-country aggregate fluctuations in open-economy frameworks and with features of international business cycles. Examples include analysis of national business cycles in small-open-economy models, see e.g. Macklem (1990), Mendoza (1991), Lundviik (1990), or Correia et al (1992), and in standard two-country open-economy models, see e.g. Backus, Kehoe and Kydland (1992a) (who study the U.S.) or Ravn (1992) (who study the U.K.). These models have also been used to study the behaviour of trade variables and relative prices, Backus (1993), Backus, Kehoe and Kydland (1992b,c), the behaviour of savings and investment dynamics, Baxter and Crucini (1993) and Finn (1990), and international comovements, Bec (1992), Canova (1993), Devereux, Gregory and Smith (1992), Ravn (1991), and Stockman and Tesar (1990)[1]. Of particular interest to this paper, it has often been stressed in this literature (see e.g. Backus, Kehoe and Kydland (1992a)) that an important (the central) puzzle of international business cycles is why the cross-country correlation of consumption levels is relatively small since standard Arrow-Debreu models of homogeneous agents would predict a near to perfect correlation because of risk sharing properties. Other problematic implications of the models relative to the data have been dismissed as simply requiring minor changes in the parameter-settings; an example of this is the impeachment of the models' predictions of low, or even negative, cross-country output correlations.

I will argue that it is not the case that the only puzzle of international business cycles is the low cross-country correlation of consumption levels. Other counterfactual implications are also apparent. Two examples of this are the high correlation of output levels and the high correlation of investment levels across countries that show up in the data but which standard open-economy models of international business cycles can not account for unless unrealistic parameter values are used.

In the next section of this paper I present the basic "facts" that a model of international business cycles should address. In the data it is typically the case that national output levels are strongly positively correlated (with the exception of one out of ten countries), that national consumption levels are positively correlated (with the exception of two countries), that investment levels and exports and imports levels are positively correlated while no typical pattern is found for government spending. Net-exports ratios of output are typically negatively related to the U.S. figures but positively related to other countries net-exports levels. Furthermore, within countries, imports are strongly positively related to output, exports are positively (but less so than imports) correlated with output, while net exports move countercyclically. Finally, as is well-known, domestic savings and investment ratios are positively related.

[1] See Backus, Kehoe and Kydland (1992d) for an overview of the literature.

In section 3 of the paper I present two standard models of international business cycles. Since I will be concerned with, among other things, the behaviour of investment, both models will incorporate endogenous capital formation. The first model is a simple two-country extension of the single-country single-good real business cycle model. What this model highlights is countries' ability to trade in international goods and financial markets and their dependence upon the world economy. The second model is a version of an international trade model in which each country is specialized in the production of a single good. This framework, used by Backus, Kehoe and Kydland (1992b,c), allows one to address questions that single-goods models leave unanswered (such as movements relative prices and imports and exports separately).

I find that the standard models have standard flaws: they can not account for important features of individual-country aggregate fluctuations and key elements of international business cycles. One potential problem that I try to address is that one normally assumes the two countries in the model-economies are symmetric and equally-sized. Since the sample of countries analyzed in section 2 of the paper by no means fulfil these requirements (at least not the second one) this presents a potential trap of the theoretical models which I try to avoid. The first alternative experiment involves changing the two-country model into two differenced-sized countries. Nevertheless, while this may be useful for aspects of individual country behaviour, it does not seem to be appropriate since we typically look at the relationship between individual countries, none of which denotes the "rest of the world". Accordingly, I augment the framework to a three-country model in which we look at the comovements of two countries both of which depend on each other as well as the world-economy.

The final experiments involve an analysis of the effects of government spendings on the counter-factual high cross-country correlations of consumption levels implied by the standard models. Government spending shocks have been shown to be a potentially important source to national business cycles (see Christiano and Eichenbaum (1992)) and could therefore also be important in an international framework. I find no major evidence in favour of government spending as a vehicle of limiting the cross-country correlation of consumption levels. Furthermore, government spending shocks have only small effects in an open-economy framework since they work through their effects on the real interest rate which is only partially determined by domestic variables. I do however, highlight a potentially interesting effect, worthwhile for future research, of government spending on trade dynamics.

The conclusion, contained in the final section of the paper, is that important characteristics of the data cannot easily be accounted for.

2 Some Facts of International Business Cycles

Since I will be concerned with the international transmission of business cycles, this section will be devoted to a look at the features of the data. I will restrict myself to look at countries for which quarterly data can be obtained for a reasonable long time period. In this paper the sample of countries is ten major OECD countries, the United States, Japan, Germany, the United Kingdom, France, Italy, Canada, Australia, Switzerland and Sweden for which I have data for time-periods going up to the second quarter of 1992 and starting at 1970[2]. In order to avoid having to deal with very short run fluctuations and long term growth considerations, all data is deseasonalized

[2] For some countries I have data starting at earlier dates. Nevertheless, in order to make comparisons easier, I chose a common initial date.

and rendered stationary by applying a low frequency filter[3]. Altogether the sample of countries account for a major part of aggregate OECD output (around 90 percent) and the countries are sufficiently heterogeneous to provide information for making quite general statements.

Our first investigation is related to the international comovements of output components or the "international business cycle". The results of this investigation are reported in table 1. Data for output components are probably some of the most readily comparable across countries because of coordinated international standards for national accounting. Previous research (see e.g. Blackburn and Ravn (1991) or Danthine and Donaldson (1993)) have highlighted two basic facts. First, that national output levels are highly correlated across countries, and second that also consumption levels are positively correlated but to a smaller degree than output levels. The positive cross-country comovements of output levels is supported by the numbers in part A of table 1 with the exception of Sweden (for Sweden all correlations except that with France are positive but insignificantly different from zero). The second statement, that consumption levels are positively correlated, is also supported but to a smaller degree since both Sweden and Australia, for none of which there is any general applicable rule, are exceptions. Finally, the third element of the traditional wisdom, that output correlations are greater than consumption correlations, can be checked informally by investigating whether the consumption correlation is below the corresponding consumption correlation subtracted two standard errors of the output correlation and vice versa. It turns out that in 20 out of 45 cases the consumption correlation is smaller than the corresponding output correlation less two standard errors of the point estimate while in three cases (Sweden-France, U.K.-Japan and U.K.-Switzerland) the output correlation is smaller than the consumption correlation subtracted two standard errors. This leaves 22 cases indecisive but only three of these have a greater point estimate of the consumption correlation than the corresponding country-pair output correlation. The general impression is that even though the evidence is mixed, output levels are typically stronger related across countries than consumption levels.

The remaining parts of table 1 relate to the cross-country correlation of other output components, correlations that so far has been almost neglected in the literature. Panel 3 reports the results for government spending levels. If these were strongly correlated across countries, government spending could constitute an important source of cross-country comovements. This is not the case, however. Eight of the 45 correlations are significantly positive (the largest of which is 0.46 and relate to Germany-U.S.), three significantly negative (Canada-Italy is the most significant with a point estimate of -0.359) while the rest are insignificantly different from zero. This indicates that a theory building on international comovements being related to international coordination of government spending could be troublesome. This, of course does not mean that government spending by itself can not be a major determinant of international business cycles.

Panels 4-6 report the cross-country correlations of total investment levels and of the sub-components, fixed investment and inventory investment. These panels contains valuable information since they reveal that cross-country comovements of investments are substantial and (with the exception of Sweden) positive. In fact, the cross-country relation between investment levels are in many cases as strong, or stronger, than that between output levels. It should be stressed that while this is true for fixed investment and total investment it does not hold for inventory investment that show no typical relation across countries[4]. Nevertheless, there seems to be an important cross-country connection in these series. Explaining this fact will be important in the next section.

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[3] In the tables I present results from Hodrick-Prescott (1980) filtered data. I have, however, also computed statistics from use of other low frequency filters (first differences and linear trends) which is available upon request. While specific numbers depend quantitatively upon the filter used, most qualitative results remain unchanged.

[4] A note of caution should be mentioned at this point since the figures for inventory investment relate to filtered output ratios while those for fixed and total investment relate to filtered logarithms. The same point is true for net exports.

Finally, panels 7-9 contain the cross-country correlations of exports, imports and the net-exports output ratio. These highlight another important result, namely that exports and imports levels are positively correlated across countries. Furthermore, except for Germany, the contemporaneous correlation of net-exports ratios with the U.S. are negative while 17 out of the remaining 36 numbers are significantly positive and only 4 significantly negative. With respect to net-exports, the United States appears to be an exception that possibly could be important.

Next, we will explore the relation between output and its' sub-components within the ten countries. Estimates of the variability and contemporaneous correlations are given in table 2. Of most interest to my purpose are those relating to the trade variables. As noted by other researchers (see the references above), these relationships have a high degree of cross-country conformity. In particular, imports are strongly positively (and significantly so for all countries) related to output and much more variable than output. Exports are also significantly positively correlated with output (with the exceptions of Australia and Japan) but, with the exception of Sweden, the contemporaneous relationship between imports and output is much stronger than that between exports and output. Furthermore, exports are more volatile than output but, aside from Germany, less variable than imports. The variability of the net-exports ratio of output is typically with a range of 0.75 to 1.1. The exceptions to this rule are the U.S., which have very smooth net-exports, and Sweden and Australia in which this ratio is around 1.5. Finally, with the exceptions of Sweden and Germany, net-exports are significantly negatively correlated with output and for some countries quite strongly so (especially in France, Italy, Japan, and Switzerland).

Table 2 also gives information about the much-discussed positive correlation between savings and investment rates first documented by Feldstein and Horioka (1980) in a cross-section framework, and later also found in time-series by e.g. Obstfeld (1986). It is well recognized that savings are difficult to measure and accordingly I will use the "basic savings" measure of Obstfeld (1986) given by output less private and government consumption. In the current sample, most correlations between domestic savings and investment ratios of output are positive, again with the exception of Sweden. Nevertheless, the evidence is not too strong since the correlation is significantly different from zero only in France, Australia, Switzerland and the U.S. with the U.S. figure being by far the largest. Accordingly, even though investment and savings ratios do seem positively related the data is not very convincing.

Concerning the other output components, the table more or less underlines the traditional wisdom. Consumption is smoother than output (not in Japan, the U.K. and Sweden, though) and substantially procyclical (Sweden excepted), fixed investment and total investment more volatile than output and with high contemporaneous correlations with output. Finally, the inventory-investment ratio of output is procyclical but with some variation in its' volatility across countries.

3 Two Prototype Models

In this section I set up two standard models of international business cycles. Both of these will incorporate capital formation in order to facilitate the analysis of investment dynamics. It would be easy to generate international comovements in line with the data if parameters could be chosen freely and if one disregarded the moments of national business cycles. In order not to bias the results, I will focus on both national and international implications of the models and I will parameterize computable versions of the theories.

3.1 A Single Good Model

The first model is a standard two-country extension of a single-good closed-economy real business cycle model. The two countries will be identified by the index i which can take on two values, 1 and 2. Each country is represented by a single consumer/producer who is a stand-in for a "large" number of identical infinitely-lived individuals. Furthermore, the economies are assumed to be perfectly competitive but possibly distorted. In addition to consumers/producers, each country is endowed with a government. The preferences of the representative agent in country i is given by the expected utility function of the form:

$$U_i = E_0 \sum_{t=0}^{\infty} \beta^t u_i(D_{it}, L_{it}) \tag{1}$$

where U is total discounted lifetime utility, E is the conditional expectations operator, β the subjective discount factor, u is the momentary utility function, D some measure of consumption and L is time devoted to leisure. Momentary preferences are given by the homothetic function

$$u_i = [D_{it}^{\theta} L_{it}^{(1-\theta)}]^{(1-\sigma)}/(1-\sigma)$$

where σ is the rate of relative risk aversion.

Agents are constrained by the amount of time available each period and the number of hours they work cannot be enjoyed as sparetime. They therefore face the time constraint

$$T = L_{it} + N_{it}$$

where N is the number of hours devoted to market activities (work). In the following we will normalize total time to one. The single output good is produced with linearly homogeneous Cobb-Douglas production function:

$$Y_{it} = Z_{it} K_{it}^{\alpha} (H_{it} N_{it})^{1-\alpha} \tag{2}$$

Here Y is the amount of output goods produced, Z is a stationary, possibly random, technology shock, K is the stock of capital, N is number of hours worked, H the rate of labour augmenting (Harrod-neutral) technological progress, and $1-\alpha$ is the labour-share of total income. The Harrod-neutral technological progress process is supposed to grow at the exogenous constant rate $\gamma - 1$ which will be assumed to equal across countries. Capital accumulates according to:

$$K_{t+1} = (1-\delta)K_t + \phi(X_t/K_t)K_t \tag{3}$$

where x is the investment level and $\phi(.)$ is a function that is meant to capture capital-adjustment costs. Adjustment costs are incorporated here in order not too generate "wild" behaviour of investment. It is a basic feature of open-economy real business cycle models that, if investment can flow freely and frictionless across countries, the variability of investment becomes enormous. One way of avoiding this problem is to introduce adjustment costs. If the φ-function is linearly homogeneous we have the standard friction-less capital accumulation equation. Furthermore, we will assume this function is weakly concave and non-negative, $\phi \geq 0, \phi' \geq 0, \phi'' \geq 0$. Further restrictions will be made below.

The government is supposed to spend an exogenous flow of government spending, G, to tax income at a proportional rate, τ, and to levy (or redistribute) lump-sum taxes T. Since, in case of a non-zero proportional tax, taxes are distortionary we have to make some assumptions at this stage in order to solve for the competitive equilibrium. Accordingly, we will assume that individuals take all government variables as exogenous which is consistent with the existence of a "large" number of individuals. This means that we can solve for the competitive equilibrium along the lines in King, Plosser and Rebelo (1988b) by first solving for the individual problem and then imposing the government budget constraint which is given by[5]:

$$G_{it} = \tau_{it} Y_{it} + T_{it} \tag{4}$$

To allow for balanced growth, we will assume that government spending, G, and transfers, T, grow along with H. Notice the assumption that the government balances its budget on a period-by-period basis; it would, of course, be trivial to allow for non-zero government debt.

