

A Multi-Country Real Business Cycle Model with Heterogeneous Agents

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Abstract

A multi-country real business cycle model is developed capturing two important aspects of heterogeneity found in household survey data: only a small fraction of the population holds stock, and a significant fraction of non-stockholders are borrowing constrained. The model is applied to data for twenty OECD countries. It generates cross-country consumption correlations consistent with those observed in the data. Potential welfare gains from international portfolio diversification by stockholders are large, leaving the observed “home bias” as a significant puzzle. The model can also account for the finding in U.S. data that consumption of stockholders is more volatile than that of non-stockholders.

I. Introduction

Standard open and closed economy real business cycle models assume the presence of a single representative agent. But there is plenty of micro evidence of heterogeneity. In particular, a common finding in household survey data is that only a small fraction of households own stock. And among non-stockholders, a significant fraction is often found to be borrowing-constrained. In the Netherlands, the Dutch Social Economic Panel reports that in 1989, 7.8% of households held shares or options. In Italy, the Survey of Household Income and Wealth reports that in 1989, 7.6% of households held equities or investment fund units. A 1977 wealth survey in France reports that only 6.4% held stocks and shares.¹ Similar evidence is available for non-European countries. The Family Savings Survey by the Statistics Bureau in Japan shows that in 1986 only 20% of surveyed households held any stock. For the U.S., Mankiw and Zeldes (1991) report that only 28% of households surveyed in the 1984 Panel Study of Income Dynamics own any stock at all. Moreover, the standard deviation of

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¹ See Kessler and Masson (1987).

consumption growth of the group of stockholders is found to be 50% higher than of the group of non-stockholders.

With respect to borrowing constraints, the Italian Survey of Household Income and Wealth reports that in 1987, 16% of the surveyed households were either denied credit or discouraged from borrowing.² Similarly, according to the 1983 U.S. Survey of Consumer Finances, 19% of households answered that in the past few years they were turned down for credit or did not apply because they thought they might be turned down.

In the closed economy real business cycle literature, some attempts have been made to allow for heterogeneity of agents. Danthine and Donaldson (1991, 1992) study models with three types of agents: entrepreneurs, young and old workers. Workers do not own stock and cannot borrow or lend. The old workers engage in an optimal risksharing arrangement with entrepreneurs, while the young are partially insured through an optimal social insurance system of a minimum wage and unemployment compensation. The authors focus on the implications of their model for standard closed economy business cycle statistics, and the equity premium puzzle. Gomme and Greenwood (1990) study a model with entrepreneurs and workers who engage in an optimal risksharing arrangement, and show that such implicit insurance contracts can account for the observed countercyclical labor income share.

A multi-country real business cycle model with two types of agents, referred to as capital owners and labor, is developed in this paper. In the spirit of the papers quoted above, as well as the household survey data, it is assumed that all capital is owned by capital owners. All labor income is earned by labor. Either all labor or only a fraction of labor is assumed to have access to an international bond market. With respect to the capital owners, we investigate the cases where they only hold domestic capital (the benchmark), and where they are perfectly internationally diversified. French and Poterba (1991) and Tesar and Werner (1994, 1995) document a significant "home bias" in stock and bond portfolios. For example, at the end of 1989, U.S. investors held 94% of their equity portfolio in U.S. stock, while Japanese residents held 98% in Japanese stock.

The model in this paper differs from those discussed above most significantly in that it is an open economy model and that it deals with a different set of questions. The first question we focus on is whether this incomplete markets setting can account for the low observed cross-country consumption correlations. And would these cross-country consumption correlations be significantly larger if capital owners are well diversified across countries? The issue of low cross-country consumption correlations has

been a central element in the open economy real business cycle literature, which has shown that consumption correlations in complete markets models are significantly higher than what is observed in the data; see e.g. Backus, Kehoe and Kydland (1992). The second question studied is the size of potential welfare gains from international portfolio diversification for capital owners. This connects with the rapidly growing literature on potential welfare gains from international risksharing. Clearly, if the welfare gains from portfolio diversification were low, small costs could account for the observed lack of diversification.

The model is applied to twenty OECD countries for the period 1970–89. It can generate consumption correlations across countries that are close to what is observed in the data. Moreover, consumption correlations are still low if capital owners are perfectly diversified across countries. The essential element of market incompleteness that generates the low cross-country consumption correlations is therefore the lack of risksharing opportunities for labor. It is also found that the welfare gains from portfolio diversification for capital owners are quite large, so that the model cannot account for the observed home-bias in portfolios. Finally, the model can generate the Mankiw-Zeldes (1991) observation for the U.S. that the variability of consumption of stockholders (capital owners) is significantly higher than that of non-stockholders (labor). More work needs to be done in order to know whether this is a stylized fact that is valid for other countries as well.

The remainder of the paper is organized as follows. The model is developed and its solution discussed in Section II. The OECD data are described in Section III. Model calibration is addressed in Section IV. The results from model simulation, and the computation of gains from portfolio diversification, are discussed in Sections V and VI. The final section summarizes the main findings.

