

September 2001

Financial Globalization and Real Regionalization

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ABSTRACT

Over the period 1972-1986, the correlations of GDP, employment and investment between the United States and an aggregate of Europe, Canada and Japan were respectively 0.76, 0.66, and 0.63. For the period 1986 to 2000 the same correlations were much lower: 0.26, 0.03, and -0.07 (real regionalization). At the same time, U.S. international asset trade has significantly increased. For example, between 1972 and 1999, United States gross FDI and equity assets in the same group of countries rose from 4 to 23 percent of the U.S. capital stock (financial globalization). We argue that these two trends are intimately related. We document that the correlation of real shocks between the U.S. and the rest of the world has declined. We then present a model in which international financial market integration occurs endogenously in response to less correlated shocks. Financial integration further reduces the international correlations in GDP and factor supplies. We find that both less correlated shocks and endogenous financial market development are needed to account for all the changes in the international business cycle.

KEYWORDS: International business cycles, international diversification

JEL CLASSIFICATION CODES : F36, F41

¹Preliminary. We thank Robert Engle, Alessandra Fogli, Philippe Martin, Andy Neumeier and seminar participants at the CEPR ESSIM 2001, the Econometric Society Summer Meetings 2001, the Duke International Economics Group Meetings in Venice, and the SIEPR Meetings in Stanford for helpful comments. Heathcote thanks the NSF Economics Program for financial support. Remaining errors are our own.

1. Introduction

Over the past 30 years, the United States economy has increasingly danced to its own tune. Over the period 1972 to 1986 the business cycle frequency correlations of output, employment and investment between the U.S. and an aggregate of Europe, Canada and Japan were 0.76, 0.66, and 0.63 respectively. For the period 1986 to 2000, the corresponding correlations were 0.26, 0.03, and -0.07. The consumption correlation also declined between the two periods, but to a smaller extent (from 0.51 to 0.13). We call this phenomenon real regionalization. At the same time, trade in international financial assets has sharply increased. Between 1972 and 1999, United States gross holdings of foreign direct investment and equity in the same group of countries rose from 4 to 23 percent of the U.S. capital stock. We label this trend financial globalization.

In this paper we argue that changes in the international business cycle and growth in international asset trade are intimately related. In particular, increasing globalization in financial markets is key to accounting for less international co-movement. We present evidence that the correlation of the stochastic shocks hitting the U.S. and the rest of the world has fallen in the post-Bretton Woods era. We then consider model economies in which the degree of international diversification is endogenous, and show that a fall in the correlation of shocks increases equilibrium diversification by increasing the potential gains from international asset trade. Finally, we investigate whether a combination of less correlated shocks coupled with the resulting deepening of international asset markets can account for the observed changes in the international real business cycle.

The first model we consider is a simple atemporal two-country endowment economy. At the start of the period agents trade shares in domestic and foreign assets which deliver imperfectly correlated dividends. A shipping cost associated with foreign dividend income constitutes an incentive to bias portfolios towards the domestic security. Reducing the correlation of dividends across countries leads to greater diversification, an increase in the cross-country correlation of consumption relative

to the correlation for output, and an increase in the volatility of net exports.

This simple model indicates that a trend towards country-specific rather than global risk combined with endogenous international financial integration is qualitatively consistent with many of the observed changes in the international business cycle. We therefore proceed to consider a richer infinite-horizon model with capital in order to assess the extent to which a calibrated model economy can capture both the quantitative extent of observed growth in international asset trade, and at the same time account for changes in cross-country correlations of the same magnitude as those observed empirically. The assets that may be traded internationally are shares in a representative domestic firm and a representative foreign firm. There is a tax on foreign dividend income, which provides an incentive for households to bias their portfolio towards domestic stocks. We consider two calibrations of the model corresponding to the early high-shock-correlation period, and the more recent period in which shocks have been less correlated.

In response to the a fall in the shock correlation we find that the equilibrium level of portfolio diversification increases, and that this increase is of the same magnitude as our empirical measures of the change in financial integration. Reducing the correlation of the shocks without allowing agents to adjust their portfolios has the effect of reducing the international correlations of macro-aggregates, but not by as much as these correlations fell empirically. However, the endogenous increase in international portfolio diversification that arises in equilibrium further reduces the international correlations of output, employment and investment. Thus we find that a combination of the fall in the correlation of productivity shocks and the resulting endogenous growth in international asset trade can jointly account for most of the observed changes in the international business cycle.

Our work is closely related to the work of several authors including Baxter and Crucini (1995), Arvanitis and Mikkola (1996), Kehoe and Perri (2001) and Heathcote and Perri (2001) who discuss the implications of limited international trade in financial assets in international real business cycle

economies. None of these papers, however, addresses the effects of growth in foreign asset holdings on business cycle dynamics.²

There are few papers that document changes in international business cycle regularities over time. One of them is Kollmann (2001) which examines earlier changes in international business cycle correlations. Finally, a long run perspective on financial globalization is offered by Obstfeld and Taylor (1999).

2. Data

In this section we present various measures of the international correlation of business cycles in the post-Bretton Woods period. We then report statistics on international diversification and the volume of international trade in financial assets.

A. United States and world business cycles

One measure of the change in the international business cycle correlation in the post-Bretton Woods period (1972 - 2000) is the difference between cross-regional correlations in two equal length subsamples. Table 1 displays the correlations of business cycle frequency fluctuations in GDP, consumption, investment and employment between the U.S. and an aggregate of the rest of the world (comprising Europe, Japan and Canada).³

²There are various papers that analyze the role of international diversification for other issues. For example, Obstfeld (1994) describes a model in which an increase in diversification increases the economy's growth rate by encouraging a switch into high-risk high-return investments. In Martin and Rey (2001) the set of assets traded is endogenous, and economic integration has implications for risk sharing and asset prices.

³For details on the data see the data appendix. Correlations are computed on the log of Hodrick-Prescott filtered quarterly series. The numbers in parentheses are the standard errors when estimating the correlation coefficients using GMM (see Backus and Kehoe 1992).