In many studies government spending is taken to be "down-the-drain" expenditure, i.e. spending that yields no benefits. A more general assumption, and hopefully more realistic as well, is that agents derive at least some utility from government expenditure. One way to model this, used by e.g. Christiano and Eichenbaum (1992) and Aiyagari, Christiano and Eichenbaum (1992), is to assume that government spending enters into the agents utility function in the form of affecting the marginal utility of private consumption:

$$D_{it} = C_{it} + \mu G_{it}$$

where C is private consumption and the parameter μ determines how much government spending affects private marginal utility. If μ is zero (one) government spending does not affect marginal utility of private consumption directly (affects private marginal utility on a one-to-one basis).

The two countries face the aggregate resource constraint given by:

$$(C_{1t} + X_{1t} + G_{1t}) + (C_{2t} + X_{2t} + G_{2t}) \leq Y_{1t} + Y_{2t} \tag{5}$$

In equilibrium no resources will be wasted so we can replace the in-equality by an equality.

At this point it will be useful to convert everything into a non-growing stationary representation. This can be done by dividing all variables by the Harrod-neutral technological progress variable H. Since the functional forms allow for balanced growth, all output components and the capital stock will be growing at the common rate $\gamma - 1$ (see King, Plosser and Rebelo (1987)). Furthermore, hours worked (and leisure) will not be growing. Letting "detrended" variables be represented by lower-case letters, the model in its' stationary representation is identical to the one above with two changes:

$$U_i = E_0 \sum_{t=0}^{\infty} (\beta^*)^t \left[(c_{it} + \mu g_{it})^{\theta} (1 - N_{it})^{(1-\theta)}\right]^{1-\sigma} / (1 - \sigma) \tag{1'}$$

$$\gamma k_{it+1} = (1 - \delta) k_{it} + \phi(x_{it}/k_{it}) k_{it} \tag{3'}$$

[5] In this constraint I have not distinguished between individual and economy-wide variables since this is trivial. One should however keep this aspect in mind.

where β^* is given by $\beta\gamma^{\theta(1-\sigma)}$.

In our first experiments we will consider the simplest version of this model in which the government levies a constant proportional tax rate and finances any differences between spending and tax-revenue by lump-sum taxes. In this model the properties of the competitive equilibrium can be analyzed by solving the model as a pseudo planning problem. First, individuals are supposed to take government actions as given which is consistent with the assumption of a "large" number of individuals. This basically involves ignoring the government budget constraint. After this the planner incurs the government budget constraint so as to make the individual behaviour consistent with aggregate constraints. Furthermore, since we are dealing with more than one representative agent (one in each country) the planner will associate each with a weight, denoted by Π. For each set of weights (Π_1, Π_2) there is an associated competitive equilibrium for a given distribution of initial wealth.

For future reference we can consider how to introduce country-size into the mode!. If we assume that countries are equally wealthy on a per-capita basis but differ in terms of the number (measure) of agents, the appropriate way of including country-sizes is to change the aggregate resource constraint to:

$$\Pi_1(C_{1t} + X_{1t} + G_{1t}) + \Pi_2(C_{2t} + X_{2t} + G_{2t}) = \Pi_1 Y_{1t} + \Pi_2 Y_{2t} \tag{5'}$$

In this formulation one unit of country i consumption, investment or government spending (at the per-capita level) takes up Π_i units of world output and one unit of country i output adds Π_i units to world output. Relative country sizes are then simply given by the ratio Π_1/Π_2.

It is well-known that no closed-form solutions exist for this model and accordingly one needs to approximate the model in some way to investigate the properties of the equilibrium. There are many ways of doing this (see the special issue of Journal of Business and Economics Statistics for an presentation of various methods). Here I will follow King, Plosser and Rebelo (1988a) by linearizing the first-order conditions around the steady state[6]. In order to do so, I will assume that the two countries are symmetric, i.e. that their "deep" parameters are identical. Assuming this, deriving the first-order conditions, linearizing around the steady state and making the appropriate substitutions yields a set of equations in the percentage deviation from steady state[7] which followingly can be used for quantitative investigations.

In order to simulate the model we need to derive the steady state and parameterize the following variables:s_N and s_k which denote the labour and capital shares of output, s_D which is the gross consumption share of output given by sum of the share of private consumption and μ times the share of government spending, s_g and s_x that are the output-shares of government spending and investment. We also need values of ξ_{cc} and ξ_{cL} (ξ_{lc} and ξ_{ll}) which are the elasticities of marginal utility of consumption (leisure) with respect to consumption and leisure, and for ξ_{kk} and ξ_{kN} (ξ_{Nk} and ξ_{NN}) which denote the elasticities of the marginal product of capital (labour) with respect to capital and labour. Finally, we need a value for ξ_ϕ[8], the elasticity of the capital adjustment costs with respect to the investment-capital ratio.

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[6] I have also solved all models by using matrix Ricatti iteration techniques. The resulting moments are almost identical to those using the technique reported in the paper.

[7] These equations are given in an appendix available upon request.

[8] This elasticity is given by the expression $(\partial 1/\phi'/\partial x/k)((x/k)/(1/\phi')$.

3.1.1 Calibration of the Single-Good Model

The parameterization, as in other real business cycle models, can briefly be described as choosing share parameters such that the model replicates mean ratios of the data, and set curvature parameters using results of existing empirical studies. When none of these options are available one either needs to perform a statistical study or to make sensitivity analysis.

Out first set of parameters concern parameters of preferences and labour supply. The number N is the steady state ratio of total time devoted to market activities. This ratio is in Baxter and Crucini (1993), along with King, Plosser and Rebelo (1988), set to 20 percent (which is 50% lower than the corresponding number in e.g. Kydland and Prescott (1982)); I will use this value, even though it seems to be low. Given this number and the parameter values of government shares of output and the production technology, the parameter θ (and therefore the elasticities of marginal utilities) has to be chosen so that $\theta = (s_D/(1-\tau)s_N)(N/1-N)/(1+(s_D/(1-\tau)s_N)(N/1-N))$. In the balanced growth steady-state equilibrium the subjective rate of discount will be determined by the real rate of interest via the relation $\beta = 1/1+r$ which in turn together with the mean growth rate, γ, and the preference parameters, θ and σ, gives β^*. The first of these parameters, the real rate of interest, is normally set to around 6.5% annually, a value that I will use here. The relative rate of risk aversion, σ, is more controversial. Standard values in the literature are 1 (logarithmic utility) or 2. I will use the more risk averse case of these, setting it equal to 2. Finally, we need a value for the effect of government spending on private marginal utility, μ. The range of plausible values of this parameter is the unit interval. A value of one implies that government spending have no effects whatsoever. In the literature standard parameter values that have been used are 0 and 0.5. I will use the former of these but later make some further analysis of the importance of this parameter.

The second set of parameters is related to the production technology and to capital formation. Given the constant returns production function and competitive markets, the parameter $1-\alpha$ is equal to the mean labour share of income. Standard values of this parameter are 58% (King, Plosser and Rebelo (1988)) and 64% (Backus, Kehoe and Kydland (1992a)). To make the study comparable to Baxter and Crucini (1993), I will use the former of these values.

Concerning the technology for accumulating capital we need to choose values for three parameters. The first of these is the rate of depreciation. A commonly used, and uncontroversial, value for this 2.5% per quarter. This implies a mean life-time of new capital of 10 years. Next we will assume, as in Baxter and Crucini (1993), that our model in steady state is identical to one with no adjustment costs. This implies that $\phi(x/k)$ is equal to x/k[9] which from (3') follows as $\gamma-(1-\delta)$. Furthermore, we will assume that Tobin's Q, which is given by $1/\phi'$, is equal to one in steady state so that the price of new capital equals that of ready-installed capital. Finally, we need to make a choice of the value for the elasticity of the adjustment costs, ξ_ϕ. The value of this parameter is more difficult to pin down. Baxter and Crucini (1993) use two different values, 0.075 ("small" adjustment costs) and 0.150 ("big" adjustment costs). I will experiment with the smaller of these values but later argue that even this value is probably too high. Given these parameter values, the capital-output ratio is endogenously given from the first order condition for new capital evaluated at steady state. In particular, it follows that the capital-output ratio is given by $\beta^*(1-\tau)s_k/(\gamma-\beta^*(1-\delta))$.

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[9] Note that the adjustment costs assumptions in Baxter and Crucini (1993) strictly speaking are inconsistent. This is because they assume that ϕ is a strictly ppositive, strictly increasing, concave function. These assumptions are inconsistent with ϕ being equal to i/k at steady state. Furthermore, the strict positiveness of ϕ implies that new capital is added even with zero investment. To avoid these problems I have assumed that ϕ is non-negative, non-decreasing and weakly concave.

The next set of parameters concerns the mean shares of output components. The output share of consumption across countries in the sample is relatively constant around 60% with a maximum of 64% in the U.S. and a minimum of 52% in Sweden[10] (see table 3). The mean shares of government expenditures and investment are more diverse across countries. The shares of government spending (investment) ranges from a low 10 percent (high 31 percent) in Japan to a high 28 percent (low 21 percent) in Sweden. Most countries are, however, relatively close to 20 percent for each components. The problem is, however, that given the share of government expenditure, the shares of consumption and investment are endogenously given by the relation between the investment share and the capital-output ratio. I choose to set the government share equal to 20%, the investment share equal to its implied value, and the consumption share is then given by the residual of these. The constant proportional income-tax rate is set to 30% so that at steady-state the government transfers are 10% of output.

The final set of parameters that we need to address are those related to the stochastic shocks of the model. There are two sources of impulses in this model, technology shocks and government spending shocks[11]. These two sets of variables will be assumed to be generated by bivariate autoregressions:

$$Z_t = A_z Z_{t-1} + e_{zt} \tag{6.1}$$
$$g_t = A_g g_{t-1} + e_{gt} \tag{6.2}$$

where $Z_t = [Z_{1t} \quad Z_{2t}]'$ and $g_t = [g_{1t} \quad g_{2t}]'$ and e_Z and wheree_g will be assumed to be serially independent normally-distributed shocks with variance-covariance matrices Ω_Z and Ω_g. The A-matrices determine the persistence and cross-country spill-overs of technology shocks and government spending shocks while Ω determines the variability and contemporaneous correlation of the innovations to these processes.

Since government spending levels, as discussed in section 2, seem largely unrelated across countries, the matrices A_g and Ω_g will be taken to be diagonal with elements a_g and σ_g^2. The persistence parameter will be assumed to 0.95 while the standard deviation will be taken to be 0.004 (2% of governments mean-share of output). We will perform some sensitivity analysis later.

The process for technology shocks are somewhat complicated to deal with since technology shocks are, after all, unobserved. One way to obtain a measure of these shocks is to derive Solow residuals and then estimate a bivariate vector autoregression of the form specified in (6.1). Nevertheless, such a task is complicated by two problems of measurement. The first problem is associated with obtaining capital stock measures for an array of countries and furthermore it is well-recognized that capital stock figures belong to some of the more unreliable macroeconomic time series. A way of avoiding this problem is to derive series for Solow residuals by assuming that capital stocks are approximately constant over the business cycle. The second problem connects to the measurement of the labour input. A "perfect" measure of the labour input would be quality-adjusted hours-worked series but it is not possible to obtain such series. One may, however, argue that due to the similarities of the set of countries in the sample, neglecting the quality-adjustment presents only a minor problem. Obtaining comparable series of hours-worked is, moreover, also a problem since the measurement of hours-per-worker deviates across countries.

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[10] Sweden is however an outlier in that perspective, the next lowest is Germany with a share of 56%.

[11] One might also wish to model tax-rates as stochastic, a case which is analyzed by e.g. Chang (1992) and Greenwood and Huffman (1991). I will ignore this source of stochastic shocks.

Backus, Kehoe and Kydland (1992a) assume that most of the variation in the Solow residuals come from the number of employed workers and accordingly they estimate Solow residuals from the relation $\ln z_t = \ln y_t - \alpha \ln E_t$ where E is the number of employed persons. They obtain the following estimates for the two-country technology-shock process from a vector-autoregression on the U.S. and an European aggregate: $a_{zz} = 0.906, a_{zz'} = 0.088, \sigma_{zz} = 0.00852$, and $cor(z,z') = 0.258$ where a_{zz} denote the diagonal elements of A_z, $a_{zz'}$ the off-diagonal elements of the same matrix, σ_{zz} the standard deviation of the innovations to the technology shocks and $cor(z,z')$ the contemporaneous correlation of these innovations[12].

I have estimated Solow residuals for nine of the ten countries in the current sample by performing an experiment essentially identical to that of Backus, Kehoe and Kydland (1992a). Sweden was excluded from the sample since no reliable employment data is provided[13]. Sample periods were coordinated to cover the period 1970.1-1992.1 to facilitate cross-country comparisons. Table 4 gives the results of this analysis when all countries are included in bivariate vector-autoregressions with the U.S[14]. Notice that the variance of the innovation to the U.S. series is very similar in the eight estimations and very close to 0.008^2, an estimate practically identical to that of Backus, Kehoe and Kydland (1992a). The standard deviations of the innovation to the other countries' processes (in the VAR's) do, however, differ substantially. Nevertheless, it is still the case that the *average* standard deviation in all cases is close to 0.008. The contemporaneous correlation coefficient (between the innovations to the processes) is in all cases pretty near to 0.25 (the extremes are Germany-U.S. with a correlation of only 0.038 and Canada-U.S. where it is 0.354).

More differences are apparent in the estimates of the A_z matrices. In particular, the spill-overs in technology differ a lot in both signs and magnitudes. There are four cases in which an innovation in one country has a negative effect upon the other country though only in one case is this effect significant (this case relates to the U.S. and Italy). Negative spill-overs present a conceptual problem since one normally would not expect a positive technology shock in one country to make the technology in other countries less effective. The negative coefficients probably reflect problems associated with measurement or the more fundamental problem that Solow residuals may mirror other underlying shocks. Nevertheless, the general impression from the estimates is that the spill-overs are moderate and only in the case of the U.S. and U.K. are they substantial and positive.
After symmetrizing the original matrices, A_z, into matrices that have identical diagonal elements and off-diagonal elements that are identical up to a sign difference, the persistence parameter is quite stable with a mean of 0.835 over the eight estimates. The spill-overs still differ but are in most cases close to 0 (the average is 0.024).

Baxter and Crucini (1993) argue that the Solow residual series are too unreliable and therefore experiment with three different ad-hoc alternatives. These three cases are 1) $a_{zz} = 0.8$, $a_{zz'} = 0.15$, and $cor(z,z') = 0.5$, 2) $a_{zz} = 0.9$, $a_{zz'} = 0.05$, and $cor(z,z') = 0.0$, and 3) $a_{zz} = 0.9$,

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[12] These parameter estimates are symmetric versions of the original least squares results.