II. The Model

Consider a world with J countries. Country i has H_i individuals. The world population is $H = \sum_{i=1}^J H_i$. All variables below are denoted in per capita terms. Each country produces the same good. The production technology in country i is CES:

$$y_{it} = e^{\theta_i} (\alpha (X_t N_{it})^{1-1/\varepsilon} + (1-\alpha) K_{it}^{1-1/\varepsilon})^{\varepsilon/(\varepsilon-1)}, \quad (1)$$

where N_{it} is the fraction of time devoted to work and K_{it} is the capital stock in country i . ε is the elasticity of substitution between capital and labor. X grows at the deterministic rate g : $X_{t+1} = (1+g)X_t$. θ_i follows an AR process:

² See Guiso, Jappelli and Terlizzese (1994) for evidence on the Italian survey data.

$$\theta_{i,t+1} = \rho_\theta \theta_{it} + u_{i,t+1}. \quad (2)$$

The production shock u_{it} is $N(0, \sigma_i^2)$ i.i.d. distributed. The contemporaneous correlation of production shocks across countries is ω . The standard deviation of the shock is allowed to be different across countries.

For now, assume that capital owners in each country hold all the capital of that country. Capital owners can also borrow and lend through an international bond market with a stochastic real interest rate r_{t+1} from period t to $t + 1$, which is common across countries. At date t , after observing the technology shock, capital owners choose how much labor to employ, how much to consume and how much to invest. Dependent on these decisions, there will be a change in their bond holdings.

Capital owners in country i maximize expected utility

$$E_1 \sum_{t=1}^{\infty} \beta^t \frac{(c_{it}^{\text{cap}})^{1-\gamma}}{1-\gamma} \quad (3)$$

where E_1 is the expectation at time 1. Leisure does not explicitly enter this utility function since capital owners are assumed not to work, leading to constant leisure. Utility (3) is maximized subject to a budget constraint, capital accumulation equation and a transversality condition:

$$B_{i,t+1} = (1+r_t)B_{it} + y_{it} - I_{it} - w_{it}N_{it} - c_{it}^{\text{cap}} \quad (4)$$

$$K_{i,t+1} = (1-\delta)K_{it} + \phi\left(\frac{I_{it}}{K_{it}}\right)K_{it} \quad (5)$$

$$\lim_{t \rightarrow \infty} E_1 \beta^t (c_{it}^{\text{cap}})^{-\gamma} B_{it} = 0. \quad (6)$$

Here B_{it} denotes bonds, w_{it} is the wage rate, and I_{it} investment in country i and period t . The adjustment cost function $\phi(\cdot)$ is concave.

First-order conditions from maximization are

$$(c_{it}^{\text{cap}})^{-\gamma} = E_t \beta (1+r_{t+1}) (c_{i,t+1}^{\text{cap}})^{-\gamma} \quad (7)$$

$$E_t \beta (1-\alpha) (c_{i,t+1}^{\text{cap}})^{-\gamma} e^{(1-1/\epsilon)\theta_{i,t+1}} (y_{i,t+1}/K_{i,t+1})^{1/\epsilon} + E_t \beta \left[1 - \delta + \phi_{i,t+1}(\cdot) - \phi'_{i,t+1}(\cdot) \frac{I_{i,t+1}}{K_{i,t+1}} \right] \frac{(c_{i,t+1}^{\text{cap}})^{-\gamma}}{\phi'_{i,t+1}(\cdot)} = \frac{(c_{it}^{\text{cap}})^{-\gamma}}{\phi'_{it}(\cdot)} \quad (8)$$

$$\alpha (X_t e^{\theta_{it}})^{1-1/\epsilon} (y_{it}/N_{it})^{1/\epsilon} = w_{it} \quad (9)$$

where E_t is the expectation conditional on information at time t . Equation (7) is an intertemporal consumption tradeoff condition; (8) is a tradeoff condition between consumption and investment; and (9) is the labor demand equation, setting the marginal product of labor equal to the wage rate.

Since hours worked is a choice variable for labor, we explicitly add leisure ($L = 1 - N$) to their utility function. Labor in country i maximizes

$$E_1 \sum_{t=1}^{\infty} \beta^t \frac{(c_{it} F(L_{it}))^{1-\gamma}}{1-\gamma}. \quad (10)$$

This is the most general form of utility capturing the observation that per capita hours worked displays no trend, while income, consumption, investment and capital all grow at the same rate in the deterministic steady state.³ Capital owners have the same utility function, but their leisure is constant. The intertemporal elasticities of substitution of consumption and leisure are, $1/\gamma$, and

$$\xi = 1 / \left(\frac{L F_{LL}}{F_L} - \gamma \frac{L F_L}{F(L)} \right) > 0,$$

respectively.

Labor chooses how much time to work and how much to consume. A fraction λ of labor in each country has access to the bond market. The rest simply consumes its income. This “rule of thumb specification” is chosen to reflect borrowing constraints. Econometric estimates of λ for the U.S. by Campbell and Mankiw (1989) and Beaudry and van Wincoop (1996), and for six OECD countries by Campbell and Mankiw (1991), show values significantly above zero.

With a time endowment of one, labor that does not have access to the bond market maximizes $w(1-L)F(L)$, leading to constant leisure, implicitly defined by $F(L) = (1-L)F_L(L)$. Let L_{it}^A , $N_{it}^A = 1 - L_{it}^A$, and c_{it}^A denote leisure, hours worked, and consumption of labor in country i that does have access to the bond market. They maximize (10), subject to the budget constraint

$$A_{i,t+1} = (1+r_t)A_{it} + w_{it}N_{it}^A - c_{it}^A, \quad (11)$$

and transversality condition

$$\lim_{t \rightarrow \infty} E_1 \beta^t (c_{it}^A)^{-\gamma} F(L_{it}^A)^{(1-\gamma)} A_{it} = 0. \quad (12)$$

Here A_{it} denotes bond holdings by labor in country i . First-order conditions from maximization are

$$(c_{it}^A)^{-\gamma} (F(L_{it}^A))^{(1-\gamma)} = E_t \beta (1+r_{t+1}) (c_{i,t+1}^A)^{-\gamma} (F(L_{i,t+1}^A))^{(1-\gamma)} \quad (13)$$

and

³ See King, Plosser and Rebelo (1987).

$$c_{it}^A = \frac{F(L_{it}^A)}{F_L(L_{it}^A)} w_{it}. \quad (14)$$

Equation (13) is an intertemporal consumption tradeoff condition, while (14) represents the intratemporal tradeoff between consumption and leisure.