Table 1. International correlations

	Y_{US}, Y_{RW}	C_{US}, C_{RW}	X_{US}, X_{RW}	L_{US}, L_{RW}
Period I, 72.1-86.2	0.76 (0.07)	0.51 (0.12)	0.63 (0.12)	0.66 (0.08)
Period II, 86.3-00.4	0.26 (0.26)	0.13 (0.27)	-0.07 (0.28)	0.03 (0.25)
Entire Sample, 72.1-00.4	0.63 (0.10)	0.42 (0.13)	0.43 (0.15)	0.37 (0.15)

Notice first that the correlations of all variables have markedly declined. The correlations of investment and employment have fallen the most, while consumption is the variable which exhibits the smallest drop in correlation. While a general decline in correlations might be simply due to a decline in the correlation of exogenous shocks (the 1970's were dominated by world-wide oil shocks), the relatively large falls in the correlations of investment and employment suggest a change in the asset market structure. In particular, development of international financial markets increases opportunities for intertemporal specialization in production, and thus might be an important factor in accounting for the reduced correlation in factor supplies.

We first document that the decline in correlation is robust to alternative detrending procedures, to changes in the sample period, and to possible bias in measures of correlation due to heteroskedasticity. We then document in more detail the change in correlation across different regions.

Table 2 shows that the drop in international correlations is robust to measuring business cycle fluctuations by first differencing logged data (taking growth rates) or by taking deviations from a linear trend. Notice that both these alternative detrending procedures show a large drop in the correlation of inputs of production, and a relatively modest fall in the consumption correlation.

Table 2. Alternative detrending procedures

		Y_{US}, Y_{RW}	C_{US}, C_{RW}	X_{US}, X_{RW}	L_{US}, L_{RW}
First differencing	72.1-86.2	0.51	0.37	0.50	0.40
	86.3-00.4	0.13	0.15	0.01	0.12
Linear detrending	72.1-86.2	0.63	0.02	0.73	0.75
	86.3-00.4	-0.01	-0.18	-0.22	0.19

The first two rows of table 3 shows that the overall reduction in correlation is still present when considering a longer time period starting in the first quarter⁴ of 1962. In this case the first subsample includes the 1960's, which were a decade of weaker international correlations.⁵ The second two rows report correlations for a shorter time period starting in 1980.1. In this case the first sub-sample excludes the common oil-shock dominated 1970's, but the decline in cross-country correlations remains.

Table 3. Alternative time periods

		Y_{US}, Y_{RW}	C_{US}, C_{RW}	X_{US}, X_{RW}	L_{US}, L_{RW}
1962-2000	62.1-81.2	0.53	0.30	0.60	0.57
	81.3-00.4	0.34	0.15	-0.02	0.14
1980-2000	80.1-90.2	0.58	0.25	0.22	0.54
	90.3-00.4	-0.16	-0.10	-0.41	-0.14

Additional evidence that our finding does not depend on the particular time period chosen is presented in figure 1. The four lines in the figure are the rolling correlation estimates for conditional correlations of output, consumption, investment and employment.⁶ The figure reveals that interna-

⁴The first quarter of 1962 is the first date for which we have complete series for all countries from the OECD.

⁵The fact that in the 1960's the international correlation of business cycles was quite low has been noticed by various authors. Kollmann (2001) has used this fact to assess the importance of monetary shocks in accounting for business cycles.

⁶See, for example, Engle (2000). In quarter t the estimate of the conditional correlation is the correlation between the two series over the interval $t - n$ to t . We set $n = 58$, which is the same sample length used in tables 1 and 2.

tional correlations for all variables were relatively stable (and high) until the mid 1980's, since when they have declined steadily.

Several authors have recently pointed out that in sub-samples with high conditional volatility, estimates of the correlation between variables tend to increase, even though there are no changes in the underlying distribution (see, for example, English and Loretan 1999). If we measure the change in business cycle volatilities in the U.S. and in our aggregate corresponding to the rest of the world (table 4) we find a marked reduction in volatility, especially for the U.S.

Table 4. Percentage standard deviations

	Y_{US}	Y_{RW}	C_{US}	C_{RW}	X_{US}	X_{RW}	L_{US}	L_{RW}
Period I, 72.1-86.2	2.18	1.16	1.13	0.79	6.07	2.70	1.34	0.52
Period II, 86.3-00.4	0.85	0.80	0.67	0.45	2.16	2.37	0.65	0.68
Entire Sample, 72.1-00.4	1.64	0.99	1.06	0.64	4.54	2.54	1.06	0.61

We therefore use the procedure proposed by Forbes and Rigobon (2001) to correct the measure of business cycle correlation using estimates of standard deviations in the two sub-samples.⁷ Corrected correlation estimates are presented in table 5. Notice that although the drop in correlation is reduced, it is still significant (in particular for investment and employment), suggesting that the reduction in international comovement is more than a statistical artifact.

⁷The corrected correlation coefficient (ρ^*) between two variables x and y in a given subsample is given by

$$\rho^* = \frac{\rho}{\sqrt{\frac{1-\rho^2}{\Delta} + \rho^2}}$$

where ρ is the standard correlation coefficient between x and y in the subsample, and Δ is the ratio of the variance of x in the subsample to the variance of x in the whole sample. The formula above is an exact estimate of ρ^* only in the case in which the variable y can be represented as a linear function of x plus an independent error term. In general our data do not satisfy this property, but Forbes and Rigobon (2001) argue that even in more general cases the correction above gives a relatively good estimate of the true correlation.

Table 5. International correlations (corrected measure)

	Y_{US}, Y_{RW}	C_{US}, C_{RW}	X_{US}, X_{RW}	L_{US}, L_{RW}
Period I, 72.1-86.2	0.66	0.48	0.51	0.52
Period II, 86.3-00.4	0.46	0.20	-0.15	0.05

Finally, to assess how robust the decline in cross-country correlations is to alternative country groupings, we report correlations between U.S. macro variables and their counterparts in Europe, Japan and Canada. Table 6 indicates that comovement between the U.S. on the one hand and either Europe or Japan on the other has declined significantly. However, the U.S. and Canadian business cycles are now more correlated than in the first half of the sample.

Table 6. International correlations

		Y_{US}, Y_i	C_{US}, C_i	X_{US}, X_i	L_{US}, L_i
Europe	72.1-86.2	0.71	0.48	0.61	0.60
	86.3-00.4	0.31	0.06	-0.03	0.01
Japan	72.1-86.2	0.61	0.38	0.59	0.39
	86.3-00.4	-0.05	-0.01	-0.17	-0.30
Canada	72.1-86.2	0.76	0.38	0.01	0.54
	86.3-00.4	0.84	0.66	0.43	0.87

B. International trade in financial assets

In this subsection we document the increase of U.S. trade in international assets. The measure of international diversification we focus on for U.S. assets is the sum of the U.S. foreign direct investment position (at current cost) plus the equity part of the stock of portfolio investment abroad, relative to the U.S. capital stock (see the data appendix for more details). The analogous measure of liabilities is the ratio of the sum of the stock of foreign direct investment in the U.S. plus foreigners

holdings of U.S. stocks to the U.S. capital stock. Consistently with the business cycle evidence presented in the previous section, we focus on U.S. holdings of assets in Western Europe plus Canada and Japan, and these countries' holdings of U.S. assets. The measure of the capital stock we use is the net stock at current cost of private non-residential assets.