[13] The differences between my estimates and those of Backus, Kehoe and Kydland (1992) may be due to the following factors. First, I linearly detrend the series in order to avoid some statistical problems. Second the sample periods differ. Third, we use slightly different series.

[14] The appendix describes how the Solow residual series are estimated and how the estimates are symmetrized.

$a_{zz'} = 0.05$, and $cor(z,z') = 0.2$. The first of these imply very big spill-overs indeed; in fact any difference due to an innovation to technology in one country disappears almost (becomes smaller than 5%) within less than 2 years while this takes more than 7 years in cases 2 and 3[15].

Since there apparently is a great deal of uncertainty associated with the processes describing technologies, I will experiment with three cases. The first (process A) relate to my own estimates taking the persistence to be 0.835, the spill-over zero and the residual correlation to be 0.25. The next (process B) is the estimates of Backus, Kehoe and Kydland (1992a). The final experiment (process C) relates to the first alternative of Baxter and Crucini (1993) implying big spill-overs. It is important to note how different these three processes are even though they all seem to represent reasonable parameterizations (the Baxter and Crucini case the least so though). Figure 1 shows the dynamic evolution of productivity following an innovation to country 1 productivity (taking the innovation-correlation into account). For the A-process the productivity shocks are very temporary and productivity levels across countries are almost unrelated. Using the B-process leads to a very long period of high productivity and it takes a long time for foreign productivity to catch up with the domestic level. In contrast to this, the B-process implies a fast catch-up but less (more) persistence in productivity than in case B (A). The effects of these differences will be evident in the experiments that follow.

3.1.2 Quantitative Analysis of the Single-Good Model

Given the parameter values discussed above, I now move on to a quantitative evaluation of the model. This will be done by simulating the model for a given set of parameter values. The results of the simulations refer to the average of simulations of the model with a length 100 quarters replicated 100 times. The results are reported in table 6[16]. Numbers in parentheses are the standard deviations of the moments over these experiments[17].

The results of our first experiments are given in rows A-C (where A-C refer to the technology processes discussed above). It is noticeable that the models do almost equally well in explaining the correlations between domestic output and consumption and investment levels and in explaining the persistence of output.

For other moments of the model the implications do, however, differ. First, model A which have the smallest root in the technology shock process predicts very low variability of consumption and higher variability of investment that the other parameterizations. The reason for this is the usual, that when shocks are less persistent, investment become more sensitive since agents take advantage of the temporary high productivity whereas consumption becomes smoother because of the usual permanent income considerations. Secondly, the cross-country correlations of output and investment differ markedly across experiments. The reason for this is that these moments are very dependent upon the technology shock processes. Figure 2 illustrates the impulse response functions following an innovation to country 1 technology (again taking the contemporaneous innovation-correlation into account). The spillovers employed in case C are so big that any difference in output and, in particular, in investment levels disappear within

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[15] If one computes bivariate vector-autoregression of the form (13.1) for all combinations of countries in my sample, one only finds two cases with spill-overs that are in the range of case 1). These two cases relate to U.K.-U.S. and Australia-Canada. Both of these cases do, however have lower persistence parameters than that of the example in Baxter and Crucini.

[16] All simulations were carried out in Gauss 2.2 VM and to make the moments comparable across experiments the random number generator was seeded at 7654321 in all experiments. Computer programmes are available from the author upon request.

[17] A more useful statistic may be the standard error of the moments. This number is given by the standard deviation divided by the square root of the number experiments so these can easily be calculated by dividing the standard deviations by 10.

a time-horizon of two years. For case B, the immediate difference in productivity is bigger which leads to oppositely directed immediate responses in investment and output as capital flows to country 1. After only a few periods, however, investment and output increases abroad as technology spills over. These effects explain the negative contemporaneous (positive) contemporaneous correlations of output and investment in case B (C). In case A the explanation is slightly different. Here the only spill-over is due to the contemporaneous correlation of the technology shocks. Furthermore, as discussed above, the shocks are less persistent and the impulses of output and investment are therefore more rapid and disappears faster. As is clear from table 6 and figure 1, domestic and foreign output are largely uncorrelated while investment levels are positively correlated. What one would expect was that investment levels were negatively correlated since there the spill-overs in technology are very small. This intuition is somewhat wrong, however. What happens is that hours-worked abroad decreases since the output good is more efficiently produced abroad. There is also a tendency for investment to be directed to country 1 but this is limited by the adjustment-costs and by the minor increase in foreign productivity. The decrease in foreign hours worked is therefore made-up for by an increase in the foreign capital stock through higher investment but all-in-all foreign output is left almost unchanged. This illustrates that the international comovements are very dependent upon the exact parameterization of the technology shock process.

The international relation between consumption levels is much less dependent upon the technology shock process. When government spending does not affect private marginal utility directly, the only mechanism that bounds this correlation away from one is the intratemporal substitution between consumption and leisure and apparently this effect is not strong enough to limit risk sharing by much.

Comparing the models' moments with those of the data we see that the correlations of domestic consumption and investment with domestic output are relatively close to those in the data. The same is true for the absolute variability and persistence of output. Second, we notice that the models somewhat overestimate the domestic savings-investment correlations since experiments A-B imply larger correlations than in any of the ten countries while the correlation in case C is slightly lower than that of the U.S. but higher than any of the other countries' savings-investment correlations.

In most other respects the models seem further away from the data. First, the relative variability of consumption and investment, and the variability of the net-exports output ratio's are underestimated. This is true for consumption independent of the country we look at, for investment with the exceptions of Italy and Sweden while the variability of the net-exports ratios is close only to the U.S. figure which is around 50% lower than in any other country. Second, while net-exports are countercyclical in all countries, all experiments imply procyclical net-exports. Third models A and B predict negative comovements in output an implication which is at odds with the data. With respect to investment levels, that are positively correlated in the data, experiments A and C do have this implication while B predicts negative or insignificant cross-country correlations. Fourthly, all experiments have very high cross-country correlations (larger than 0.9) of consumption levels. Finally, all models imply very counterfactually that the net-exports ratios of output are almost perfectly negatively correlated across countries.

On this background it does not seem unfair to conclude that these models cannot account for the international business cycle. The models seem in most respects to be very much at odds with the data. Furthermore, only case C had the implication of positive cross country comovements of both output and investment, as in the data. Do, however, recall that this model implies enormous spill-overs of technology that seem highly unrealistic.

Before moving on to some alternative experiments it is worth considering a point in connection to the above analysis. Recall that we included capital-adjustment costs on the basis of limiting the variability of investment but also that it was hard to find any evidence on the elasticity of these costs. The adjustment-cost elasticity in the above experiments was the one named "small" in Baxter and Crucini (1993), but rather surprisingly the models under-estimate the variability of investment relative to the data. An alternative procedure would therefore be to choose the adjustment-cost parameter such that it implies a variability of investment in the range of what is observed in the data. In the data, the investment variability depends very much upon which measure of investment we are using; while the mean over the ten countries for the ratio standard deviations of fixed investment to the standard deviation of output is 2.9 the corresponding statistic for total investment is 4.5. Since all investment in the theoretical model relates to fixed investments we may want to use the former of these figures. Furthermore, it is noticeable that the variability of investment in Italy is very much lower than that in any other country and by excluding Italy the mean ratio of variability of fixed investment to output is raised to 2.97.

The columns numbered A1-D1 of table 4 contain the moments of the model, with the four cases of technology shock processes listed above, when the adjustment-cost parameter is decreased so that the implied variability of investment to output is near 3[18]. It is evident that adjustment-costs have important effects upon the moments of the model. By nature, its' most important function is to limit the investment variability but this affects other relationships. For the present analysis, a significant observation is that a lower ξ_ϕ reduces the cross-country comovements of investment levels and most substantially so for case C where the correlation is reduced from 0.9 to 0.37. This effect is explained by the fact that capital now flows more rapidly to the more productive economy. As a result of this, the correlations between output and net-exports fall but still remain positive. The other counter-factual implications of the models remain as in the previous experiments.

Our final experiment with the standard models is a check upon a suggestion in Backus, Kehoe and Kydland (1992a) who state that the low cross-country comovements of the international real business cycle models can be overturned by a slight change in the parameters of the model. Their example is almost identical to that of case A in that they introduce a closer link between technology across countries. In particular they assume that $a_{zz} = 0.79$, $a_{zz'} = 0.20$, and $cor(z,z') = 0.5$. This parameterization implies quite extreme spill-overs - any productivity difference due to an innovation to technology disappears (is smaller than 5%) with 1-2 years and this is probably highly unrealistic. The results of this parameter configuration are listed in columns D and D1 with D corresponding to a value for ξ_ϕ of 0.075 and D1 with this elasticity chosen so that the implied ratio standard deviation of investment to the standard deviation of output is three. It is noted that most moments resemble that of experiment C with the following differences. First, cross-country output levels are only slightly positively correlated. Second, the variability of investment is very small. The savings-investment correlation on the other hand is insignificantly different from zero. When the elasticity of adjustment-costs is modified, the positive correlation across countries of investment levels disappear and the positive correlation of output levels is significantly reduced (but the savings-investment correlation is raised to a value close to that of the other experiments). Furthermore, the model suffers from the same flaws as the other cases since net-exports are procyclical and quite smooth, consumption levels almost perfectly correlated across countries, and net-exports levels de-facto perfectly negatively correlated.

Summing up, the experiment with the standard single-good two-country model have illustrated that it can not account for key-features of the data.

[18] The implied elasticities of adjustment costs are listed in the appendix.

3.2 A Multiple Goods Model

We will now set up a two-country model in which each country specializes in the production of a single differentiated good. This will allow us, among other things, to make a distinction between exports and imports separately as well as look into relative price movements[19]. The existence of several goods presents a potential problem insofar that we have to make some assumptions about how these goods are converted into a similar standard. One set of assumption would be that countries trade only in consumption goods and that only with-in country goods are useful for capital formation[20]. Such assumptions are, however, not very useful in the sense that they exclude trade in investment that by some authors have been claimed to be the main determinant of trade balance movements (see Stockman and Svensson (1987)). An alternative formulation is to include a technology that converts the output good into a final good. Such an approach is taken by Backus, Kehoe and Kydland (1992b,c) who make use of the Armington aggregator (Armington (1969)) as such a tool. I will follow this approach.

The model is identical to the single-good model with the following changes. Each country produces an output good, Y_i, that can be used at home or exported:

$$Y_{1t} = A_{1t} + A_{2t} \tag{7.1}$$
$$Y_{2t} = B_{1t} + B_{2t} \tag{7.2}$$

where A_{it} and B_{it} are the amount of country 1 and 2 output goods that are used in country i. The production functions continue to be given by (2). Using the output goods, a final good is produced in either country. The function that converts output-goods into final-goods is assumed to be a homogeneous CES function with an elasticity of substitution given by $1/\rho$:

$$V_{1t} = (\omega_1 A_{1t}^{1-\rho} + \omega_2 B_{1t}^{1-\rho})^{1/(1-\rho)} \tag{8.1}$$
$$V_{2t} = (\omega_1 B_{2t}^{1-\rho} + \omega_2 A_{2t}^{1-\rho})^{1/(1-\rho)} \tag{8.2}$$

where $(\omega 1, \omega 2)$ determines the import share (or, alternatively, preference for homegoods). The two economies are subject to the following resource constraints:

$$V_{it} = C_{it} + X_{it} + G_{it} \tag{9}$$

The remaining parts of the model are unchanged with the following exception that we exclude capital-adjustment costs. These were included only to avoid enormous variability of investment in the single-good economy. The present model does not suffer under this problem unless the Armington aggregator is linearly homogeneous. Accordingly, we reformulate the capital accumulation into the standard neoclassical case of:

$$K_{t+1} = (1-\delta)K_t + X_t \tag{10}$$

[19] The relative price in the model of the previous section is, of course, by definition always 1.

[20] This is the set-up used in Ravn (1990) and Stockman and Tesar (1990).

One may, of course, also wish to include adjustment costs in the present model but this is neglected here. This model can, as the previous one, be converted into a non-growing representation by dividing by H, and, as above, all final goods and output goods will grow along with the Harrod-neutral technological progress.

We can measure the equilibrium terms of trade, the relative price of imports to exports, as:

$$p_{1t} = \frac{\partial v/\partial b_{1t}}{\partial v/\partial a_{1t}} = \frac{\omega_2 b_{1t}^{-\rho}}{\omega_2 a_{1t}^{-\alpha}}$$

$$p_{2t} = \frac{\partial v/\partial a_{2t}}{\partial v/\partial b_{2t}} = \frac{\omega_2 a_{2t}^{-\rho}}{\omega_2 b_{2t}^{-\alpha}}$$

and domestic imports and exports in terms of the domestic final good as:

$$ex_1 t = a_{2t}$$
$$im_{1t} = p_{1t} b_{1t}$$

Finally, the net-exports ratio of output will be given by:

$$nx_{1t} = (a_{2t} - p_{1t} b_{1t})/y_{1t}$$

Here we will neglect country size and analyze a symmetric version of the model in which Π_i is set equal to 1/2[21]. We can then approximate the model's behaviour near steady-state as above. Before doing so, I will make a few normalizations. First, assume that the two economies to be symmetric, so that, in steady state, $a_1 = b_2$ and $a_2 = b_1$. From this it is easy to show the following relations:

$$\frac{a_1}{b_1} = \frac{b_2}{a_2} = \left(\frac{\omega_1}{\omega_2}\right)^{1/\rho}$$

Next, denote the import share of output by M_s, i.e. $a_1 = (1 - M_s)y_1$ and $b_1 = M_s y_1$, which then implies that $(1 - M_s)/M_s = (\omega_1/\omega_2)^{(1/\rho)}$. Next we will make the normalization that, in steady state, the output of final goods equal the output of good y. This normalization seems reasonable in light of the symmetry assumptions. This implies that:

$$\omega_1 = (1 - M_s)^\rho \tag{11.1}$$
$$\omega_2 = M_s^\rho \tag{11.2}$$

This model needs the calibration of only two additional variables, the steady state import share, M_s, and the elasticity of substitution ρ. The import share can be calibrated to match the long-run average in the data. The problem with this is that the import (and export) shares of output vary a lot across countries from a high 38.6% in Switzerland to only 7.7% in the U.S.