Finally, equilibrium in the labor and bond markets requires

$$N_{it} = \lambda N_{it}^A + (1 - \lambda) \bar{N}, \quad (15)$$

$$\sum_{i=1}^J \frac{H_i}{H} (A_{it} + B_{it}) = 0. \quad (16)$$

Here \bar{N} denotes the constant labor supply by workers who do not have access to the bond market. World bond market equilibrium is achieved through the endogenous world interest rate.

This completes the description of the model. The equilibrium is fully described by the dynamic system of $10J + 1$ equations (2), (4), (5), (7)–(9), (11), (13)–(16), plus the initial state of the economy K_{i0} , θ_{i0} , A_{i0} , B_{i0} and transversality conditions on the level of bonds for labor and capital owners. There are $10J + 1$ corresponding variables: I_{it} , K_{it} , N_{it} , N_{it}^A , θ_{it} , c_{it}^{cap} , c_{it}^A , w_{it} , B_{it} , A_{it} , r_{t+1} . As in almost all real business cycle models, there is no closed form solution. The numerical solution method of King, Plosser and Rebelo (1987) has been shown to work well for both open and closed economy models. After loglinearization around the steady state, the method obtains loglinear approximations of the decision rules for the control variables. An extension to multi-country analysis, developed in van Wincoop (1995b), is used to solve the model here. Details can be found in an Appendix that is available from the author on request.

III. The OECD Data

The model is applied to annual data for twenty OECD countries from 1970 to 1989. Aggregate consumption contains a significant durables spending component. Here we follow van Wincoop (1994) to correct for durability by converting flow data into stock data. The following consumption categories from the United Nations National Accounts Statistics are used: (1) food, (2) clothing and footwear, (3) furniture, household equipment and operation, (4) personal transportation, (5) rest. The final category consists primarily of services, which are mostly non-durables. For categories (2), (3) and (4), which are to a great extent durables, a rate of

depreciation of 0.5, 0.4, and 0.3, respectively, is assumed in order to calculate their stock.⁴ Assuming a CES consumption index, the five categories are aggregated into a single consumption index. The results are not very sensitive to the assumed elasticity of substitution among the various categories, which is therefore assumed to be one. For the four remaining OECD countries, Portugal, New Zealand, Luxembourg and Turkey, data are not available at this disaggregated level.⁵

Data on investment (gross fixed capital formation) and output (GDP) at constant prices are also from the United Nations National Accounts Statistics.

Data on hours worked are taken from the Yearbook of Labour Statistics, but are not available for all countries. Employment data for the entire sample period are not available for five countries and data on hours worked per week in non-agricultural activities are available for only six countries for the entire sample period. Instead, I used data on hours worked per week in the manufacturing sector, which are available for almost all countries for the entire sample period. For countries in the sample where hours per week in non-agricultural activities are available as well, they are highly correlated with hours per week in the manufacturing sector. Total hours are therefore approximated as total employment times hours per week in the manufacturing sector. Data on total hours are available for the entire sample period for 14 countries.

Data on consumption, investment, output and total hours worked are all divided by the population.

A laborshare variable is constructed by dividing labor income by GDP minus indirect taxes plus subsidies. These data are from the OECD National Account Statistics.

The second column of Table 1 reports various moments based on these variables. In order to make results comparable to previous studies, all

⁴ This implies that these categories will depreciate to 10% of their original value over a period of 3.3, 4.5, and 6.5 years, respectively. For these consumption categories, the stock of durables at time zero is computed as

$$D(0) = \frac{1}{g+v} \sum_{t=1}^T \frac{1}{T} \frac{1}{(g+v)^t} E(t),$$

where v is the rate of depreciation and g the mean growth rate of the flow variable E over the sample. Subsequently the stock of durables evolves according to $D(t+1) = (1-v)D(t) + E(t+1)$.

⁵ For Japan, the UN does not publish data on category (4), personal transport. Those data were obtained from the Annual Report on National Accounts by the Economic Planning Agency, Government of Japan.

variables other than consumption growth are HP(100) filtered, leaving cycles of 4 to 6 years. Time series moments are averages over countries (standard deviations) or over pairs of countries (correlations). The “low frequency moments” are across pairs of countries.