Figures 2 and 3 report the time paths from 1972 to 2000 for U.S. assets and liabilities relative to this group of countries. In each case we report the FDI position separately, as well as FDI plus equity holdings jointly. These figures illustrate dramatic growth in diversification over the sample period. In particular, U.S. holdings of foreign stocks have grown strongly since the mid 1980's, while the stocks of FDI and foreign owned equity in the U.S. have risen steadily over the entire period. Overall, U.S. liabilities have grown faster than assets, reflecting the series of current account deficits over the past two decades. Moreover inward and outward acquisitions of capital have taken different forms: almost all of the increase in U.S.-owned capital abroad reflects an increase in the stock of equity portfolio investment, while most of the increase in foreign ownership of the U.S. capital stock reflects an increase in the direct investment position.

The observed growth in diversification appears to be robust to a wider definition of the rest of the world, to broader classes of assets, and to alternative valuation methods. First, in addition to our benchmark measure described above, we examine assets and liabilities for the U.S. versus the entire rest of the world. Second, we use stock market capitalization instead of the current-cost replacement value for tangible assets to value capital stocks. These results are summarized in tables 7 and 8. Alternative methodologies generate differences in the measured level of international diversification, but the finding that diversification was much higher in the 1990's than in the 1970's clearly remains. Note that Europe, Canada and Japan jointly account for almost all foreign holdings of U.S. assets and for the lions share of U.S. asset holdings abroad, though other countries are attracting an increasing share of U.S. equity portfolio investment. Growth in diversification generally appears

smaller when stock market capitalization rather than capital stock replacement cost estimates are used as a denominator (which is not surprisingly in light of surging stock markets), but even in this case we find strong growth in the stocks of U.S. equity portfolio investment abroad and foreign direct investment in the U.S. Comparing the U.S. with the Europe / Canada / Japan aggregate, for example, U.S. holdings of foreign securities averaged 1.1 percent of total non-US developed economies market capitalization over the first half of the sample, while the corresponding figure for the second half of the sample was 5.5 percent.

Table 7. US foreign assets and liabilities as % of US capital stock

		US vs. EU+CA+JP			US vs. ROW	
		<i>FDI</i>	<i>Eq</i>	<i>FDI + Eq</i>	<i>FDI + Eq</i>	<i>Total</i>
Period I	Assets	6.2	0.5	6.7	9.6	24.1
72 - 85	Liabilities	2.7	1.6	4.3	5.0	17.2
Period II	Assets	6.9	5.9	12.8	17.7	39.3
86 - 99/00	Liabilities	7.3	4.8	12.1	14.0	45.0

Table 8. US foreign assets and liabilities as % of stock market cap.

		US vs. EU+CA+JP			US vs. ROW	
		<i>FDI</i>	<i>Eq</i>	<i>FDI + Eq</i>	<i>FDI + Eq</i>	<i>Total</i>
Period I	Assets	9.5	1.1	10.7	15.2	47.2
72 - 85	Liabilities	5.0	4.2	9.2	10.6	44.5
Period II	Assets	9.4	5.5	14.9	21.0	41.0
86 - 99/00	Liabilities	14.1	6.2	20.3	23.1	65.5

Table 9 provides yet another measure of global asset trade based on the fact that the current account is a measure of the change in a country's net foreign asset position. Thus larger (positive or negative) values for the current account reflect more international asset trade. The table indicates that larger current account and net exports positions (as a fraction of GDP) have been observed in the second sub-period, indicating a significant increase in the use of international borrowing and lending. The last three columns of table 9 report other interesting phenomena related to changes in international financial markets. The third column shows that the volatility of the U.S. real exchange rate has significantly declined over time; in the model we will present below more lower real exchange rate volatility is a natural consequence of increased financial integration. The fourth and fifth columns report correlations, at quarterly frequency, between U.S. stock market price indexes and returns (P_{US}, R_{US}) and comparable indexes and returns for the rest of the world (P_{RW}, R_{RW}).⁸

Table 9. Other variables of interest

	Averages (%)		Std. Dev. (%)	Correlation	
	$ CA/Y $	$ NX/Y $	RX	P_{US}, P_{RW}	R_{US}, R_{RW}
Period I 72.1 - 86.2	0.94	1.10	5.34	0.59	0.64
Period II 86.3 - 00.4	2.04	1.64	4.00	0.27	0.56

Table 9 suggests that the decline in the correlation of business cycles has been associated with a decline in the correlation of international stock performance. This suggests that both greater international diversification and less correlated investment may be driven by a weaker international

⁸Real exchange rates and stock prices are logged and HP filtered. Stock returns are computed as log first differences of stock price indexes. See the data appendix for details.

correlation in the return to capital.⁹

Figure 4 finally provides more evidence on the link between financial globalization and real regionalization by combining the evidence above on diversification with the evidence presented earlier on the change in the international business cycle. The top line (right scale) is the United States foreign asset position (FDI plus equity) from figure 2. The bottom line (left scale) reports the rolling window correlation for investment from figure 1. The picture provides striking evidence that the two phenomena emerged at about the same time.

3. A simple model of financial diversification

In this section we consider a simple model that is helpful for understanding potential interaction between the international correlation of shocks, the degree of international asset trade, and cross-country correlations in macro aggregates.

Consider an atemporal two-country exchange economy. A Lucas tree in each country produces some non-storable fruit. The quantity of fruit produced depends on the realization of the state of nature s . The endowment (of fruit) of the domestic tree is denoted $X(s)$, while the foreign endowment is $X^*(s)$. Prior to any trade, the representative domestic agent owns the domestic tree, while the foreign agent owns the foreign tree. Agents first trade shares in their trees. Then the state of nature is revealed, contracts are honored, and agents consume any fruit to which they have claims. We now describe the representative domestic agent's problem (the foreign agent's problem is analogous).