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[21] If one wish to include country size, (14.1) and (14.2) should be altered into $Y_{1t} = A_{1t} + (\Pi_2/\Pi_1)A_{2t}$ and $Y_{2t} = B_{1t} + (\Pi_1/\Pi_2)B_{2t}$.

The average across countries is around 22.5% with six countries being relatively close to this number. Backus, Kehoe and Kydland (1992b) experiment with shares of 15% (normal import-share) and 30% (big share). Here I will assume the steady state share to be 22.5%, which economically, as well as quantitatively, is not very different from 15%, but some sensitivity analysis will follow. The benchmark value of the elasticity of substitution will be set equal to 1.5 which corresponds to the value used by Backus, Kehoe and Kydland (1992b,c). Part II of table 6 reports the results from simulations of this model. The three first columns, A-C, differ in the technology shock processes and relate to the same cases as in the previous section. Since we now have separate information on imports and exports, moments of these variables are included in the table.

It is noticeable that the model does well in replicating moments of the data that the single-good model could not account for (and it does this in all three cases). In particular, net-exports are now counter-cyclical and this arises - just as in the data - because imports are more procyclical than exports. The pro-cyclicality of imports is, however, very pronounced (above 0.95 in all cases) and higher than observed in the data. This procyclicality is caused by the substitution between inputs in the Armington aggregator; even though a domestic shock increases the share of domestic inputs in the Armington aggregator (since these goods become relatively cheaper) the substitution between goods amounts to an increase in imports. Furthermore, the increase in imports combined with the increase in the terms of trade make net-exports deteriorate in spite of increased exports. Over time, the trade balance recovers and the initial deficit is changed into a surplus.

Thirdly, relative to the single-good model, the output correlation is increased though only substantially positive in the "big" spill-over case. Fourth, cases A and C both imply positive comovements of exports levels across countries (as is the case in the data) while only the latter of these contains a sizable positive correlation of imports levels. Notice also that the present model does not imply very big variability of investments though the point estimates are in the higher end of the range observed in the data.

Nevertheless, the model still suffers under problems similar to the single-good model. First, the consumption levels are generally smoother than we see in the data. Second the net-exports variability resembles only that of the U.S. Furthermore, and maybe more seriously, investment levels are contemporanously negatively correlated across countries (but for reasons that are more subtle than in the single good model[22]) and net-exports levels, just as in the previous case, are almost perfectly negatively correlated. Finally, while exports and imports in the data typically have standard deviations that are 2-3 times higher than output, the model uniformly implies that output, imports, and exports have standard deviations that are almost identical. These implications invalidate the positive effects above.

A key parameter in relation to the movements in relative prices (see Backus, Kehoe and Kydland (1992b,c)) is the elasticity of substitution, ρ. This parameter has been shown to have important effects upon the comovements between e.g. net-exports and the terms of trade and may therefore also be perceived to be important for the international comovements that are addressed in the current paper. In order to investigate this issue, columns B1 and B2 of the table reports the results of using two extreme values of this parameter, 0.5 (B1) and 3 (B2) and both experiments use the technology shock process of column B. While the parameter do affect the

[22] Because of the general substitution framework there is a tendency for foreign investment to increase when domestic productivity is high. This, however, is limited by the desire to increase exports when relative prices are high, which is discussed above, and by the desire to maintain a high consumption level.

moments of the model, it does not seem to have big enough effects to circumvent the counter-factual implications listed above. The very inelastic case, forexample, *do* increase the variability of imports and the comovements of output and exports levels but on the other hand, investment levels still covary negatively across countries and the negative cross-country correlation of imports is worsened.

To investigate in more detail whether the exact values of the two additional parameters, the import share and the elasticity ρ, are important for the international comovements, the cross-country correlations of investment, exports, and imports levels were computed for a range of different values keeping the rest of the parameters constant and using the technology shock process of column B. The results are illustrated in figure 1. The negative comovements of investment levels appear to be a very robust implication of the model that, at least given the other parameters of the model, not easily can be changed. Imports levels also seem robustly to be negatively related unless the import share of output is quite low (below 11-12% which corresponds only to the U.S. case). Exports levels have a greater tendency to become positively correlated since this occurs both for a low import share and/or for a low elasticity.

Summing up, even though the product-specialization model is able to account for aspects of the data, such as imports being more procyclical than exports and net-exports being counter-cyclical, the model is in a number of ways not consistent with the data and it is therefore questionable whether one can claim much success in its' positive elements.

4 Some Further Experiments

In this section I will judge whether some basic changes in the standard models can ward off the counter-factual elements of the theory. The two first experiments are concerned with trying to take account of country-size.

4.1 Country Size in the Two-Country Model

As discussed in section 3.1, country-size can relatively easy be incorporated into the two-country model by changing the parameter Π which enters into both the resource constraints and the objective function of the planner. Analyzing the effects of country-size in this way has been done by e.g. Baxter and Crucini (1993), Ravn (1992) and Stockman and Tesar (1990). This procedure emphasize that big countries have larger effects upon world interest rates and accordingly country size may be important. Nevertheless, it may be argued that this is not the proper way of modelling country size. In particular, within a two-country set-up, the big country will always have very pronounced effects upon the world-economy, effects that seem unreasonable since it as well is only a part of the world-economy. What this set-up *may* be appropriate for is analyses of national business cycles in open economy frameworks. Irregardless of this, I first experiment with this set-up in order to evaluate whether incorporating country size change our understanding of international comovements.

In order to save space, I will concentrate upon the single-good model augmented with country size[23]. Table 4 lists the ten countries' mean share of output in the period 1960-88. The U.S. is seen to be all-dominating with a share of total output within the ten countries only slightly smaller than 50 percent. The other countries are divided into medium sized economies (Japan,

[23] In fact, the model of section 3.2 is also more difficult to handle in the two-country asymmetric country-size framework. The problem is associated with the import shares since there are cross-country consistency restrictions in equilibrium. As an example, assume that the big country accounts for 80% and has an import share of 15%, then this would correspond to an import (and export) share of 60% (!) of the small country (unless the goods are differently priced).

France, Germany, Italy, the U.K., and maybe Canada) which account for 7-13 percent of total activity, and small economies (Sweden, Switzerland, and Australia) each accounting for 1-2 percent of output. Over time, most of these shares have remained relatively constant with some decreases in the shares of especially the U.S and the U.K. and with an upward trend in Japan's share.

My experiments will relate to two situations. The first is a large country (the U.S) against a medium sized country choosing the weight so that $\Pi_1 = 5/6$ and $\Pi_2 = 1/6$. The next experiment is a small country vs. the big economy, setting the weights equal to $\Pi_1 = 95\%$ and $\Pi_2 = 5\%$.

The results of the simulations are given in part III of table 6. The headings A-C refer to the same parameterizations of the technology shocks as in part I; the indices 2 and 3 denote the two cases of country sizes and "big" and "small" refer to the moments of the big and small economies of the model. The message from the simulations are that international comovements are left almost unaltered by the country sizes - neither the cross-country correlations of output, consumption nor investment levels change by much. Elements of national business cycles do, however, change. In particular, the big country starts behaving as a closed economy and the small country becomes very dependent upon the world economy. The most important effects are the following. First, consumption and investment become more (less) variable relative to output in the big (small) economy whereas net-exports and output become more (less) variable in the small (economy). In fact, the variabilities of net-exports increase to numbers comparable with the those in the data. On the other hand, the model also predicts very procyclical net-exports in small countries - a counterfactual implication when contrasted with the data. Furthermore, the contemporaneous correlation between consumption and output and investment and output decreases (increases) as the country becomes smaller (bigger)[24].

These effects follows naturally from the set-up of the asymmetric two-country model. What happens is that the big economy become less able to smooth its' consumption stream using output of the small economy and this makes consumption more sensitive to domestic income. Furthermore, resources can be transferred at a cheap cost to the small economy and, in fact, consumption in the small country become more sensitive to foreign income than domestic income. It also becomes easier to transfer output to investment in the small country but since output of this country adds only little to world output, investment in the end becomes smoother in the small country and more variable in the big country.

Another implication of the model is that the savings-investment correlation should be larger in bigger economies. This, in fact, follows from a relation like the Fisher separation. In the big economy there is a direct relation between the returns to capital, which determines investments, and the world interest rate, which determines savings. This is due to the capital stock of the big economy dominating the world capital stock. Savings in a small economy, as measured here, become very sensitive to foreign income through the effects on consumption, whereas investment still depends on domestic factors. No such clear-cut pattern is found in the data albeit from the fact that the savings-investment correlation is largest in the U.S. - the second and third largest correlations relate to Australia and France. Accordingly, one may feel tempted to restate the Feldstein-Horioka (1980) savings-investment puzzle in terms of country-size.

For reasons which should be clear from the discussion, one is led to conclude that the two-country model with asymmetric country sizes does not seem to make theory much nearer to the data.

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[24] None of these relations to country size seem evident in the data. In fact, and oppostiely to the model's prediction, the variability of output is largest in the biggest economy (the U.S.) and the relative variability of consumption smallest in the biggest economy. Only with respect to the comovements of investment with domestic output do the model and the data seem congruent.

4.2 A Three-Country Model

As discussed above, a two-country model do not seem to be the appropriate tool for analyzing comovements between single economies - after all, any country is only a part of the world economy. In the second column of table 5, I have computed the mean shares of world output of the ten countries and it is noticed that the U.S. share shrinks from 47% to 27% percent and the second largest economy (Japan) from 13 to 7.5 percent. The essence of this observation is that all economies are subject to changes in the state of the world economy. An important consequence of this is that shocks in the world economy, that to some degree, at least, are exogenous to the domestic economy, constitute as common shocks to individual economies though this, of course, may not be completely right in reality due to differences in trade patterns, degree of openness, shares of non-traded goods etc.

The question is how one would model the nature of this common dependence upon the world economy. One way to do this would be to assume that the world real interest rate is exogenous, an assumption used by Marinan and Van Wincoop (1993). Here I will follow another route of investigation and use a very simple modification of the framework in the previous sections. In particular, I will set up a three-country open-economy framework in which one of the countries denote the world-economy. The state of the "world-economy" in this set-up relates naturally to the concept of common dependence of individual economies on the world economy. To keep things simple, I will use the standard single-good framework even though the multiple traded goods model can be handled without the pitfalls that occur in an asymmetric two-country model[25].

The three-country model requires only a few modifications of the framework of section 3.1. The two first are innocuous and relate to the world resource constraint and the planner's objective function. These may now be rewritten as:

$$W = \sum_{i=1}^{3} \Pi_i U_i \tag{12}$$

$$\sum_{i=1}^{3} \Pi_i (Y_{it} - C_{it} - X_{it} - G_{it}) = 0 \tag{13}$$

where we can make the normalization that the shares sum to one. As before, the shares can be related to country size.

The last modification is in practice harder to handle. This modification refers to the technology-shock processes which we now will expand to a three-variate first-order autoregressive process[26]:

$$Z_t = A_z Z_{t-1} + e_{zt} \tag{14}$$

where $Z_t = [Z_{1t} \quad Z_{2t} \quad Z_{3t}]'$ and $e_t = [e_{1t} \quad e_{2t} \quad e_{3t}]'$.

The problem associated with this is the measurement of world output and employment. In principle, one could construct measures for these series but in practise this is not possible both because of the availability of series on a quarterly basis but also because of differences in measurements of output and in particular of employment. The OECD do provide data for

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[25] As discussed above the two-country model with asymmetric country sizes imposes cross-country restrictions on import-shares since these have to add up in steady state. In the three-country model this is no longer the case on a country by country basis, but of course a similar constraint still relates on the overall three-country steady state.

[26] I will keep the assumption of government spending being independent stochastic processes.

aggregate OECD series which in principle could be used apart from the fact that OECD account for only slightly more than 60% of world activity. Another more serious problem is that the OECD series are unreliable in the sense that they are constructed on the basis of annual data and subsequently compiled into quarterly series.

An alternative procedure, applied here, is to use the processes of the previous sections appropriately adjusted for the number of countries. I use the following three processes:

$$A_1 = \begin{pmatrix} 0.835 & 0 & 0 \\ 0 & 0.835 & 0 \\ 0 & 0 & 0.835 \end{pmatrix}, A_2 = \begin{pmatrix} 0.906 & 0.044 & 0.044 \\ 0.044 & 0.906 & 0.044 \\ 0.044 & 0.044 & 0.906 \end{pmatrix}, A_3 = \begin{pmatrix} 0.8 & 0.075 & 0.075 \\ 0.075 & 0.8 & 0.075 \\ 0.075 & 0.075 & 0.8 \end{pmatrix}$$

These parameterizations have the properties that they keep at least one of the eigenvalues of the corresponding two-country processes; forexample, while the transition matrix used in experiments B of table 6.I have eigenvalues of 0.994 and 0.818 the matrix A_2 have eigenvalues of 0.994, 0.862 and 0.862. In principle, there are many ways of transforming the bivariate transition matrices into three-variate processes none of which are unique.

Part IV of table 6 lists the results of simulations of the three-country model. Two alternative cases are analyzed. The first is a case with a big (Π_1 = 27%) and a medium sized (Π = 5%) country facing the world economy. The share of the big country is set equal to U.S.'s mean share of world output as given in table 5 while the medium sized country's share is close to that of the U.K., Germany, France and Japan. The other case is two small countries, each with a share of 1 percent, facing the world economy, a case corresponding to Sweden, Australia, Switzerland or Canada. The number in the table lists in the moments of the two individual countries in each simulation.

The most interesting aspects of these simulations relate to the international perspective since the effects of country size on national business cycle characteristics are identical to those in the previous section. First, note that the near-perfect negative cross country correlations of net-exports are circumvented so that all models now imply positive comovements across countries in net-exports. This is a straightforward result of the common-shocks element of the model - a positive technology shock or a negative government spending shock in the world economy decreases simultaneously the balance of trade in the two individual economies.

On the other hand, the model is not very clear in the predictions concerning comovements of output levels; in fact, only with the technology shock process C is the output correlation substantial and positive but this is at the cost of either a very low, or even a negative, correlation between national savings and investments levels. Furthermore, all alternatives preserve the very high correlations between national consumption levels. The reason for this is, again, that the intratemporal substitution between leisure and consumption is not strong enough to reduce the risk sharing properties of the model with any substantial amount. Also the procyclical behaviour of net-exports remains since the basic mechanism of the two-country model is maintained in the three-country model.