On average, consumption is slightly less volatile than income. If we had not controlled for durability, the average standard deviation of consumption growth would have been 2.25 per cent, slightly higher than output volatility. The average consumption correlation across pairs of countries is 0.46, slightly higher than the 0.43 correlation of income across countries. The cross-country consumption correlation is usually reported to be lower than the cross-country income correlation. The first study to emphasize this finding is Backus, Kehoe and Kydland (1992). They report cross correlations with the same variable in the U.S. for both output and consumption, using quarterly HP filtered data from 1960 to 1989. The average

Table 1. *Data and model moments*

	Model		
	Data	Benchmark	Portfolio diversification
	Standard deviations		
c_i	1.87	1.87 (0.13)	1.65 (0.14)
y_i	1.99	1.99 (0.21)	1.99 (0.21)
I_i	6.24	6.24 (0.33)	6.24 (0.33)
g_{c_i}	1.88	2.25 (0.13)	1.97 (0.14)
$g_{c_i}^{cap}$	—	3.10 (0.14)	1.54 (0.25)
$g_{c_i}^{labor}$	—	2.14 (0.14)	2.14 (0.14)
N_i	1.84	1.84 (0.30)	1.84 (0.30)
$w_i N_i / Y_i$	2.38	0.49 (0.08)	0.49 (0.08)
	Correlations		
c_i, c_j	0.46	0.23 (0.09)	0.34 (0.10)
y_i, y_j	0.43	0.43 (0.11)	0.43 (0.11)
c_i, y_j	0.81	0.91 (0.01)	0.94 (0.01)
	Low frequency moments		
$\sigma_{corr(c_i, c_j)}$	0.27	0.28 (0.03)	0.26 (0.03)
$\sigma_{corr(y_i, y_j)}$	0.32	0.26 (0.04)	0.26 (0.04)
$corr[corr(c_i, c_j), corr(y_i, y_j)]$	0.75	0.88 (0.03)	0.91 (0.03)

Notes: The data moments are based on annual data for 20 OECD countries from 1970 to 1989. Data other than consumption growth are HP filtered. Time series moments are averages over countries or sets of countries. Low frequency moments are standard deviations and one correlation across pairs of countries. Model moments are averages of corresponding data moments over 100 simulations of a 20-year period, with standard deviations in brackets. The first column under model moments shows the results for the benchmark parameterization, where capital owners only hold domestic capital. The last column shows the results for the same parameterization as in the benchmark, but allowing for perfect portfolio diversification by capital owners.

cross-country correlations for consumption and output are 0.19 and 0.31, respectively. The difference is easily explained. Backus, Kehoe and Kydland used consumption data that are not adjusted for durability. If we do not control for durability in our sample, the average cross-country consumption correlation is 0.39, 0.04 below that of the output correlation. And if we only consider cross correlations with the U.S., the consumption correlation is 0.1 lower than the output correlation for unadjusted data, quite similar to what was found by Backus, Kehoe and Kydland.⁶

Nonetheless, the average cross-country consumption correlation we find is still quite low. Differences in the consumption series across countries are further illustrated in Figure 1, which plots the HP filtered series for the last 10 countries in the sample. While some common movements can be noted, such as the consumption boom at the end of the 1970s, and the recession in the early 1980s, these pictures also reflect the widely different experiences of individual countries. Countries differ in the number of cycles they go through, the timing of the cycles, and their sensitivity to the global business cycle. Figure 2 shows a scatter plot of consumption and income correlations across all sets of countries. Note first that there is significant variation of both consumption and income correlations across countries. Table 1 reports that $corr(c_i, c_j)$ has a standard deviation of 0.27 across all

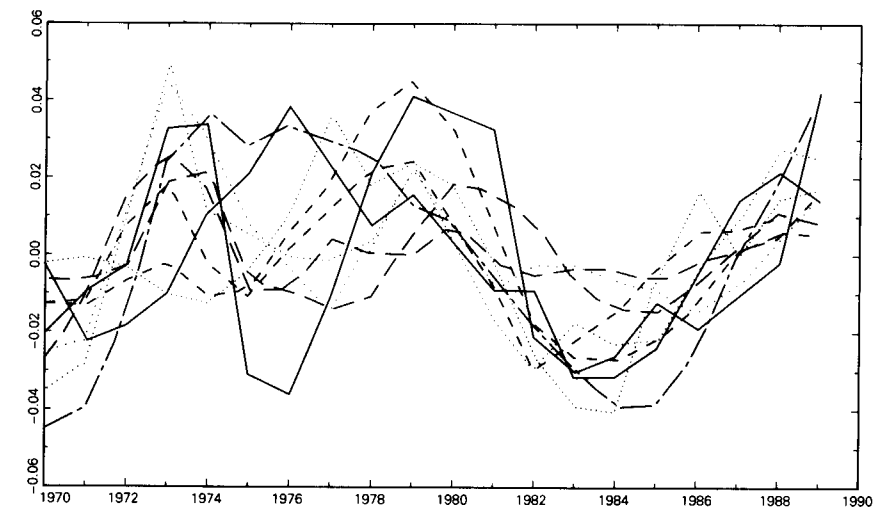


Fig. 1. HP(100) filtered consumption (last 10 countries sample).

⁶ Baxter and Crucini (1991) also found cross-country consumption correlations that are lower than output correlations. But they also use consumption data that are not adjusted for durability.

sets of countries. Figure 2 also shows that when the output correlation across two countries is high, the consumption correlation tends to be high as well. Table 1 reports a correlation of 0.75 between $\text{corr}(c_i, c_j)$ and $\text{corr}(y_i, y_j)$ across sets of countries. Possibly related to this is a high time series correlation of 0.81 between consumption and income. Consumption appears quite sensitive to country specific shocks to output.

IV. Model Calibration

We now turn to the choice of parameters in the benchmark parameterization.