At the start of the period, the domestic household buys a fraction λ^f of the foreign tree, subject to the constraint

$$(1) \quad \lambda P + \lambda^f P^* = P$$

⁹Note that other authors (for example Longin and Solnik 1995) have documented an increase in the international correlation of stock returns. However these authors have typically focussed on return correlations at frequencies higher than business cycles, and on the late 1990's when correlation increased even at business cycle frequencies.

where P is the price of the domestic tree, P^* the price of the foreign tree, and $1 - \lambda$ the fraction of the domestic tree sold.

An important assumption is that endowment income from abroad is subject to a proportional tax or shipping cost χ . Thus given a choice for λ , consumption in state s is given by

$$(2) \quad c(s) = \lambda X(s) + \lambda^f (1 - \chi) X^*(s)$$

$$(3) \quad = \lambda X(s) + \frac{P(1 - \lambda)}{P^*} (1 - \chi) X^*(s)$$

Thus the domestic household solves

$$\max_{\lambda} E [u(c(s))]$$

subject to eq. 2 and the short-selling constraint $\lambda \leq 1$.¹⁰

To the extent that the domestic and foreign endowments are imperfectly correlated in some states, there is an incentive for households to diversify internationally, which amounts to choosing $\lambda < 1$. However, the shipping cost χ provides an incentive to bias portfolios in favor of domestic stocks.

The representative domestic household's first order condition is

$$E [u'(c(s))X(s)] \geq \frac{P}{P^*} (1 - \chi) E [u'(c(s))X^*(s)]$$

$$= \quad \text{if } \lambda < 1.$$

¹⁰We do not allow agents to go short in foreign shares, since for $\chi > 0$ this would allow agents to increase expected consumption. Agents may go short in domestic shares but opt not to in equilibrium.

Market clearing for trees implies

$$\lambda + \lambda^{h*} = 1 \text{ and}$$

$$\lambda^f + \lambda^* = 1,$$

Market clearing for fruit requires

$$c(s) + c^*(s) + [(1 - \lambda)X(s) + (1 - \lambda^*)X^*(s)]\chi = X(s) + X^*(s) \quad \forall s.$$

We assume that the joint distribution over foreign and domestic fruit is perfectly symmetric.

Thus $P = P^*$ and $\lambda = \lambda^*$.

There are two possible types of equilibria. In the first type $\lambda = 1$. We call this the no diversification equilibrium. In the second $\lambda < 1$: this is the diversification equilibrium.

Suppose we are in the diversification equilibrium. Given exponential utility and normally distributed endowments, it is possible to solve for the equilibrium λ analytically.

Assume period utility is given by

$$u(c) = -\frac{1}{A}e^{-Ac}$$

and that the random variable (X, X^*) has a bivariate normal distribution, with $E[X] = E[X^*] = \mu$, $var[X] = var[X^*] = \sigma^2$, and $cov[X, X^*] = \rho\sigma^2$.

Using the definition of covariance, the household's first order condition may be rewritten

$$cov[u'(c), X] + E[u'(c)]E[X] = (1 - \chi)(cov[u'(c), X^*] + E[u'(c)]E[X^*])$$

Since X and X^* have a bivariate normal distribution, $c \sim N(\mu_c, \sigma_c^2)$ where

$$\mu_c = [\lambda + (1 - \lambda)(1 - \chi)]\mu, \quad \sigma_c^2 = [\lambda^2 + 2\lambda(1 - \lambda)(1 - \chi)\rho + (1 - \lambda)^2(1 - \chi)^2]\sigma^2.$$

Applying Stein's lemma¹¹,

$$\text{cov} [u'(c), X] = E [u''(c)] \text{cov} [c, X].$$

Substituting this in the first order condition and using the fact that given exponential utility

$$\frac{E [u''(c)]}{E [u'(c)]} = -A$$

the domestic agent's first order condition simplifies to

$$-A \text{cov} [c, X] + E [X] = (1 - \chi) (-A \text{cov} [c, X^*] + E [X^*]).$$

Now

$$\text{cov} [c, X] = E [cX] - E [c] E [X] = \lambda \sigma^2 + (1 - \lambda)(1 - \chi) \rho \sigma^2$$

and

$$\text{cov} [c, X^*] = \rho \lambda \sigma^2 + (1 - \lambda)(1 - \chi) \sigma^2.$$

Substituting these expressions back into the first order condition and re-arranging gives the following expression for λ :

$$\lambda = \frac{(1 - \chi)^2 - (1 - \chi) \rho + \frac{\chi \mu}{A \sigma^2}}{1 - 2(1 - \chi) \rho + (1 - \chi)^2}.$$

Note that the optimal lamda depends only on the cost χ , the correlation of shocks ρ , and the ratio $\mu/(A\sigma^2)$.

Now we are in a position to calculate the correlation of consumption across countries

$$\begin{aligned} \text{corr}(c, c^*) &= \frac{E [(\lambda X + (1 - \lambda)(1 - \chi) X^*) (\lambda X^* + (1 - \lambda)(1 - \chi) X)] - \mu_c^2}{\sigma_c^2} \\ (4) \quad &= \rho + \frac{2\lambda(1 - \lambda)(1 - \chi)(1 - \rho^2)\sigma^2}{\sigma_c^2}. \end{aligned}$$

¹¹Stein's lemma states that if (a, b) are normal variables, and g is a differentiable function, then

$$\text{cov} [g(a), b] = E [g'(a)] \text{cov} [a, b].$$

Note that if $\chi = 0$, then $\lambda = 0.5$ implying perfect diversification. Substituting these values into eq. 4, $\text{corr}(c, c^*) = 1$ implying perfect risk sharing.

Lastly, consider the volatility of net exports. We define net exports for the domestic country as domestic fruit produced minus the sum of fruit consumed domestically plus imports of fruit that *rot en route*:

$$NX(s) = X(s) - c(s) - (1 - \lambda)\chi X^*(s).$$

Then

$$\begin{aligned} \sigma_{nx}^2 &= \text{Var}(X - (\lambda X + (1 - \lambda)X^*)) \\ &= 2(1 - \lambda)^2 \sigma^2 (1 - \rho). \end{aligned}$$

Figures 5, 6 and 7 illustrate how international diversification (given by $1 - \lambda$), the cross-country consumption correlation, and the standard deviation of net exports change as we vary ρ , the correlation in the quantity of fruit produced by domestic and foreign trees. In this example $A = 1$, $\mu = 2$, and $\sigma = 0.1$. At a consumption level μ , these values translate to a coefficient of relative risk aversion (corresponding to $A\mu$) of 2, and a percentage standard deviation of output (corresponding to $100 \times \sigma/\mu$) of 5. We consider a range of alternative values for the shipping cost / tax : $\chi \in \{0, 0.003, 0.005, 0.01\}$.