It is also worth noticing that the international positive comovements of investment levels in the data is implied by both cases A and C. However, since all experiments imply very smooth investment levels one may suspect this to be caused by high adjustment-costs as in section 3.1. In fact, if one chooses the elasticity of the adjustment-costs so that the standard deviation is three times bigger than the standard deviation of output, the positive investment correlation is reduced and become insignificant.

4.3 The Effects of Government Spending

The last experiments concerns the role of government spending shocks in the model. As discussed in section 2, government spending in the data seems unrelated across countries and the correlation with domestic output is very small with the exception of Sweden. One possible role for government spending in the model is to limit the cross-country correlation of consumption levels[27]. Recall that in the simulations up to this point, the direct effect of government spending on private marginal utility has been assumed to be zero. When this parameter is non-zero there may be a scope for government spending to reduce this correlation just as Christiano and Eichenbaum (1992) finds that it has a role in reducing the correlation between hours-worked and productivity.

The first observation concerns the effect upon economic activity. This question may be analyzed by use of the coefficients of the linearized system. Inspecting these for the parameterizations of the model of the previous sections it turns out that the effects of government spending are very small compared to those of technology shocks and smaller than in a closed economy framework. The latter observation is explained by the fact that government spending affects output through the reaction of labour supply following the change in the real interest rate brought about by the government spending shock. Since the real interest rate is determined in the world economy, the effects of government spending shocks are smaller in open-economy frameworks. As an example, in the symmetric two-country model, the effects of government spending shocks on domestic output are 30 times smaller than those of an equal sized innovation to technology. This ratio is decreases to 15 in the big country (when this accounts for 5/6 of world output) of section 4.1 but is as low as 90 for the corresponding small country.

The only set of variables for which government spending do seem to have a significant role in the models presented so far, is for the trade variables in the differentiated goods model of section 3.2. In this model the effect of a positive shock to government spending (with technology shock process A) is a decrease in domestic exports of 14% while a technology shock of equal size increases exports by only 4%. Imports, however are still dominated by technology shocks the effects of which are around 8 times bigger than the effects of government spending. Insofar as net-exports are concerned, a unit shock to government spending has an immediate effect of a 6.5% deterioration while the corresponding number for a technology shock is 29%. This indicates that a potential role for government spending in real business cycles is their effect on trade dynamics.

I will now explore whether government spending shocks can have a role in decreasing the cross-country correlation of consumption levels in the open-economy real business cycle framework. I will analyze the effects of two sets of parameters. The first parameter is government spendings' impact on private marginal utility while the other concerns the variability of government spending relative to technology shocks. The cross-country correlation of consumption levels as functions of these two parameters is illustrated in figure 3. The indices A-C again denote the three different technology shock processes.

Increasing the parameter μ has the effect of causing more "direct" crowding-out of private consumption expenditure since government spending becomes a better substitute for private spending. In principle this could reduce the risk-sharing property of the model substantially since our consumption measure relates solely to private consumption expenditure. Nevertheless, figure 3 of the panel illustrates that the effects on the cross-country correlation of increases in this parameter are very minor. The reason for this results is that while increasing μ leads to more crowding out, it also results in a smaller effect upon labour supply and the intratemporal substitution mechanism between consumption and leisure therefore becomes even smaller. Altogether, the two opposing forces leaves the risk-sharing property almost unaltered.

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[27] This possibility has been explored by Bec (1992) in a two-country simulation framework. An empirical analysis of international risk sharing is provided by Canova and Ravn (1993) who do not find much evidence in favour of government spending shocks being the explanation of the "low" international correlation of consumption levels.

The cross-country correlation of consumption as a function of the standard deviation of government spending relative to the standard deviation of technology shocks in the range of 5% to 1000% is illustrated in panel B (the parameter μ is set to 0.5). This ratio is seen to be a much more important device in reducing the consumption correlation of the model. In fact, if the variability of government spending was a free parameter, one could generate a correlation of almost any given size. If one computes the relative variability of government spending shocks to technology shocks that would reduce the cross-country correlation to the highest number observed in the data (0.675 for U.K. vs. Japan) and use the technology shock process A (which implies the lowest correlation of the three cases) one ends up with a number around 2.7-2.75. This implies a standard deviation of government spending around 12% of its mean share which is way above that in the data. Furthermore, it also implies that the model implies a ratio of the standard deviation of government spending to the standard deviation of output of 1.6 which is around 50% higher than the maximum in the data (1.17 for the U.K.).

Summing up, the effects of government spending on economic activity and international risk sharing appear to be disappointing but a potentially interesting role to investigate in the future is the effect upon trade dynamics.

5 Summary and Conclusions

The question I have analyzed in this paper is whether standard international real business cycle models can account for the international comovements that we observe in the data. While economies of the real world do move together as measured by cross-country correlations of output, consumption, investment, imports and exports, some of these comovements can not easily be explained by standard theories. This observation, in my opinion, puts doubt upon the transmission mechanisms and the structure of the current international real business cycle models. This result is of course not to be interpreted that these models can not be useful at all, rather it indicates that important research lies ahead.

One potential problem that needs to be addressed is the measurement of the stochastic processes of the economy. In particular, I experimented with three different parameterizations of the technology-shock processes, all of which seem reasonable but which imply very different dynamic behaviour of technology. Which of these that were used in the experiments affected the results in important ways thereby making it difficult to evaluate the model. There seems to be a necessity for future research on this subject.

There seems to several possibly awarding avenues for future research. One possibility would be to investigate the structure of the goods markets in more detail. The existence of non-traded goods posits one facet of the real world not incorporated in the models analyzed in the current paper. Ravn (1992) and Stockman and Tesar (1990) analyze models with non-traded goods and both finds that these can alter the predictions of the theory substantially. Nevertheless, a problem with these models is that they generally are hard to quantify because of the lack of data on a more disaggregate level.

Another interesting possibility would be to investigate the effects of imperfect labour, goods, or financial markets. The standard models typically assume that there exists a complete set of contingent markets so that countries can trade in contingent debt. While such markets to some degree do exist it seems, however, to be the case that most international asset trade take place in non-contingent debt, the effects of which are analyzed by Baxter (1992) and Baxter and Crucini (1991). Another assumption employed in the standard models is that goods markets are competitive, an assumption that, while being convenient, is probably quite unrealistic. Rotemberg and Woodford (1992) analyze the effects of imperfect competition on the goods markets in a closed-economy framework and find that the market-structure is important. Extending this to an open-economy framework could be interesting.

As a final interesting avenue for future research, a literature is developing around the effects of non-recursive structures associated with information and incentive problems as well as with investment decisions. Of particular interest to international aspects of business cycles is the observation that information and incentive problems may provide explanations for the lack of international risk sharing (see e.g. Atkeson (1991), Atkeson and Lucas (1992) and Marcet and Marimon (1992)). Analyzing the effects of such obstacles in fully-specified aggregate quantitative models seem exciting.

6 Appendix

1. Data description.
All data were compiled from the Datastream database and relate to quarterly seasonally adjusted data. The numbers in tables 1-2 were computed from detrended data using the Hodrick-Prescott (1980) filter choosing λ to be 1,600. In order to make results comparable, the sample periods were uniformly chosen to be 1970.1-1992.2 (with the exception of Sweden where the last observation was 1989.1). All data-series are OECD data for output components and employment. Output relate to GDP in fixed prices except for the U.S. where it is GNP. Consumption is private consumers expenditure in fixed prices with only small differences in definitions. Government spending is government expenditure (Australia, Canada and the U.S.) or government consumption (the rest) in fixed prices. Fixed investment is gross fixed capital formation and inventory investment is the change in stocks, both series in fixed prices. Imports and exports both relate to goods and services and are also in fixed prices. Net-exports is measured as exports less imports divided by output while savings are measured as output less consumption and government spending. Employment relate to total civilian employment (Australia and the U.S.), total employment (Canada, Japan, the U.K. and Germany), employment in industry (France and Italy), or employment in manufacturing (Switzerland).

2. Computation of Solow-residual processes.
Series for "raw" Solow residuals were computed by subtracting the labour-share times the log of the number of employed from the log of output. The labour share was set equal to 58%. I also experimented with a share of 64% but this makes little difference to the moments. To make the results comparable across countries, the time periods were equalized to 1970-1992.2. I detrended the series with linear trends after normalizing the first observation in each series to 1.

Next, I estimated bivariate relationships of the form (7.1) with each country against the U.S. The numbers in table 4 have the U.S. listed as the first variable. From these estimations I computed "semi-symmetric" versions of the A-matrices. These "semi-symmetric" matrices were required to have identical diagonal elements and off-diagonal elements of identical absolute value but of possibly different sign. These matrices were computed by requiring the real and imaginary parts of the eigenvalues of the symmetric versions to be identical to the original transition matrices and by imposing an obvious sign convention. The "semi-symmetric" versions are unique up to the usual sign problem associated with the off-diagonal elements.

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Table 1. Cross country Correlations. I. Output levels

	AUS	CAN	ITA	JAP	SWI	UK	US	WG	SWE
FRA	0.309 (0.080)	0.382 (0.077)	0.579 (0.073)	0.528 (0.060)	0.629 (0.059)	0.614 (0.056)	0.592 (0.064)	0.625 (0.066)	-0.234 (0.081)
AUS		0.771 (0.045)	0.439 (0.062)	0.335 (0.058)	0.413 (0.075)	0.427 (0.081)	0.594 (0.060)	0.371 (0.078)	0.149 (0.093)
CAN			0.451 (0.051)	0.413 (0.065)	0.413 (0.061)	0.645 (0.060)	0.726 (0.035)	0.392 (0.079)	0.167 (0.094)
ITA				0.370 (0.085)	0.735 (0.056)	0.404 (0.091)	0.383 (0.082)	0.560 (0.077)	0.194 (0.123)
JAP					0.525 (0.053)	0.328 (0.086)	0.587 (0.052)	0.673 (0.043)	0.122 (0.099)
SWI						0.300 (0.085)	0.477 (0.072)	0.575 (0.072)	0.059 (0.105)
UK							0.647 (0.052)	0.462 (0.078)	0.108 (0.093)
US								0.697 (0.055)	0.025 (0.101)
WG									0.194 (0.095)

II. Private total consumption levels

	AUS	CAN	ITA	JAP	SWI	UK	US	WG	SWE
FRA	0.177 (0.076)	0.372 (0.083)	0.388 (0.101)	0.471 (0.075)	0.291 (0.081)	0.505 (0.076)	0.599 (0.078)	0.351 (0.097)	0.251 (0.080)
AUS		0.327 (0.074)	0.271 (0.095)	0.151 (0.096)	-0.077 (0.105)	0.099 (0.091)	-0.029 (0.081)	-0.180 (0.080)	-0.117 (0.105)
CAN			0.362 (0.067)	0.115 (0.084)	0.325 (0.065)	0.524 (0.068)	0.517 (0.056)	0.289 (0.105)	0.166 (0.115)
ITA				0.354 (0.076)	0.466 (0.085)	0.423 (0.063)	0.288 (0.100)	0.301 (0.089)	0.188 (0.092)
JAP					0.376 (0.096)	0.675 (0.046)	0.401 (0.074)	0.227 (0.089)	-0.060 (0.097)
SWI						0.488 (0.058)	0.280 (0.086)	0.568 (0.053)	-0.246 (0.097)
UK							0.539 (0.062)	0.329 (0.077)	0.046 (0.097)
US								0.556 (0.071)	-0.094 (0.089)
WG									-0.030 (0.089)

III. Government spending levels

	AUS	CAN	ITA	JAP	SWI	UK	US	WG	SWE
FRA	-0.129 (0.083)	-0.107 (0.083)	0.430 (0.085)	0.186 (0.088)	0.038 (0.098)	0.159 (0.097)	-0.225 (0.081)	-0.072 (0.094)	0.161 (0.090)
AUS		0.101 (0.086)	-0.173 (0.093)	0.014 (0.097)	-0.122 (0.102)	0.085 (0.091)	0.197 (0.093)	0.173 (0.104)	0.158 (0.079)
CAN			-0.359 (0.084)	-0.100 (0.105)	-0.139 (0.090)	-0.128 (0.081)	0.044 (0.083)	-0.215 (0.076)	0.148 (0.092)
ITA				0.019 (0.078)	0.165 (0.087)	0.101 (0.101)	0.190 (0.097)	0.216 (0.082)	0.054 (0.090)
JAP					0.114 (0.078)	0.190 (0.114)	-0.021 (0.091)	0.092 (0.097)	0.106 (0.093)
SWI						0.037 (0.097)	0.022 (0.083)	-0.142 (0.082)	0.140 (0.089)
UK							0.185 (0.081)	0.098 (0.076)	0.255 (0.082)
US								0.459 (0.065)	0.332 (0.084)
WG									0.212 (0.085)

IV. Fixed investment levels

	AUS	CAN	ITA	JAP	SWI	UK	US	WG	SWE
FRA	0.583	0.617	0.664	0.691	0.748	0.363	0.246	0.433	0.064
	(0.059)	(0.058)	(0.046)	(0.043)	(0.037)	(0.089)	(0.087)	(0.074)	(0.090)
AUS		0.383	0.491	0.665	0.502	0.298	0.427	0.294	0.178
		(0.068)	(0.066)	(0.052)	(0.067)	(0.080)	(0.075)	(0.092)	(0.088)
CAN			0.537	0.421	0.458	0.250	0.080	0.059	0.275
			(0.058)	(0.059)	(0.047)	(0.113)	(0.087)	(0.077)	(0.100)
ITA				0.498	0.668	0.298	0.270	0.356	0.205
				(0.061)	(0.053)	(0.080)	(0.078)	(0.083)	(0.103)
JAP					0.650	0.446	0.523	0.535	-0.006
					(0.045)	(0.071)	(0.061)	(0.066)	(0.094)
SWI						0.249	0.375	0.395	-0.013
						(0.071)	(0.073)	(0.062)	(0.091)
UK							0.424	0.196	0.256
							(0.049)	(0.091)	(0.111)
US								0.556	0.033
								(0.076)	(0.096)
WG									0.121
									(0.077)