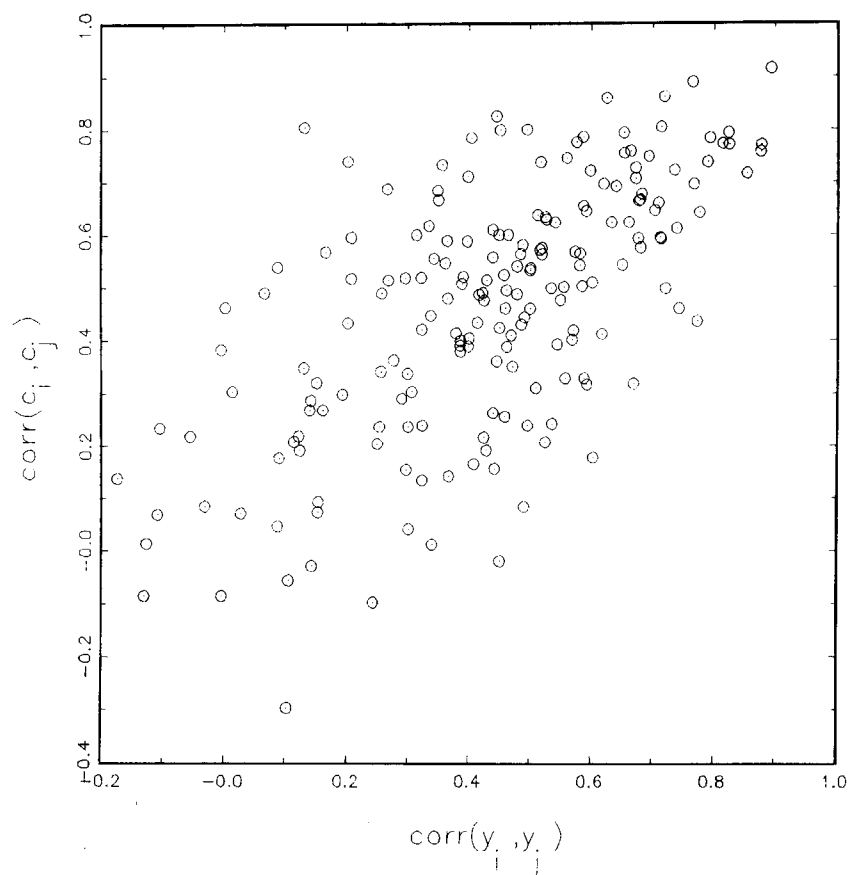


Fig. 2. Cross-country consumption and output correlations.

Beaudry and van Wincoop (1996) show that estimates of the intertemporal elasticity of substitution of consumption (IES) $1/\gamma$ are very imprecise when based on aggregate data. Using regional U.S. data including 19 states, it was found that a 1% increase in the real interest rate, holding income constant, leads to a 0.5% increase in expected consumption growth, with a standard error of 0.12%. This result holds no matter whether it is based on the standard Euler equation or “rule of thumb” consumers are allowed for, even though the rule of thumb specification performs better, with an estimated 50% of consumption by rule of thumb consumers (similar to estimates in the Campbell-Mankiw papers). This implies an IES of one when half of consumption is accounted for by “rule of thumb” consumers, but an IES of 0.5 when no allowance is made for “rule of thumb” consumers. Because of the *ad hoc* character of the rule of thumb specification, under the benchmark specification it is assumed that $\lambda = 1$ and $\gamma = 2$ (IES = 0.5). The combination $\lambda = 0.5$ and $\gamma = 1.001$ (IES = 1) is considered in the sensitivity analysis.

In the deterministic steady state of the model, the consumption growth rate is $g = (r + \beta - 1)/\gamma$. The average per capita growth rate of consumption over all countries and the 20-year sample period is 2.3%, so that $g = 0.023$. Using data from the IFS statistics on money market interest rates, and the CPI index, the average real interest rate over the sample and the 14 countries for which data are available is 0.85%. For positive time discount rates, this observation cannot be matched in the model. This is what Weil (1989) referred to as the low risk-free rate puzzle. Instead, here I set $\beta = 0.99$, implying $r = 5.6\%$ when $\gamma = 2$ and $r = 3.3\%$ when $\gamma = 1$.

According to the Yearbook of Labor Statistics, the average workweek is 39.87 hours. The average is taken over the entire sample period and over the fourteen countries used to calculate total hours worked. This is a fraction 39.87/168 of the time endowment. Together with a choice for the intertemporal elasticity of substitution of labor, ξ , this is used to set the first- and second-order derivatives of the function $F(L)$ at the steady state.⁷ Since a higher ξ generally implies more volatility of hours, ξ is set such that the standard deviation of (HP filtered) hours worked matches that found in the data.

The average labor share over the entire sample period and all countries

⁷Use the fact that in steady state $F(L) = (1-L)F_L(L)$, and that

$$\xi = 1 \left/ \left(\frac{LF_{LL}}{F_L} - \gamma \frac{LF_L}{F(L)} \right) \right.$$

and assume $F(\bar{L}) = 1$.

is 0.6012. The parameter α is set such that this is also the steady state laborshare in the model. More uncertainty exists about the appropriate choice for ε . Setting it at 1 (Cobb-Douglas production) is inconsistent with the large average standard deviation of the labor share of 2.38%. Instead, ε is set at 4 in the benchmark parameterization since this allows us to generate the Mankiw and Zeldes (1991) observation that consumption of stockholders is significantly more volatile than that of non-stockholders. The rate of depreciation of capital δ is chosen to be 0.1, a common assumption in real business cycle models. The other three "production" parameters involve the adjustment cost function ϕ . It is assumed that $\phi(\delta+g) = \delta+g$ and $\phi'(\delta+g) = 1$, so that the deterministic steady state of the model is the same as that without adjustment costs. $\eta = -(\phi'/\phi'') \div (I/K)$ is the elasticity of the investment-capital ratio with respect to Tobin's q ($1/\phi'$). A higher η leads to more investment volatility in the model. It is set such that the average investment volatility generated by the model matches that found in the data.