Figure 5 shows that when $\chi = 0$ and there is no cost to diversification, agents always choose to be fully diversified ($\lambda = 0.5$). When $\chi = 1\%$, the constraint that agents cannot go short in foreign stocks is always binding and there is complete home bias ($\lambda = 1$). For intermediate values for the cost parameter, international diversification increases as the correlation of the shocks declines.

Figures 6 and 7 indicate that when the cost associated with diversification is large enough to guarantee perfect home bias, the correlation of consumption falls one for one with the correlation

of the shocks, while the standard deviation of net exports is always zero. When there is no cost to diversification and equilibrium is characterized by complete diversification, consumption is always perfectly correlated across countries, and the volatility of net exports increases as the correlation of the shocks falls. For intermediate values for the cost parameter, the correlation of consumption declines one for one with the shock correlation for highly correlated shocks. However, once the correlation falls below a certain value, some degree of diversification becomes optimal, the correlation of consumption rises above the correlation of the shocks, and the volatility of net exports increases.

Thus this simple model is qualitatively consistent with some key features of the evidence presented in the data section of the paper. In particular, for intermediate values for the cost parameter, a decrease in the correlation of shocks is associated with (i) an increase in diversification, (ii) an increase in the correlation of consumption relative to the correlation of the shocks, and (iii) an increase in the volatility of net exports.

While the model economy described above is analytically and conceptually tractable, it abstracts from production and thus cannot address the observed changes in employment and investment correlations. We therefore proceed to consider a multi-period world economy in which the asset market structure is analogous to the one described above except that dividends are now determined endogenously by firms making capital investment and employment decisions. This model can be calibrated and simulated to assess whether the mechanism through which financial globalization impacts the real business cycle is quantitatively as well as qualitatively consistent with the empirical evidence.

4. Economies with capital

The modelling framework is the one developed by Backus, Kehoe and Kydland, 1994. There are two countries, each of which is populated by the same measure of identical, infinitely lived households. Firms in each country use country-specific capital and labor to produce an intermediate good.

The intermediate good produced in the domestic country is labeled a , while the good produced in the foreign country is labeled b . These are the only traded goods in the world economy. Within each country goods a and b are combined to produce country-specific final consumption and investment goods. However, the final goods production technologies are asymmetric across countries, in that they are biased towards using a larger fraction of the locally produced intermediate good. The only source of uncertainty in the model takes the form of country-specific productivity shocks to intermediate goods firms. These firms make investment and employment decisions, and distribute any non-reinvested earnings to shareholders.

The only innovation in the model described here relative to previous work concerns the assumed asset market structure. Recall that the goal of the paper is to assess the potential role of asset market integration in accounting for observed changes to the real side of the international business cycle. Since it is hard to discuss asset market development in the context of a model with complete markets, it is clear that an incomplete markets framework is appropriate. Our approach is to assume that all asset trade occurs in the first period, and that the only assets traded at that date are shares in domestic and foreign intermediate firms. The main advantage of this particular structure is that it may be readily mapped to data on U.S. gross foreign assets and gross foreign liabilities. Thus it will be easy to construct model analogues to the empirical measures of diversification discussed in the data section of the paper.

Several authors have considered international real business cycle models in which a single non-contingent bond is the only asset traded (see, for example, Baxter and Crucini 1995 and Arvanitis and Mikkola 1996). We choose not to follow this line of research for several reasons. First with a single bond there is no distinction in the model between gross and net foreign assets, and thus the model cannot hope to capture the fact that the U.S. has accumulated more and more foreign assets while running large current account deficits. Second, Baxter and Crucini document that with a

single non-contingent bond which is traded freely at each date, allocations are very similar to those with complete markets unless productivity shocks are extremely persistent. Since our empirical estimates suggest stationary shocks in both sub-periods, adopting the single bond environment would in practice deliver similar predictions to assuming complete markets.¹²

Why do we restrict all asset trade to occur at time zero? The reason is that when we solved for equilibrium allocations in an environment with free trade in stocks at each date, we found that equilibrium allocations were identical to those under complete markets. Thus if asset market incompleteness is going to have any bite, some restrictions on stock trade are required. Moreover, there are surely costs to trading in practice, and these costs are likely larger for international as opposed to domestic asset trades. Our asset market structure may be conceptualized as equivalent to assuming that an international stock market is open at each date, that stocks may be freely traded at date 0, and that at subsequent dates trading costs are large enough to make it optimal for representative agents to do no international asset trade. Thus households decide on their domestic / foreign portfolio split at date 0, and then passively maintain this split for all future dates.¹³

We now describe the preferences and the production technologies of the economy, discuss the details of the asset market structure and define equilibrium.

The economy

The world consists of two countries, each of which is populated by the same measure of identical, infinitely-lived households. In each period t the economy experiences one event $s_t \in S$.

¹²In results not reported we find that models with either complete markets or a single non-contingent bond deliver cross-country correlations for macro aggregates that closely resemble those observed since the mid 1980s when the shock process is calibrated to the second sub-period. However, these models predict too little international co-movement in the first sub-period, given the estimated shock process for the first period. This failure to generate strong international business cycle co-movement is a well-known puzzle in the literature (see, for example, Backus, Kehoe and Kydland 1995). The point is that neither of the standard versions of the international real business cycle model can simultaneously account for the cross-country correlations observed in both sub-periods.

¹³When we come to simulate the model we are in fact somewhat more generous in the trading opportunities with which we endow agents than is apparent from the description of the model. In particular, we shall assume that following a change in the shock process, agents are given a single opportunity to costlessly re-optimize their portfolios. In this sense a change in the shock process resets the date to $t = 0$.

We denote by s^t the history of events up to and including date t . The probability at date 0 of any particular history s^t is given by $\pi(s^t)$.

Period utility for a household in the domestic country after history s^t is given by¹⁴

$$(5) \quad U(c(s^t), 1 - n(s^t)) = \frac{1}{\gamma} \left[c(s^t)^\mu (1 - n(s^t))^{1-\mu} \right]^\gamma$$

where $c(s^t)$ denotes consumption and $n(s^t)$ labor supply at date t given history s^t . Households supply labor to domestically located perfectly competitive intermediate-goods-producing firms (i -firms).

I -firms in the domestic country produce good a , while those in the foreign country produce good b .