V. Inventory investment levels

	AUS	CAN	ITA	JAP	SWI	UK	US	WG	SWE
FRA	0.272	0.090	0.480	0.295	0.522	0.360	-0.130	0.177	0.064
	(0.099)	(0.121)	(0.101)	(0.081)	(0.057)	(0.088)	(0.089)	(0.100)	(0.104)
AUS		0.451	0.353	0.302	0.322	0.206	0.317	0.216	0.207
		(0.092)	(0.082)	(0.072)	(0.081)	(0.103)	(0.086)	(0.105)	(0.096)
CAN			0.281	0.221	0.124	0.146	0.443	0.398	0.158
			(0.096)	(0.080)	(0.100)	(0.095)	(0.093)	(0.072)	(0.090)
ITA				0.497	0.301	0.345	0.101	0.429	0.413
				(0.064)	(0.102)	(0.096)	(0.115)	(0.083)	(0.113)
JAP					0.175	0.452	0.036	0.163	0.092
					(0.082)	(0.057)	(0.087)	(0.076)	(0.091)
SWI						0.184	-0.098	0.287	0.187
						(0.086)	(0.083)	(0.069)	(0.096)
UK							0.183	0.291	-0.368
							(0.089)	(0.088)	(0.081)
US								0.193	-0.167
								(0.095)	(0.076)
WG									0.054
									(0.127)

VI. Total investment levels

	AUS	CAN	ITA	JAP	SWI	UK	US	WG	SWE
FRA	0.409	0.353	0.568	0.511	0.674	0.399	0.153	0.411	0.004
	(0.071)	(0.091)	(0.080)	(0.054)	(0.049)	(0.078)	(0.114)	(0.088)	(0.111)
AUS		0.561	0.521	0.577	0.391	0.472	0.457	0.277	-0.084
		(0.061)	(0.076)	(0.052)	(0.066)	(0.079)	(0.081)	(0.089)	(0.119)
CAN			0.462	0.431	0.462	0.189	0.279	0.269	0.283
			(0.067)	(0.058)	(0.056)	(0.089)	(0.070)	(0.082)	(0.085)
ITA				0.341	0.588	0.339	0.130	0.429	0.390
				(0.092)	(0.072)	(0.084)	(0.101)	(0.107)	(0.104)
JAP					0.605	0.473	0.467	0.548	-0.068
					(0.047)	(0.074)	(0.074)	(0.072)	(0.103)
SWI						0.219	0.264	0.377	0.063
						(0.073)	(0.093)	(0.083)	(0.103)
UK							0.594	0.441	-0.172
							(0.059)	(0.089)	(0.089)
US								0.409	-0.301
								(0.086)	(0.080)
WG									-0.006
									(0.109)

VII. Exports Levels

	AUS	CAN	ITA	JAP	SWI	UK	US	WG	SWE
FRA	-0.141	0.529	0.377	0.532	0.637	0.364	0.407	0.473	0.470
	(0.130)	(0.062)	(0.063)	(0.080)	(0.052)	(0.101)	(0.077)	(0.069)	(0.078)
AUS		0.120	0.050	-0.042	-0.154	0.244	-0.320	-0.125	0.003
		(0.102)	(0.096)	(0.097)	(0.100)	(0.087)	(0.120)	(0.127)	(0.091)
CAN			0.306	0.006	0.561	0.268	0.382	0.099	0.548
			(0.102)	(0.086)	(0.075)	(0.087)	(0.072)	(0.095)	(0.070)
ITA				0.164	0.372	0.336	0.175	0.137	0.232
				(0.090)	(0.066)	(0.082)	(0.118)	(0.079)	(0.098)
JAP					0.401	0.279	0.181	0.459	-0.122
					(0.080)	(0.097)	(0.078)	(0.074)	(0.102)
SWI						0.450	0.441	0.391	0.193
						(0.072)	(0.086)	(0.075)	(0.124)
UK							0.217	0.254	0.325
							(0.096)	(0.097)	(0.111)
US								0.231	0.288
								(0.098)	(0.095)
WG									0.393
									(0.079)

VIII. Imports Levels

	AUS	CAN	ITA	JAP	SWI	UK	US	WG	SWE
FRA	0.028	0.392	0.682	0.518	0.737	0.432	0.215	0.354	0.440
	(0.081)	(0.073)	(0.051)	(0.072)	(0.042)	(0.074)	(0.093)	(0.077)	(0.078)
AUS		0.225	0.055	0.393	-0.165	0.088	-0.128	-0.123	0.097
		(0.069)	(0.080)	(0.084)	(0.084)	(0.076)	(0.091)	(0.106)	(0.073)
CAN			0.560	0.470	0.454	0.407	0.280	0.288	0.172
			(0.064)	(0.053)	(0.067)	(0.068)	(0.092)	(0.089)	(0.113)
ITA				0.571	0.646	0.473	0.433	0.599	0.411
				(0.050)	(0.058)	(0.070)	(0.076)	(0.069)	(0.083)
JAP					0.514	0.574	0.167	0.346	0.185
					(0.051)	(0.050)	(0.080)	(0.076)	(0.090)
SWI						0.533	0.504	0.451	0.029
						(0.065)	(0.066)	(0.063)	(0.095)
UK							0.453	0.165	0.264
							(0.061)	(0.107)	(0.082)
US								0.234	0.031
								(0.098)	(0.084)
WG									0.130
									(0.090)

IX. Net Exports Levels

	AUS	CAN	ITA	JAP	SWI	UK	US	WG	SWE
FRA	-0.177	-0.066	0.359	0.386	0.382	0.097	-0.191	0.198	0.222
	(0.081)	(0.083)	(0.097)	(0.075)	(0.069)	(0.097)	(0.094)	(0.077)	(0.099)
AUS		0.350	-0.019	0.189	-0.365	0.303	-0.362	-0.492	-0.201
		(0.077)	(0.084)	(0.081)	(0.084)	(0.083)	(0.064)	(0.061)	(0.075)
CAN			0.067	0.110	0.122	-0.013	-0.595	-0.020	0.296
			(0.104)	(0.089)	(0.086)	(0.073)	(0.068)	(0.083)	(0.086)
ITA				0.224	0.252	0.289	-0.220	-0.057	0.226
				(0.086)	(0.091)	(0.084)	(0.096)	(0.101)	(0.084)
JAP					0.573	0.512	-0.279	0.174	-0.087
					(0.067)	(0.075)	(0.078)	(0.119)	(0.111)
SWI						0.345	-0.077	0.531	-0.152
						(0.081)	(0.104)	(0.082)	(0.106)
UK							-0.024	-0.018	-0.044
							(0.090)	(0.098)	(0.083)
US								0.151	-0.320
								(0.110)	(0.086)
WG									0.108
									(0.062)

Note: Numbers are point estimates and standard errors of these computed from GMM-estimations of the moments. Sample periods and definitions of the data are given in the appendix.

Table 2. Moments of National Business Cycles

A. Variability

	Percentage Standard Deviation								
	Abs.	Relative to output							
Country	Y	C	G	FI	II/Y	TI	EX	IM	NX/Y
France	0.929	0.874	0.704	3.051	0.665	5.098	2.592	4.205	0.756
	(0.065)	(0.088)	(0.064)	(0.120)	(0.055)	(0.255)	(0.161)	(0.243)	(0.049)
Austr.	1.170	0.784	1.299	4.368	0.921	5.987	3.141	6.048	1.466
	(0.087)	(0.055)	(0.122)	(0.354)	(0.075)	(0.363)	(0.312)	(0.877)	(0.130)
Canada	1.445	0.889	0.762	3.061	0.672	4.558	2.812	3.212	0.907
	(0.094)	(0.034)	(0.073)	(0.232)	(0.050)	(0.237)	(0.193)	(0.143)	(0.060)
Italy	1.482	0.762	0.349	1.919	0.910	3.840	2.302	2.627	0.787
	(0.128)	(0.047)	(0.039)	(0.093)	(0.079)	(0.110)	(0.231)	(0.151)	(0.061)
Japan	1.085	1.049	0.543	2.645	0.420	3.058	3.987	5.109	0.733
	(0.097)	(0.068)	(0.157)	(0.126)	(0.039)	(0.134)	(0.322)	(0.449)	(0.053)
Switz.	1.501	0.681	0.505	2.312	1.053	4.265	1.611	2.448	1.103
	(0.132)	(0.037)	(0.063)	(0.193)	(0.102)	(0.214)	(0.115)	(0.160)	(0.063)
U.K.	1.518	1.170	0.566	2.503	0.763	4.401	1.770	2.450	0.954
	(0.114)	(0.057)	(0.080)	(0.237)	(0.056)	(0.299)	(0.217)	(0.225)	(0.073)
U.S.	1.715	0.768	0.563	3.300	0.482	4.472	2.545	2.789	0.523
	(0.116)	(0.034)	(0.056)	(0.086)	(0.043)	(0.181)	(0.259)	(0.184)	(0.029)
Germ.	1.372	0.941	0.884	2.623	0.796	3.858	2.368	1.876	0.887
	(0.100)	(0.059)	(0.108)	(0.135)	(0.050)	(0.188)	(0.208)	(0.122)	(0.059)
Sweden	1.390	1.083	0.587	2.129	1.354	5.406	2.730	3.469	1.575
	(0.086)	(0.113)	(0.065)	(0.189)	(0.119)	(0.473)	(0.299)	(0.343)	(0.139)

Abs. denotes absolute standard deviation. Relative to output denotes the standard deviation of the variable divided by the standard deviation of output.

B. Comovements

	Contemporaneous Correlation with Domestic Output								
Country	C	G	FI	II/Y	TI	EX	IM	NX/Y	S,I
France	0.637	0.250	0.824	0.587	0.838	0.592	0.779	-0.535	0.437
	(0.053)	(0.085)	(0.031)	(0.078)	(0.035)	(0.077)	(0.042)	(0.082)	(0.068)
Austr.	0.532	0.046	0.695	0.487	0.765	0.051	0.328	-0.239	0.371
	(0.061)	(0.096)	(0.036)	(0.082)	(0.032)	(0.113)	(0.076)	(0.043)	(0.039)
Canada	0.866	-0.149	0.641	0.600	0.797	0.654	0.781	-0.257	0.019
	(0.032)	(0.088)	(0.037)	(0.074)	(0.034)	(0.039)	(0.036)	(0.080)	(0.091)
Italy	0.850	0.122	0.833	0.742	0.892	0.307	0.779	-0.533	0.126
	(0.031)	(0.094)	(0.026)	(0.054)	(0.023)	(0.089)	(0.048)	(0.072)	(0.097)
Japan	0.786	0.058	0.877	0.301	0.841	0.032	0.538	-0.458	0.241
	(0.039)	(0.088)	(0.020)	(0.116)	(0.026)	(0.063)	(0.050)	(0.072)	(0.127)
Switz.	0.775	0.272	0.846	0.616	0.871	0.660	0.814	-0.446	0.378
	(0.022)	(0.073)	(0.022)	(0.062)	(0.019)	(0.059)	(0.021)	(0.050)	(0.069)
U.K.	0.858	-0.070	0.719	0.516	0.767	0.437	0.609	-0.374	0.086
	(0.038)	(0.097)	(0.036)	(0.073)	(0.031)	(0.072)	(0.064)	(0.081)	(0.082)
U.S.	0.880	-0.009	0.940	0.564	0.920	0.348	0.746	-0.404	0.677
	(0.019)	(0.098)	(0.012)	(0.070)	(0.013)	(0.070)	(0.039)	(0.069)	(0.051)
Germ.	0.662	0.090	0.797	0.427	0.789	0.464	0.692	-0.090	0.078
	(0.048)	(0.087)	(0.037)	(0.080)	(0.047)	(0.066)	(0.057)	(0.090)	(0.107)
Sweden	0.147	0.373	0.327	0.666	0.630	0.336	0.343	-0.019	-0.262
	(0.103)	(0.080)	(0.096)	(0.068)	(0.055)	(0.101)	(0.084)	(0.104)	(0.083)

See notes to table 1.

Table 3. Shares of Output Components

Country	C	G	TI	FI	II	X	M	NX
France	59.2 (1.13)	18.5 (0.53)	23.8 (2.54)	22.9 (1.98)	0.91 (0.86)	21.1 (2.99)	22.6 (2.70)	-1.49 (1.41)
Austral.	59.0 (1.25)	17.7 (1.23)	25.0 (2.74)	24.6 (2.31)	0.44 (1.09)	15.8 (2.36)	16.3 (3.49)	-0.52 (2.49)
Canada	58.9 (1.12)	24.1 (1.30)	16.7 (2.03)	16.2 (2.13)	0.53 (0.97)	21.9 (4.59)	21.0 (5.60)	0.94 (1.82)
Italy	61.9 (2.02)	16.5 (0.48)	24.4 (2.58)	23.0 (2.23)	1.35 (1.10)	19.7 (2.33)	22.5 (2.45)	-2.71 (1.66)
Japan	60.3 (1.84)	9.85 (0.91)	31.3 (2.62)	30.3 (2.31)	0.98 (0.78)	12.4 (3.74)	13.9 (2.05)	-1.42 (2.89)
Switz.	62.3 (1.60)	13.3 (0.83)	26.9 (3.37)	25.5 (2.56)	1.41 (1.65)	36.1 (4.72)	38.6 (6.64)	-2.47 (2.60)
U.K.	60.9 (2.37)	21.3 (1.16)	18.1 (1.81)	17.6 (1.38)	0.47 (0.97)	24.0 (4.51)	24.2 (4.71)	-0.25 (2.10)
U.S.	63.6 (2.60)	20.8 (2.43)	15.9 (1.28)	15.3 (0.96)	0.56 (0.60)	6.77 (1.86)	7.74 (2.26)	-0.98 (1.12)
Germany	56.1 (2.18)	19.5 (0.78)	23.4 (3.02)	22.7 (1.12)	0.69 (1.12)	27.0 (7.62)	26.0 (6.74)	0.99 (1.81)
Sweden	51.8 (2.02)	28.0 (1.47)	20.9 (2.87)	20.7 (1.62)	0.22 (1.76)	30.6 (3.62)	31.4 (2.17)	-0.81 (3.15)

Numbers are computed from raw-series defined in the appendix. The numbers in paranthese are standard errors of the shares over the sample periods.