The parameters σ_i , ρ_{it} , and ω concern the shocks to the country specific production technologies. Since data on hours worked as well as the capital stock are available for only nine countries, Solow residuals are not calculated. Instead, the ratio of the standard deviations of Solow residual innovations in countries i and 1 (σ_i/σ_1) is set equal to the ratio of the standard deviations of output in these two countries. The parameters σ_1 , ρ_{it} , ω , ξ and η are set jointly so that the average standard deviations of HP filtered consumption, output, hours worked, investment, and the cross-country correlation of output, all match those in the data. This allows us to focus on other aspects of the model, which are the object of this paper.

The relative country size H_i/H is based on 1980 GDP shares. Finally, since the level of bonds is non-stationary, the level of bonds at time zero is another parameter. For both workers and capital owners it is set at zero.

To summarize, the parameters in the benchmark parameterization are $\lambda = 1$, $\gamma = 2$, $g = 0.0234$, $\beta = 0.99$, $\xi = 0.4931$, $\alpha = 0.802$, $\varepsilon = 4$, $\delta = 0.1$, $\eta = 2.705$, $\sigma_u = 0.025$, $\rho_{it} = 0.9898$, $\omega = 0.1189$, $B_0 = 0$, and $A_0 = 0$.

V. Results

The results based on the benchmark parameterization are shown in the third column of Table 1. The moments are based on 100 simulations of a 20-year period. Standard deviations are shown in parentheses.

The cross-country consumption correlation is 0.23, even somewhat lower than in the data. The low cross-country consumption correlation is, of course, a result of the assumed market incompleteness. Previous studies that have considered only international trade in bonds, without any other

risksharing instruments, have also found low cross-country consumption correlations. Baxter and Crucini (1995) even obtain a cross-country consumption correlation of -0.28 in a two country bond economy. van Wincoop and Marrinan (1994) find small positive cross-country consumption correlations in a 15-country bond economy.

The model can be used to illustrate that the low cross-country consumption correlation is not primarily the result of the assumed absence of international portfolio diversification. The last column of Table 1 shows the results under the assumption that capital owners are perfectly diversified across countries. Capital owners in different countries are then indistinguishable, and their budget constraint becomes

$$B_{t+1} = (1+r_t)B_t + \sum_{i=1}^J \frac{H_i}{H} (y_{it} - I_{it} - w_{it}N_{it}) - c_t^{\text{cap}}. \quad (17)$$

Since consumption of capital owners is now perfectly correlated across countries, the overall consumption correlation is raised as well. But it rises only slightly, to 0.34.

The reason for this is that the endogenous fraction of consumption accounted for by capital owners is quite small. In the deterministic steady state, the ratio of consumption by capital owners to total consumption is

$$\frac{y - wN - I}{y - I} = \frac{(1-s)(r-g)}{r-g+s(\delta+g)} \quad (18)$$

where $s = wN/y$ is the laborshare of income. Substituting the parameter values chosen in the previous section, we find that only 12.4% of consumption is by capital owners. The low cross-country consumption correlation under perfect portfolio diversification can be attributed to the lack of risksharing opportunities for labor. Even when asset portfolios become more diversified in the future, cross-country consumption correlations are not likely to be affected much.

The variability of the cross-country consumption correlation across pairs of countries under the benchmark parameterization is very close to that in the data. And, consistent with the data, the model implies a close relationship between consumption and output, as measured by both their time series correlation and the correlation between $\text{corr}(c_i, c_j)$ and $\text{corr}(y_i, y_j)$ across pairs of countries.

Under the benchmark parameterization, the standard deviation of the growth rate of capital owners' consumption is 45% higher than that of labor, almost identical to what was found by Mankiw and Zeldes (1991) for

U.S. stockholders versus non-stockholders. This result is closely related to the assumed high degree of substitution between capital and labor. When capital is a good substitute for labor, the demand for labor is quite elastic with respect to the wage rate in the medium to long run, as firms can overcome the short-run adjustment costs associated with capital accumulation. Therefore future wages rise less in response to a positive production shock, so that consumption of capital owners rises more than that of labor.⁸

Tables 2 and 3 show the results from sensitivity analysis. Parameters changed relative to the benchmark specification are shown at the top of the