The i -firms' production function is Cobb-Douglas in capital and labor:

$$(6) \quad F(z(s^t), k(s^{t-1}), n(s^t)) = e^{z(s^t)} k(s^{t-1})^\theta n(s^t)^{1-\theta}$$

where $z(s^t)$ is an exogenous technology shock.

The law of motion for the vector of shocks $\widehat{z}(s^t) = [z(s^t), z^*(s^t)]$ is given by

$$(7) \quad \widehat{z}(s^t) = A\widehat{z}(s^{t-1}) + \widehat{\varepsilon}(s^t)$$

where A is a 2×2 matrix, and $\widehat{\varepsilon}(s^t)$ is a 2×1 vector of independently distributed random variables with variance-covariance matrix V .

Let $w(s^t)$ be the wage in terms of the domestically-produced intermediate good. The i -firm's maximization problem after history s^t is given by

$$\max_{\{k(s^t), n(s^t)\}} \sum_{t=0}^{\infty} \sum_{s^t} Q(s^t) d(s^t)$$

subject to $k(s^t), n(s^t) \geq 0$, where $Q(s^t)$ is the price the firm uses to value dividends at s^t relative to consumption at date 0, and dividends (in units of the final consumption / investment good) are

¹⁴The equations describing the foreign country are largely identical to those for the domestic country. We use star superscripts to denote foreign variables.

given by

$$d(s^t) = q_a(s^t) [F(z(s^t), k(s^{t-1}), n(s^t)) - w(s^t)n(s^t)] - [k(s^t) - (1 - \delta)k(s^{t-1})].$$

In this expression $q_a(s^t)$ is the price of good a in units of the final good, and δ is the depreciation rate for capital. The expression for profits of the foreign firm is similar, except that variables are starred, and $q_a(s^t)$ is replaced by $q_b^*(s^t)$. The first order conditions for the firm's choices for $k(s^t)$ and $n(s^t)$ are

$$(8) \quad -Q(s^t) + \sum_{s^{t+1}} Q(s^{t+1}) [q_a(s^{t+1})F_2(z(s^{t+1}), k(s^t), n(s^{t+1})) + (1 - \delta)] = 0$$

and

$$F_3(z(s^t), k(s^{t-1}), n(s^t)) - w(s^t) = 0.$$

After trading in any active asset markets, households sell their holdings of intermediate goods to domestically located final-goods-producing firms (f -firms). The f -firms are perfectly competitive and produce final goods using intermediate goods a and b as inputs to a constant returns to scale technology:

$$(9) \quad G(a(s^t), b(s^t)) = \left[\omega a(s^t)^{\frac{\sigma-1}{\sigma}} + (1 - \omega) b(s^t)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

$$G^*(a^*(s^t), b^*(s^t)) = \left[(1 - \omega) a^*(s^t)^{\frac{\sigma-1}{\sigma}} + \omega b^*(s^t)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

where σ is the elasticity of substitution between goods a and b , and $\omega > 0.5$ determines the size of the local input bias in the composition of domestically produced final goods.

The f -firm's static maximization problem in the domestic country after history s^t is given by

$$\max_{a(s^t), b(s^t)} \{G(a(s^t), b(s^t)) - q_a(s^t)a(s^t) - q_b(s^t)b(s^t)\}$$

subject to $a(s^t), b(s^t) \geq 0$.

Let $rx(s^t)$ denote the real exchange rate, defined as the price of foreign relative to domestic consumption. Since the prices of traded intermediate goods in each country are defined relative to local final consumption, applying the law of one price to intermediate goods generates expressions for $rx(s^t)$:

$$rx(s^t) = \frac{q_a(s^t)}{q_a^*(s^t)} \quad \text{and} \quad rx(s^t) = \frac{q_b(s^t)}{q_b^*(s^t)}.$$

Gross domestic product after history s^t in units of the final good is given by

$$y(s^t) = q_a(s^t)F(z(s^t), k(s^t), n(s^t)).$$

Net exports as a fraction of GDP is given by

$$nx(s^t) = \frac{q_a(s^t)a^*(s^t) - q_b(s^t)b(s^t)}{y(s^t)}.$$

International asset market structure

All asset trade occurs in the initial period, which is period 0. Since firms are assumed to make the investment decisions, this means that in every period except the first, the household simply consumes the sum of labor income and any dividend income from its shareholdings. Thus for $t \geq 1$ the state by state budget constraint is given by

$$(10) \quad c(s^t) \leq q_a(s^t)w(s^t)n(s^t) + \lambda d(s^t) + \lambda^f rx(s^t)(1 - \tau)d^*(s^t) + \psi(s^t).$$

Here λ (λ^f) denotes the fraction of the domestic (foreign) firm held by the domestic household. Foreign dividend income is taxed locally at a constant rate τ , and revenue $\psi(s^t)$ is redistributed to domestic households in a lump-sum fashion.

At the start of period 0, the domestic household owns the entire domestic firm. In this period alone the household chooses purchases of domestic and foreign stocks subject to the budget constraint

$$(11) \quad c_0 + P_0\lambda + rx_0P_0^*\lambda^f \leq q_{a,0}w_0n_0 + P_0 + d_0.$$

In this equation P_0 denotes the (ex-dividend) price of the domestic firm in units of period 0 domestic consumption, and P_0^* denotes the price of the foreign firm in units of period 0 foreign consumption. Note that the timing convention is that in period 0 the household receives dividend income from his initial portfolio, and then trades shares in the two representative firms ex-dividend. The household also faces a constraint that precludes short positions in foreign stocks: $\lambda^f \geq 0$.¹⁵

At date 0, domestic households choose λ , $\lambda^f \geq 0$, $c(s^t) \geq 0$ and $n(s^t) \in [0, 1]$ for all s^t and for all $t \geq 0$ to maximize

$$(12) \quad \sum_{t=0}^{\infty} \sum_{s^t} \pi(s^t) \beta^t U(c(s^t), 1 - n(s^t))$$

subject to 11 and 10. Let γ be the multiplier associated with 11, $\mu(s^t)$ be the multiplier associated with 10, and χ be the multiplier associated with the short-selling constraint for foreign stocks. The first order conditions characterizing the solution to the domestic household's problem are (with respect to λ , λ^f , $c(s^t)$, and $n(s^t)$ respectively)

$$(13) \quad -P_0 \gamma + \sum_{t=1}^{\infty} \sum_{s^t} d(s^t) \mu(s^t) = 0,$$

$$(14) \quad -P_0^* r x_0 \gamma + \chi + \sum_{t=1}^{\infty} \sum_{s^t} r x(s^t) (1 - \tau) d^*(s^t) \mu(s^t) = 0,$$

$$(15) \quad \pi(s^t) \beta^t U_1(c(s^t), 1 - n(s^t)) - \mu(s^t) = 0, \quad \text{and}$$

$$(16) \quad -\pi(s^t) \beta^t U_2(c(s^t), 1 - n(s^t)) + \mu(s^t) q_a(s^t) w(s^t) = 0$$

Note that the value the household assigns to an additional unit of consumption (dividend income) in state s^t relative to additional unit of consumption at date 0 (the household's stochastic discount factor) is

$$\frac{\mu(s^t)}{\gamma} = \frac{\pi(s^t) \beta^t U_1(c(s^t), 1 - n(s^t))}{U_1(c_0, 1 - n_0)}.$$

¹⁵We allow short positions in domestic stocks.