Table 4. Estimates of Solow Residual Processes

A. Bivariate Autoregressions with the U.S and country X

X	Estimate of A	Symmetriced A	Residual moments
France	$\begin{pmatrix} 0.923 & -0.116 \\ (0.058) & (0.093) \\ 0.113 & 0.761 \\ (0.038) & (0.060) \end{pmatrix}$	$\begin{pmatrix} 0.842 & -0.082 \\ 0.082 & 0.842 \end{pmatrix}$	$\begin{pmatrix} 0.00775 & 0.212 \\ 0.212 & 0.00499 \end{pmatrix}$
Austr.	$\begin{pmatrix} 0.873 & 0.024 \\ (0.055) & (0.055) \\ 0.078 & 0.741 \\ (0.072) & (0.072) \end{pmatrix}$	$\begin{pmatrix} 0.807 & 0.079 \\ 0.079 & 0.807 \end{pmatrix}$	$\begin{pmatrix} 0.00781 & 0.202 \\ 0.202 & 0.01024 \end{pmatrix}$
Canada	$\begin{pmatrix} 0.866 & 0.020 \\ (0.060) & (0.040) \\ 0.044 & 0.929 \\ (0.065) & (0.043) \end{pmatrix}$	$\begin{pmatrix} 0.898 & 0.043 \\ 0.043 & 0.898 \end{pmatrix}$	$\begin{pmatrix} 0.00781 & 0.354 \\ 0.354 & 0.00841 \end{pmatrix}$
Italy	$\begin{pmatrix} 0.945 & -0.119 \\ (0.053) & (0.045) \\ 0.240 & 0.777 \\ (0.068) & (0.057) \end{pmatrix}$	$\begin{pmatrix} 0.860 & -0.147 \\ 0.147 & 0.860 \end{pmatrix}$	$\begin{pmatrix} 0.00752 & 0.278 \\ 0.278 & 0.00963 \end{pmatrix}$
Japan	$\begin{pmatrix} 0.906 & -0.040 \\ (0.062) & (0.063) \\ 0.130 & 0.774 \\ (0.061) & (0.062) \end{pmatrix}$	$\begin{pmatrix} 0.840 & -0.029 \\ 0.029 & 0.840 \end{pmatrix}$	$\begin{pmatrix} 0.00808 & 0.275 \\ 0.275 & 0.00797 \end{pmatrix}$
Switz.	$\begin{pmatrix} 0.892 & -0.015 \\ (0.060) & (0.055) \\ 0.144 & 0.768 \\ (0.066) & (0.060) \end{pmatrix}$	$\begin{pmatrix} 0.830 & -0.042 \\ -0.042 & 0.830 \end{pmatrix}$	$\begin{pmatrix} 0.00781 & 0.241 \\ 0.241 & 0.00866 \end{pmatrix}$
U.K.	$\begin{pmatrix} 0.789 & 0.107 \\ (0.061) & (0.044) \\ 0.117 & 0.793 \\ (0.103) & (0.073) \end{pmatrix}$	$\begin{pmatrix} 0.790 & 0.112 \\ 0.112 & 0.790 \end{pmatrix}$	$\begin{pmatrix} 0.00756 & 0.160 \\ 0.160 & 0.01267 \end{pmatrix}$
W.G.	$\begin{pmatrix} 0.899 & -0.028 \\ (0.057) & (0.048) \\ 0.205 & 0.726 \\ (0.071) & (0.061) \end{pmatrix}$	$\begin{pmatrix} 0.813 & 0.042 \\ 0.042 & 0.813 \end{pmatrix}$	$\begin{pmatrix} 0.00780 & 0.038 \\ 0.038 & 0.00983 \end{pmatrix}$

Note: Estimations were performed using least-squares. Numbers in the column "residual moments" denote: residual standard deviations in the diagonal, residual correlations in the off-diagonal. Numbers in parantheses are standard errors. Numbers are computed from bivariate vector-autoregressions with no deterministic terms included. The estimation procedure is described in the appendix.

Table 5. Relative country sizes, means of 1960-1988

Country	Share of 10 country output	Share of world output
USA	46.8	27.2
JAPAN	13.0	7.5
FRANCE	7.6	4.4
WG	9.2	5.3
ITALY	6.8	3.9
SWEDEN	1.3	0.8
SWITZ.	1.3	0.7
UK	7.7	4.5
AUS.	2.2	1.3
CAN	4.1	2.4

Parameter Values for simulations:

Parameter values common to all experiments unless otherwise stated:

Labour Share of Income =58%,
Relative Rate of Risk Aversion, σ=2,
Steady state no. of Hours Worked = 20%,
Depreciation rate of Capital =2.5% per quarter,
Real Interest Rate per quarter =1.625% per quarter,
Growth Rate =0.4% per quarter,
Discount factor β^* =0.988,
Steady-state government share of output =20%,
Proportional tax rate =30%,
Steady-state consumption share =59.3%
Government spending effect on private utility, μ=0,
standard deviation of government spending =0.004,
Persistence of government spending =0.95,
Standard deviation of technology shocks = 0.00852.

Experiments with standard single-good two-country model

Experiment A:
Steady-state Tobin's Q =1
Persistence of technology shock ρ_{ZZ} =0.835,
Spillover of technology shock $\rho_{ZZ'}$ =0.0,
Correlation of innovations $cor(Z,Z')$ =0.25,
Adjustment-cost elasticity ξ_{ϕ} =0.075,

Experiment B:
Steady-state Tobin's Q =1
Persistence of technology shock ρ_{ZZ} =0.906,
Spillover of technology shock $\rho_{ZZ'}$ =0.088,
Correlation of innovations $cor(Z,Z')$ =0.258,
Adjustment-cost elasticity ξ_{ϕ} =0.075,

Experiment C:
Steady-state Tobin's Q =1
Persistence of technology shock ρ_{ZZ} =0.8,
Spillover of technology shock $\rho_{ZZ'}$ =0.15,
Correlation of innovations $cor(Z,Z')$ =0.5,
Adjustment-cost elasticity ξ_{ϕ} =0.075,

Experiment D:
Steady-state Tobin's Q =1
Persistence of technology shock ρ_{ZZ} =0.79,
Spillover of technology shock $\rho_{ZZ'}$ =0.2,
Correlation of innovations $cor(Z,Z')$ =0.5,
Adjustment-cost elasticity ξ_{ϕ} =0.075,

Experiment A1:
As A but ξ_{ϕ} =0.0575

Experiment B1:
As B but ξ_{ϕ} =0.03125

Experiment C1:
As C but ξ_{ϕ} =0.01875

Experiment D1:
As D but ξ_{ϕ} = 0.01

Experiments with product-differentiation model

Import Share =22%
ω_1 = 0.8474 and ω_2 = 0.3664
Indices A-C refer to the same technology shock processes as above.

Experiments with two-country assymmetric country-size model.

Indices A-C refer to the same technology shock processes as in standard two-country model.
Indices 2 refer to experiments where Π_1 = 1/6 and Π_2 = 5/6.
Indices 3 refer to experiments where Π_1 = 5% and Π_2 = 95%

Experiments with three-country model.

Experiment A:
Persistence of technology shock ρ_{ZZ} =0.835,
Spillover of technology shock $\rho_{ZZ'}$ =0.0,
Correlation of innovations $cor(Z,Z')$ =0.25,

Experiment B:
Persistence of technology shock ρ_{ZZ} =0.906,
Spillover of technology shock $\rho_{ZZ'}$ =0.044,
Correlation of innovations $cor(Z,Z')$ =0.258,

Experiment C:
Persistence of technology shock ρ_{ZZ} =0.8,
Spillover of technology shock $\rho_{ZZ'}$ =0.05,
Correlation of innovations $cor(Z,Z')$ =0.5,

Table 6. Simulation Results
I. The Single-Good Two-Country Model

	Experiment							
Moment	A	B	C	D	A1	B1	C1	D1
STD(y)	1.535	1.372	1.338	1.212	1.557	1.413	1.393	1.251
	(0.187)	(0.178)	(0.147)	(0.135)	(0.191)	(0.191)	(0.158)	(0.146)
AU(y)	0.640	0.645	0.617	0.588	0.611	0.674	0.632	0.611
	(0.080)	(0.074)	(0.079)	(0.081)	(0.081)	(0.075)	(0.078)	(0.079)
STD(c)/STD(Y)	0.366	0.646	0.587	0.771	0.348	0.618	0.527	0.723
	(0.037)	(0.084)	(0.053)	(0.074)	(0.035)	(0.081)	(0.047)	(0.071)
STD(x)/STD(Y)	2.803	1.799	2.306	1.598	3.064	3.052	3.005	3.009
	(0.448)	(0.275)	(0.226)	(0.160)	(0.502)	(0.440)	(0.386)	(0.418)
STD(nx/y)	0.625	0.647	0.618	0.630	0.545	0.434	0.356	0.323
	(0.079)	(0.080)	(0.058)	(0.060)	(0.077)	(0.092)	(0.048)	(0.055)
COR(c,y)	0.796	0.696	0.844	0.809	0.800	0.697	0.850	0.813
	(0.055)	(0.073)	(0.036)	(0.043)	(0.054)	(0.077)	(0.034)	(0.043)
COR(x,y)	0.951	0.986	0.906	0.904	0.964	0.913	0.976	0.906
	(0.016)	(0.005)	(0.023)	(0.027)	(0.012)	(0.023)	(0.007)	(0.019)
COR(nx/y,y)	0.718	0.780	0.582	0.623	0.700	0.572	0.515	0.332
	(0.085)	(0.071)	(0.107)	(0.094)	(0.089)	(0.117)	(0.142)	(0.155)
COR(y,y*)	-0.055	-0.255	0.281	0.175	-0.041	-0.267	0.312	0.181
	(0.153)	(0.145)	(0.140)	(0.145)	(0.154)	(0.147)	(0.139)	(0.146)
COR(c,c*)	0.914	0.966	0.977	0.984	0.906	0.963	0.973	0.982
	(0.028)	(0.012)	(0.008)	(0.005)	(0.031)	(0.013)	(0.010)	(0.006)
COR(x,x*)	0.482	-0.185	0.901	0.852	0.339	-0.682	0.371	-0.366
	(0.119)	(0.149)	(0.031)	(0.045)	(0.135)	(0.083)	(0.133)	(0.129)
COR(nx,nx*)	-0.998	-0.998	-0.999	-0.999	-0.998	-0.997	-0.999	-0.999
	(0.001)	(0.001)	(0.000)	(0.000)	(0.002)	(0.002)	(0.000)	(0.000)
COR(s/y,x/y)	0.795	0.792	0.505	0.061	0.864	0.867	0.899	0.862
	(0.066)	(0.073)	(0.096)	(0.124)	(0.049)	(0.043)	(0.035)	(0.039)

II. The Product-Specialization Two-Country Model

Moment	Experiment A	B	C	B1	B2
STD(y)	1.527	1.288	1.369	1.162	1.381
	(0.189)	(0.173)	(0.165)	(0.151)	(0.190)
AU(y)	0.648	0.672	0.594	0.667	0.683
	(0.079)	(0.074)	(0.078)	(0.074)	(0.073)
STD(c)/STD(Y)	0.329	0.683	0.532	0.773	0.632
	(0.022)	(0.068)	(0.035)	(0.059)	(0.072)
STD(x)/STD(Y)	4.543	4.287	4.298	4.106	4.780
	(0.180)	(0.288)	(0.255)	(0.273)	(0.353)
STD(ex)/STD(y)	0.966	0.986	1.073	0.998	1.181
	(0.139)	(0.146)	(0.132)	(0.160)	(0.157)
STD(im)/STD(y)	1.047	1.083	1.102	1.663	1.090
	(0.045)	(0.053)	(0.045)	(0.094)	(0.111)
STD(nx/y)	0.397	0.409	0.387	0.514	0.558
	(0.044)	(0.047)	(0.036)	(0.058)	(0.071)
COR(c,y)	0.891	0.820	0.905	0.901	0.763
	(0.026)	(0.054)	(0.020)	(0.027)	(0.067)
COR(x,y)	0.950	0.864	0.914	0.869	0.831
	(0.013)	(0.039)	(0.020)	(0.040)	(0.044)
COR(ex,y)	0.475	0.240	0.479	0.214	0.136
	(0.120)	(0.144)	(0.118)	(0.150)	(0.149)
Cor(im,y)	0.966	0.955	0.970	0.926	0.765
	(0.013)	(0.015)	(0.008)	(0.029)	(0.080)
COR(nx/y,y)	-0.462	-0.544	-0.423	-0.653	-0.361
	(0.132)	(0.116)	(0.126)	(0.099)	(0.143)
COR(y,y*)	0.194	-0.089	0.442	0.114	-0.202
	(0.148)	(0.154)	(0.120)	(0.152)	(0.152)
COR(c,c*)	0.599	0.874	0.921	0.787	0.912
	(0.123)	(0.044)	(0.027)	(0.068)	(0.032)
COR(x,x*)	-0.120	-0.781	-0.212	-0.709	-0.843
	(0.144)	(0.058)	(0.137)	(0.075)	(0.043)
COR(ex,ex*)	0.300	-0.015	0.308	0.169	-0.399
	(0.157)	(0.170)	(0.137)	(0.152)	(0.144)
COR(im,im*)	0.074	-0.232	0.176	-0.590	-0.343
	(0.147)	(0.142)	(0.142)	(0.102)	(0.135)
COR(nx,nx*)	-0.999	-0.999	-0.999	-0.999	-0.999
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
COR(s/y,x/y)	0.952	0.924	0.952	0.952	0.885
	(0.018)	(0.023)	(0.014)	(0.016)	(0.030)