Table 2. Sensitivity analysis and gains from portfolio diversification

	Data	Model				
		Benchmark	$\varepsilon = 1.001$	$\gamma = 1.001$	$\lambda = 0.5$ $\gamma = 1.001$	$\lambda = 0.5$
Standard deviations						
c_t	1.87	1.87 (0.13)	1.78 (0.10)	1.35 (0.07)	1.84 (0.12)	1.56 (0.08)
y_t	1.99	1.99 (0.21)	1.69 (0.12)	2.22 (0.15)	1.82 (0.15)	2.01 (0.13)
I_t	6.24	6.24 (0.33)	4.24 (0.22)	6.61 (0.35)	6.06 (0.32)	6.34 (0.33)
g_{c_t}	1.88	2.25 (0.13)	2.12 (0.10)	1.63 (0.07)	2.21 (0.12)	1.88 (0.08)
$g_{c_t}^{\text{cap}}$	—	3.10 (0.14)	2.11 (0.09)	3.24 (0.14)	3.01 (0.14)	3.11 (0.13)
$g_{c_t}^{\text{labor}}$	—	2.14 (0.14)	2.14 (0.14)	1.55 (0.07)	2.10 (0.12)	1.82 (0.08)
N_t	1.84	1.84 (0.30)	1.04 (0.07)	1.00 (0.11)	1.06 (0.16)	0.51 (0.05)
$w_t N_t / Y_t$	2.38	0.49 (0.08)	0.00 (0.00)	0.48 (0.04)	0.39 (0.05)	0.43 (0.03)
Correlations						
c_t, c_t	0.46	0.23 (0.09)	0.11 (0.06)	0.06 (0.04)	0.18 (0.08)	0.09 (0.05)
y_t, y_t	0.43	0.43 (0.11)	0.18 (0.08)	0.17 (0.08)	0.29 (0.10)	0.14 (0.07)
c_t, y_t	0.81	0.92 (0.02)	0.95 (0.01)	0.91 (0.01)	0.94 (0.01)	0.96 (0.01)
Low frequency moments						
$\sigma_{\text{corr}(c_t, c_t)}$	0.27	0.28 (0.03)	0.30 (0.02)	0.30 (0.02)	0.28 (0.02)	0.29 (0.02)
$\sigma_{\text{corr}(y_t, y_t)}$	0.32	0.26 (0.04)	0.32 (0.03)	0.30 (0.02)	0.29 (0.03)	0.30 (0.02)
$\text{corr}[\text{corr}(c_t, c_t), \text{corr}(y_t, y_t)]$	0.75	0.88 (0.03)	0.93 (0.02)	0.89 (0.05)	0.93 (0.02)	0.96 (0.02)
Welfare gain portfolio diversification (%)		2.26	1.18	4.35	3.96	2.10

Notes: The data moments and model moments for the benchmark parameterization correspond to those in Table 1. The remaining columns show results from sensitivity analysis. The changed parameter in comparison with the benchmark parameterization is indicated at the top of each column. The last row of the table shows welfare gains for capital owners from international portfolio diversification under each parameterization. The gains are in terms of a percentage increase in the expected consumption path that leads to an equivalent improvement in welfare.

⁸ For a more detailed discussion of this issue, see van Wincoop (1993).

tables. While the tables consider some significant changes in all parameters, the main results are unchanged. The correlation of consumption across countries is always low, ranging from 0.04 to 0.58, and the variability of $\text{corr}(c_t, c_t)$ across sets of countries is closely consistent with the data. The average cross-country consumption correlation is nonetheless always slightly less than the cross-country income correlation. In all cases there is a close relationship between the cross-country income and consumption correlations and a high time series correlation between consumption and income. These moments are even slightly higher than in the data, except for $\rho = 0.9999$, which approximates a unit root in the productivity process. Adding fiscal shocks to the model would probably weaken the strong relationship between consumption and output somewhat. The standard deviation of consumption growth of capital owners is always significantly higher than that of labor, except when ε is lowered to 1 (Cobb-Douglas production), in which case consumption of the two agents is equally volatile. The reason for this should be clear given the discussion above. Note that while the laborshare is constant for a Cobb-Douglas production function, under all other parameterizations the standard deviation of the laborshare is nonetheless still far below that in the data. Finally, the main results do not change significantly if only half of labor has access to the bond market. Labor is sensitive to idiosyncratic income shocks whether it has access to the bond market or not.

VI. Welfare Gains From Portfolio Diversification

As observed in the introduction, international portfolio diversification is very limited. This may be a result of low potential welfare gains from choosing a more evenly distributed portfolio. This issue is closely related to a recent growing literature on welfare gains from international risksharing, although that literature considers gains from complete markets (rather than just trade in claims on capital) and assumes that countries are inhabited by identical agents.

The welfare gains from international risksharing are generally found to be quite large. van Wincoop (1994, 1996) finds welfare gains for a set of 20 OECD countries corresponding to a 1% to 10% permanent increase in the level of consumption. Obstfeld (1994), in a model with endogenous growth, finds even significantly larger welfare gains. Cole and Obstfeld (1991) report very small gains from international risksharing, but they consider risksharing among only two countries. Moreover, their parameterizations generally imply a very high riskfree interest rate, which, as shown below, leads to significant discounting of the future. And in their model, cross-country consumption correlations are already quite large