From the household's first order condition for λ (eq. 13) the equilibrium market price of the domestic firm at date 0 in units of date 0 consumption is given by

$$P_0 = \frac{\sum_{t=1}^{\infty} \sum_{s^t} d(s^t) \mu(s^t)}{\gamma} = \frac{\sum_{t=1}^{\infty} \sum_{s^t} d(s^t) \pi(s^t) \beta^t U_1(c(s^t), 1 - n(s^t))}{U_1(c_0, 1 - n_0)}$$

This expression says that the equilibrium price of a share in the domestic firm is equal to the marginal value for the domestic agent of the stream of dividend income to which the share is a claim.

Note that if the domestic and foreign economies are perfectly symmetric at date 0, then in equilibrium

$$(17) \quad P_0 = P_0^*, \quad rx_0 = 1, \quad \text{and} \quad \lambda^f = 1 - \lambda = \lambda^{h*} = 1 - \lambda^*.$$

where λ^* (λ^{h*}) denotes the fraction of the foreign (domestic) firm held by the foreign household.

What state contingent consumption prices $Q(s^t)$ should the domestic firm use in this economy when making state contingent investment and employment decisions, which determine state by state dividend payments? Since asset markets are incomplete internationally, domestic and foreign agents are unable to perfectly insure against country specific shocks. Thus they will potentially use different shadow prices to discount dividends in any particular state. If a domestic firm has both domestic and foreign shareholders, these shareholders may therefore disagree on the firm's optimal strategy for reinvesting earnings versus paying out dividends. For example, in some states agents in country 1 may have a low marginal utility of consumption and thus prefer the firm to reinvest rather than make dividend payments. At the same time agents in country 2 may attach much higher marginal value to dividend payments from the domestic firm, and would therefore prefer a larger dividend payment in the current period rather than the promise of higher dividends in the future.

We assume that firms price state-contingent dividends using a weighted sum of values of the

domestic and foreign shareholders' stochastic discount factors. Thus $Q(s^t)$ is given by

$$(18) \quad Q(s^t) = \frac{\omega \pi(s^t) \beta^t U_1(c(s^t), 1 - n(s^t))}{U_1(c_0, 1 - n_0)} + \frac{(1 - \omega) \pi(s^t) \beta^t U_1(c^*(s^t), 1 - n^*(s^t))}{rx(s^t) U_1(c_0^*, 1 - n_0^*)}$$

where ω is the weight the domestic firm assigns to domestic shareholders. Moreover, we will focus on the particular case in which $\omega = \Lambda$, where Λ is the aggregate weight of domestic firms in the portfolios of domestic agents. In this case firms weight the preferences of domestic and foreign agents in strict proportion to the average fractions of the firm they hold. If a required property of equilibrium is that firms cannot choose Pareto-improving investment policies even when sidepayments between shareholders are possible, then firms effectively maximize profits with respect to a system of shadow prices that average the idiosyncratic shadow prices of all shareholders (see Diamond 1967, Drèze 1974, and Grossman and Hart 1979). This corresponds precisely to the objective function assumed here.

To assess how sensitive equilibrium allocations are to alternative weighting schemes, we also consider an specification in which $\omega = 1$, implying that the firm ignores foreign shareholders (irrespective of the quantity of stock they hold), and maximizes the value of the firm for domestic shareholders. In this case, using 18 and 15, the inter-temporal condition describing equilibrium domestic capital accumulation reduces to the relation that would obtain with complete markets. Note, however, that there are no assets in this economy that equate the international ratio of marginal utilities of consumption to the real exchange rate, as would occur in a complete markets environment.

Using 13 and 17, the condition defining the optimal portfolio split between domestic and foreign stocks for the domestic household is

$$\sum_{t=1}^{\infty} \sum_{s^t} \pi(s^t) \beta^t U_1(c(s^t), 1 - n(s^t)) d(s^t)$$

$$\begin{aligned}
&\geq (1 - \tau) \sum_{t=1}^{\infty} \sum_{s^t} \pi(s^t) \beta^t U_1(c(s^t), 1 - n(s^t)) r x(s^t) d^*(s^t) \\
&= \text{if } \lambda^f > 0
\end{aligned}$$

Thus in equilibria featuring some degree of international diversification, the equilibrium marginal value for the domestic agent of the stream of dividend income associated with an additional domestic share is equal to the value to the domestic agent of the stream of after-tax foreign dividends associated with an additional share of the foreign firm. Both these marginal values are equal to the market price (equal across countries) of buying shares at date 0. This equation is used later to determine the equilibrium value for $\lambda = \lambda^*$ given a tax rate τ .

Note that $\lambda = 1$ corresponds to the case of complete home bias in asset holding.

Definition of equilibrium

An equilibrium is a set of prices for all s^t and for all $t \geq 0$ such that when households and firms solve their problems taking these prices as given all markets clear.

The markets for goods a and b clear :

$$a(s^t) + a^*(s^t) = F(z(s^t), k(s^t), n(s^t))$$

$$b(s^t) + b^*(s^t) = F^*(z(s^t), k(s^t), n(s^t)).$$

Final goods market clear in both countries :

$$c(s^t) + x(s^t) = G(a(s^t), b(s^t))$$

$$c^*(s^t) + x^*(s^t) = G^*(a^*(s^t), b^*(s^t)).$$

Stock markets clear :

$$\lambda + \lambda^{h*} = 1 \quad \lambda^f + \lambda^* = 1$$

The governments budgets balance :

$$\tau\lambda^f rx(s^t)d^*(s^t) = \psi(s^t) \quad \frac{\tau\lambda^{h*}d(s^t)}{rx(s^t)} = \psi^*(s^t)$$

5. Parameter values and computation

Our benchmark parameter values are reported in table 10. In the calibration process we identify country 1 as the United States and country 2 as the same aggregate of major trading partners described in the data section of this paper.