III. Two-Country Model with Assymetric Sizes

	Experiment											
Moment	A2 Small	A2 Big	B2 Small	B2 Big	C2 Small	C2 Big	A3 Small	A3 Big	B3 Small	B3 Big	C3 Small	C3 Big
STD(y)	1.675	1.380	1.515	1.243	1.407	1.288	1.726	1.339	1.567	1.199	1.432	1.267
	(0.021)	(0.163)	(0.197)	(0.154)	(0.154)	(0.151)	(0.213)	(0.158)	(0.204)	(0.149)	(0.157)	(0.150)
AU(y)	0.644	0.625	0.653	0.659	0.605	0.632	0.646	0.623	0.652	0.660	0.601	0.637
	(0.078)	(0.078)	(0.077)	(0.073)	(0.080)	(0.080)	(0.078)	(0.079)	(0.076)	(0.073)	(0.080)	(0.080)
S(c)/S(Y)	0.336	0.459	0.586	0.745	0.559	0.630	0.337	0.503	0.575	0.798	0.553	0.651
	(0.053)	(0.020)	(0.095)	(0.054)	(0.065)	(0.030)	(0.057)	(0.018)	(0.097)	(0.048)	(0.069)	(0.026)
S(x)/S(Y)	2.886	3.170	1.637	2.412	2.383	2.748	2.920	3.342	1.591	2.665	2.483	2.964
	(0.423)	(0.077)	(0.247)	(0.085)	(0.141)	(0.065)	(0.409)	(0.061)	(0.232)	(0.120)	(0.110)	(0.071)
S(nx/y)	1.042	0.209	1.078	0.216	1.030	0.206	1.188	0.063	1.230	0.065	1.175	0.062
	(0.133)	(0.026)	(0.134)	(0.027)	(0.097)	(0.020)	(0.152)	(0.008)	(0.154)	(0.008)	(0.111)	(0.006)
COR(c,y)	0.465	0.956	0.455	0.878	0.709	0.940	0.330	0.968	0.364	0.919	0.654	0.959
	(0.117)	(0.012)	(0.111)	(0.036)	(0.063)	(0.017)	(0.132)	(0.008)	(0.122)	(0.012)	(0.074)	(0.011)
COR(x,y)	0.879	0.987	0.926	0.975	0.656	0.993	0.847	0.992	0.878	0.960	0.542	0.990
	(0.039)	(0.004)	(0.027)	(0.008)	(0.076)	(0.002)	(0.048)	(0.003)	(0.042)	(0.012)	(0.096)	(0.003)
COR(nx/y,y)	0.769	0.632	0.823	0.721	0.633	0.541	0.784	0.603	0.835	0.695	0.650	0.519
	(0.072)	(0.099)	(0.058)	(0.078)	(0.098)	(0.091)	(0.068)	(0.105)	(0.054)	(0.083)	(0.095)	(0.095)
COR(y,y*)	-0.036	-	-0.240	-	0.286	-	-0.023	-	-0.227	-	0.291	-
	(0.152)		(0.143)		(0.136)		(0.151)		(0.143)		(0.134)	
COR(c,c*)	0.932	-	0.969	-	0.978	-	0.944	-	0.972	-	0.979	-
	(0.022)		(0.011)		(0.008)		(0.018)		(0.010)		(0.007)	
COR(x,x*)	0.488	-	-0.118	-	0.921	-	0.496	-	-0.062	-	0.934	-
	(0.119)		(0.162)		(0.026)		(0.118)		(0.166)		(0.021)	
COR(nx,nx*)	-0.998	-	-0.998	-	-0.999	-	-0.998	-	-0.998	-	-0.999	-
	(0.001)		(0.001)		(0.000)		(0.001)		(0.001)		(0.000)	
COR(s/y,x/y)	0.517	0.969	0.052	0.980	-0.107	0.952	0.497	0.997	-0.281	0.998	-0.264	0.996
	(0.129)	(0.010)	(0.165)	(0.006)	(0.136)	(0.014)	(0.146)	(0.001)	(0.142)	(0.006)	(0.131)	(0.001)

IV. Three-Country Model

	Experiment								
	$\Pi_1 = 5\%, \Pi_2 = 27\%$						$\Pi_1 = \Pi_2 = 1\%$		
Moment	A Small	A Big	B Small	B Big	C Small	C Big	A	B	C
STD(y)	1.681	1.579	1.620	1.508	1.465	1.381	1.711	1.656	1.482
	(0.214)	(0.207)	(0.224)	(0.217)	(0.177)	(0.174)	(0.217)	(0.228)	(0.178)
AU(y)	0.627	0.662	0.663	0.667	0.611	0.610	0.626	0.663	0.609
	(0.085)	(0.091)	(0.077)	(0.084)	(0.082)	(0.086)	(0.085)	(0.077)	(0.082)
S(c)/S(Y)	0.303	0.341	0.491	0.540	0.502	0.537	0.344	0.517	0.515
	(0.052)	(0.056)	(0.087)	(0.094)	(0.064)	(0.067)	(0.066)	(0.102)	(0.076)
S(x)/S(Y)	2.261	2.489	1.880	2.066	2.002	2.230	2.248	1.842	2.150
	(0.181)	(0.186)	(0.073)	(0.113)	(0.222)	(0.222)	(0.231)	(0.119)	(0.076)
S(nx/y)	1.051	0.867	0.975	0.804	1.004	0.828	1.216	1.127	1.167
	(0.134)	(0.114)	(0.145)	(0.120)	(0.106)	(0.090)	(0.140)	(0.155)	(0.112)
COR(c,y)	0.457	0.606	0.396	0.521	0.668	0.737	0.293	0.281	0.598
	(0.139)	(0.112)	(0.159)	(0.134)	(0.095)	(0.071)	(0.155)	(0.166)	(0.106)
COR(x,y)	0.885	0.907	0.960	0.955	0.755	0.823	0.831	0.926	0.627
	(0.035)	(0.032)	(0.013)	(0.013)	(0.071)	(0.049)	(0.049)	(0.025)	(0.095)
COR(nx/y,y)	0.808	0.749	0.855	0.798	0.711	0.640	0.779	0.826	0.682
	(0.061)	(0.083)	(0.050)	(0.073)	(0.081)	(0.105)	(0.074)	(0.007)	(0.091)
COR(y,y*)	0.091	-	-0.029	-	0.316	-	0.161	0.068	0.352
	(0.191)		(0.205)		(0.158)		(0.189)	(0.204)	(0.153)
COR(c,c*)	0.903	-	0.956	-	0.972	-	0.921	0.961	0.973
	(0.033)		(0.016)		(0.010)		(0.029)	(0.015)	(0.010)
COR(x,x*)	0.411	-	-0.272	-	0.795	-	0.398	-0.311	0.812
	(0.143)		(0.182)		(0.063)		(0.146)	(0.177)	(0.059)
COR(nx,nx*)	0.168	-	0.164	-	0.185	-	0.466	0.462	0.482
	(0.184)		(0.197)		(0.153)		(0.153)	(0.165)	(0.125)
COR(s/y,x/y)	0.533	0.622	0.733	0.743	0.051	0.259	0.360	0.534	-0.133
	(0.120)	(0.108)	(0.080)	(0.070)	(0.175)	(0.140)	(0.141)	(0.129)	(0.163)

Figure 1. Productivity Dynamics

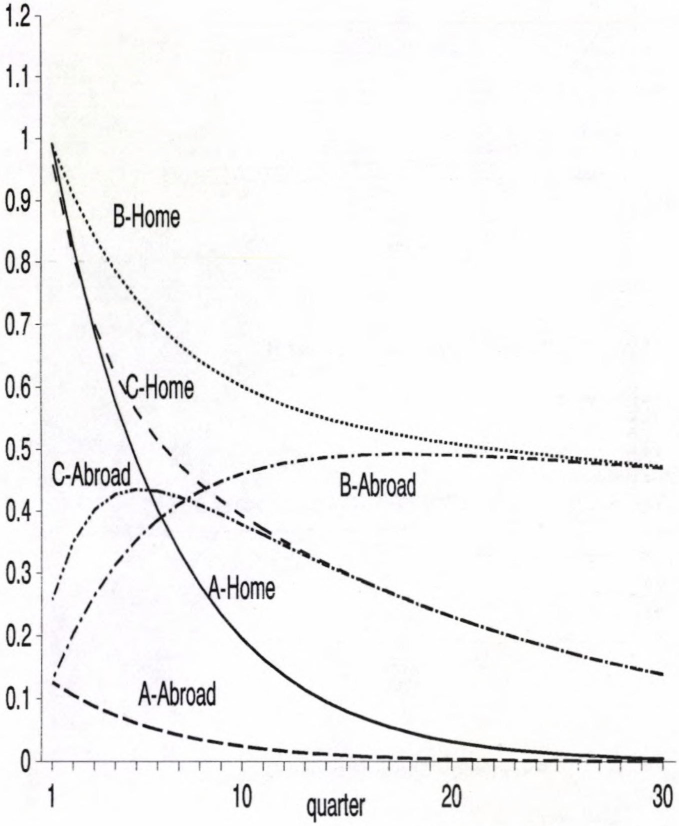


Figure 2. Dynamics of Output and Investment

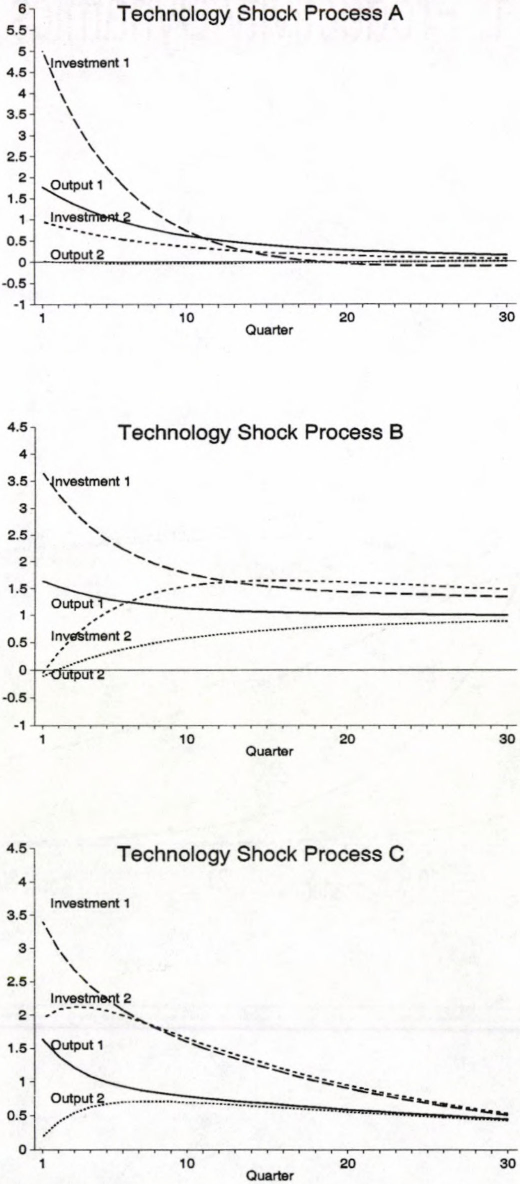


Figure 3. International Comovements

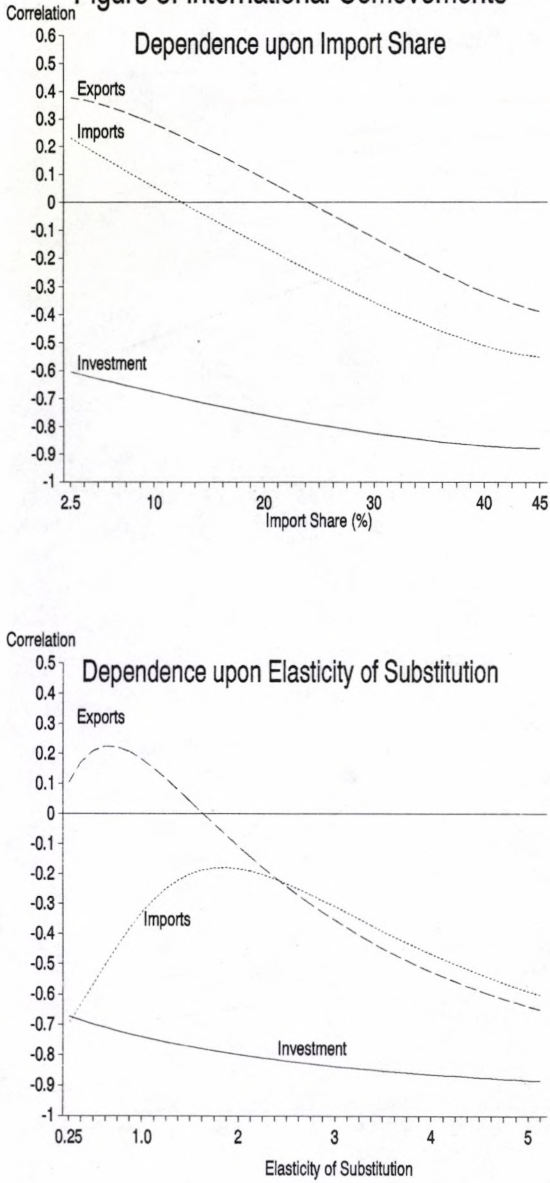
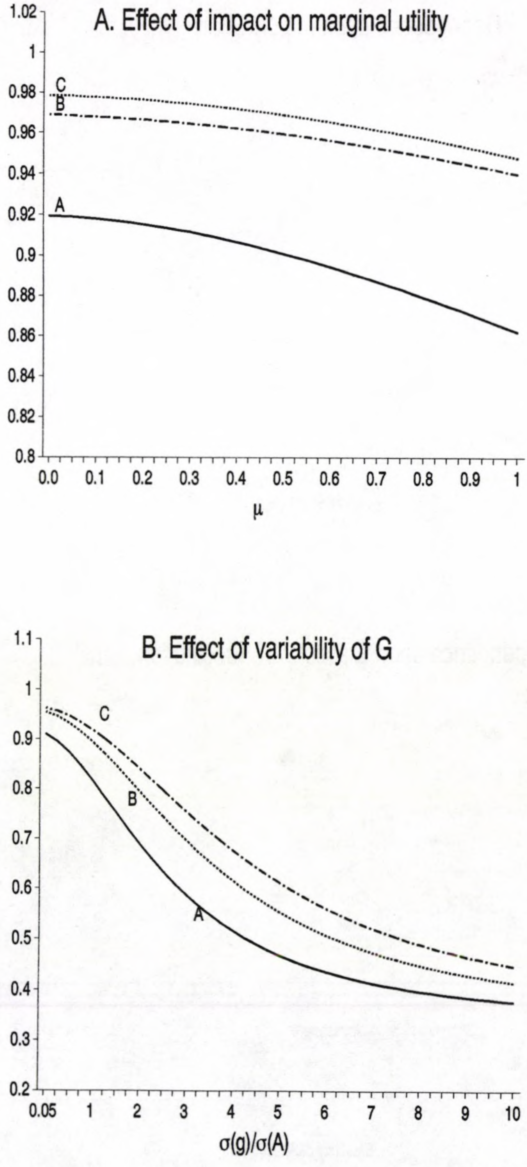


Figure 4. Risk-Sharing and Government Spending



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