Table 3. Sensitivity analysis and gains from portfolio diversification

	Model					
	Data	Benchmark	$\rho = 0.9999$ ($\Delta\rho = 0.0101$)	$\omega = 0.3$ ($\Delta\omega = 0.1811$)	$\eta = 1.5$ ($\Delta\eta = -1.205$)	$\xi = 0.0001$ ($\Delta\xi = -0.493$)
c_t	1.87	1.87 (0.13)	1.41 (0.18)	1.99 (0.23)	1.97 (0.13)	1.89 (0.10)
y_t	1.99	1.99 (0.21)	1.99 (0.31)	2.24 (0.34)	1.92 (0.16)	1.78 (0.11)
I_t	6.24	6.24 (0.33)	5.56 (0.29)	5.92 (0.38)	4.29 (0.23)	5.79 (0.30)
g_c	1.88	2.25 (0.13)	1.69 (0.19)	2.38 (0.21)	2.38 (0.13)	2.29 (0.10)
g_c^{gap}	—	3.10 (0.14)	2.89 (0.16)	3.05 (0.19)	3.76 (0.17)	2.92 (0.13)
g_c^{labor}	—	2.14 (0.14)	1.57 (0.20)	2.30 (0.22)	2.18 (0.12)	2.21 (0.09)
N_t	1.84	1.84 (0.30)	5.29 (0.40)	2.05 (0.36)	1.17 (0.22)	0.00 (0.00)
$w_t N_t / Y_t$	2.38	0.49 (0.08)	1.20 (0.10)	0.56 (0.10)	0.34 (0.06)	0.38 (0.03)
c_t, c_j	0.46	0.23 (0.09)	0.58 (0.11)	0.45 (0.13)	0.18 (0.08)	0.04 (0.03)
y_t, y_j	0.43	0.43 (0.11)	0.75 (0.09)	0.63 (0.11)	0.31 (0.10)	0.12 (0.07)
c_t, y_j	0.81	0.92 (0.02)	0.55 (0.12)	0.93 (0.02)	0.96 (0.01)	0.93 (0.02)
$\sigma_{corr(c_t, c_t)}$	0.27	0.28 (0.03)	0.19 (0.05)	0.22 (0.04)	0.28 (0.02)	0.30 (0.02)
$\sigma_{corr(y_t, y_t)}$	0.32	0.26 (0.04)	0.15 (0.05)	0.18 (0.05)	0.27 (0.03)	0.30 (0.02)
$corr[corr(c_t, c_t), corr(y_t, y_t)]$	0.75	0.88 (0.03)	0.52 (0.13)	0.88 (0.04)	0.95 (0.02)	0.90 (0.05)
Welfare gain portfolio diversification (%)		2.26	1.53	1.79	3.33	1.98

Notes: See Table 2.

even in the absence of risksharing since shocks spill over across countries due to the endogenous adjustment of the terms of trade.⁹ Lucas (1987) finds very small gains from eliminating all business cycle risk in the U.S. But Lucas assumes trend stationary consumption, which implies very small risk horizons of 10 years or more. As is well known, for a given interest rate, optimizing behaviour leads to a random walk in consumption.

van Wincoop (1994) shows that when consumption follows a geometric random walk with drift, the welfare gain from a reduction in the standard deviation of consumption growth by $d\sigma_{gc}^2$, measured in terms of the welfare equivalent permanent percentage increase in the consumption path, is

$$\frac{dc}{c} = \frac{-0.5\gamma}{r - \bar{g}} d\sigma_{gc}^2. \tag{19}$$

Here r is the riskfree interest rate, and \bar{g} is the risk-adjusted growth rate of consumption, defined as $\bar{g} = g - 0.5\gamma\sigma_{gc}^2$. Equation (19) turns out to be quite general, and even holds under non-expected utility (Kreps-Porteus) preferences and habit formation preferences, as long as γ is interpreted as the rate of relative risk aversion.

Since in our model consumption of capital owners indeed has a unit root, and approximately follows a random walk,¹⁰ we can apply (19) using the average standard deviation of consumption growth of capital owners in the model before and after portfolio diversification. The last row of Tables 2 and 3 shows the welfare gain from portfolio diversification for all parameterizations considered. The welfare gains are quite large, ranging from 1.18% to 4.35%.

Under the benchmark parameterization we can see in Table 1 that the standard deviation of consumption growth of capital owners drops from 3.10% to 1.54% as a result of portfolio diversification. This leads to a welfare gain of 2.26%. The gain is somewhat lower (1.18%) when ε is lowered to 1 since the standard deviation of capital owners is then lower, equal to that of labor, before portfolio diversification. When $\gamma = 1$ the welfare gain is 4.35%. Even though the rate of relative risk aversion is now lower, the riskfree rate is lower as well (3.3%). The riskfree rate is $1 - \beta + (1/\psi)\bar{g}$, where $\psi = 1/\gamma$ is the intertemporal elasticity of substitution of consumption. Under non-expected utility preferences, the rate of rela-

⁹ Backus, Kehoe and Kydland (1992) also found low welfare gains from risksharing in the content of a two-country model. But again, like Cole and Obstfeld (1991), they found counterfactually high cross-country consumption correlations even in the absence of risk-sharing, in their case due to significant international technology spillover effects.

¹⁰ In the simulations, the average autocorrelation of consumption growth of capital owners is 0.05, with a standard error of 0.06.

tive risk aversion and the intertemporal elasticity of substitution can be separated. Holding ψ at 1, corresponding to $r = 3.3\%$, the welfare gain would be three times as large (about 13%) if we raised the rate of relative risk aversion from 1 (lower than most empirical estimates) to 3.

We may conclude that there are substantial benefits from international portfolio diversification in the context of this model, so that the model does not provide an explanation for the observed lack of portfolio diversification in the data.

VII. Summary and Conclusions

Consumer survey data are significantly at odds with the standard representative agent assumption. Only a small fraction of the population holds stock, and of the non-stockholders, a significant fraction is borrowing constrained. In this paper, a multi-country real business cycle model with two types of agents, capital owners and labor, is studied. All capital is held by the capital owners. Labor has either access to an international bond market, or no access to any asset market at all. The model is applied to twenty OECD countries for the period 1970–89. It can generate consumption correlations across countries that are close to what is observed in the data. Moreover, consumption correlations are still low if capital owners are perfectly diversified across countries. The essential element of market incompleteness that generates the low cross-country consumption correlations is therefore the lack of risksharing opportunities for labor. It is also found that the potential welfare gains from portfolio diversification for capital owners are quite large, so that the model cannot account for the observed home bias in portfolios. Finally, the model can generate the Mankiw-Zeldes (1991) observation for the U.S. that the variability of consumption of stockholders (capital owners) is significantly higher than that of non-stockholders (labor). More work needs to be done in order to know whether this is a stylized fact that is valid for other countries as well.

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