The steady state share of imports in production of the final good is set to 15%, which is approximately the ratio of imports or exports to GDP in the United States. The elasticity of substitution between the domestic and foreign intermediate good is set to unity, which is similar to the value of 0.92 estimated by Heathcote and Perri (2001).

Most other parameters take standard values. However, there is strong evidence that the international correlation of productivity has declined over the past thirty years. To estimate productivity processes we follow essentially the same procedure as Backus, Kehoe and Kydland (1992). Since quarterly data on the capital stock are not available for all countries, we rely on employment data, and identify productivity at date t as¹⁶

$$\widehat{z}(s^t) = \log(\widehat{y}(s^t)) - (1 - \theta) \log(\widehat{n}(s^t)).$$

where $\widehat{y}(s^t)$ and $\widehat{n}(s^t)$ are 2×1 vectors describing real GDP and total employment in the U.S. and the rest of the world. We assume that labor's share of income, $1 - \theta$, is the same across regions and equal to 0.64. Our total sample period is 1972 : 1 to 2000 : 4.

We first eliminate secular growth in productivity by linearly detrending the series for the vector $\widehat{z}(s^t)$. We then assume that detrended productivity evolves according to the law of motion

¹⁶Cooley and Prescott (1995) note that the capital stock varies very little over the business cycle, so omitting capital should not greatly affect the time series properties of z at business cycle frequencies.

described in the model section:

$$(19) \quad \widehat{z}(s^t) = A\widehat{z}(s^{t-1}) + \widehat{\varepsilon}(s^t),$$

where A is a 2×2 matrix and $\widehat{\varepsilon}(s^t)$ is a 2×1 vector of normally distributed disturbances with mean zero, standard deviation (common across regions) σ_ε and correlation coefficient ρ_t . We will assume that ρ_t is the only model parameter that changes over time in our simulations.¹⁷ Moreover we model this time variation in a very simple fashion by assuming that in the first half of our sample period this parameter takes on one value (ρ_1) while in the second half of the sample it takes a different value (ρ_2). This corresponds to the same sample split we used to document changes in the data.

To obtain estimates for the elements of A we estimate eq. 19 using SURE on data for the entire sample period, which gives

$$(20) \quad A = \begin{pmatrix} 0.91 & 0.00 \\ 0.00 & 0.91 \end{pmatrix}.$$

These estimates are similar to those found by Backus, Kehoe and Kydland (1992) for the United States versus Europe, though our process displays no spill-overs.¹⁸ The estimated values for σ_ε , ρ_1 and ρ_2 are reported in table 10.

The only remaining parameter is the tax rate τ that applies to foreign dividend income. We pick this parameter so that in the first sub-period, equilibrium diversification in the model defined by $1 - \lambda$ is exactly equal to the average ratio (over time and across assets and liabilities) of the gross U.S. foreign direct investment position plus the foreign equity portfolio stock relative to the U.S. capital stock. This implies picking a value for τ such that $1 - \lambda = 0.055$ (see table 7)

¹⁷Another possibility would have been to allow the off-diagonal element (determining the degree of spillover) to change through time. However, this has the effect of changing the persistence of shocks to relative productivity, which makes results more difficult to interpret. Moreover, given a relatively short sample period, it is difficult to separately identify changes in the correlation of innovations from changes in the spill-over terms.

¹⁸One reason for this difference is that we subtract linear trends from the productivity series prior to estimation while Backus and al. estimate A directly on the raw data.

To summarize, all parameter values except the innovation correlation ρ , are held constant across simulations of the model for the two sample periods. In the results section we shall consider two alternative experiments. In the first (constant diversification) agents choose their portfolios at the start of the first period and are unable to reoptimize when the shock correlation unexpectedly changes at the start of the second period. In the second (endogenous diversification) agents can reallocate their assets across countries when the productivity correlation is reduced.

Table 10. Parameter values

Preferences	
Discount factor	$\beta = 0.99$
Consumption share	$\mu = 0.34$
Risk aversion	$1 - \gamma = 1$
Technology	
Capital share	$\theta = 0.36$
Depreciation rate	$\delta = 0.025$
Import share of i -firms	$is = 0.15$
Elasticity of substitution	$\sigma = 1.0$
Productivity transition matrix	$A = \begin{pmatrix} 0.91 & 0.00 \\ 0.00 & 0.91 \end{pmatrix}$
Correlation of innovations	72.1 – 86.2 86.3 – 00.4 $\rho_1 = 0.40$ $\rho_2 = -0.03$
Std. dev. of innovations	$\sigma_\varepsilon = 0.006$
Tax rate on foreign dividends	$\tau = 0.045\%$

6. Solution method

Given an exogenous choice for the home bias parameter λ , we could solve the stock economy via a linear approximation. However, we find that in order to accurately compute the equilibrium value for λ when the portfolio split is a choice variable, greater numerical accuracy is required. This is a common feature of portfolio problems, and reflects the fact that welfare costs of deviating from the optimal portfolio are small. We therefore solve the stock economy model using a global solution method which is designed to generate close approximations to equilibrium allocations across the entire state space.

In particular, we first approximate the joint process for productivity with a nine state Markov chain. Each state defines particular values for the productivities of the domestic and foreign representative firms. The values for the states and the transition probabilities are such that the implied Markov process exhibits the same persistence, variance and cross-country correlation as the analogous continuous process estimated via a VAR (see the calibration section). The states and transitions are assumed to be symmetric across the two countries, so that over a long simulation, business cycles will have the same statistical properties in both countries.

Given a discrete representation for the productivity process, we solve for equilibrium allocations given a particular value for the home bias parameter $\lambda = 1 - \lambda^f$ using standard Euler equation iteration. We assume that for each productivity state the right hand side of the inter-temporal Euler equation is piecewise linear over a two dimensional grid defined over the domestic and foreign capital stocks. Given an initial guess for this function, we use the set of equations characterizing equilibrium to solve for allocations. We then update our initial guess and iterate until allocations have converged across the entire grid.

The non-standard step in the solution procedure involves determining the equilibrium value for λ , which reflects households' optimal portfolio diversification at the start of time. We assume

that at date zero, both the productivity levels and the capital stocks are equal across countries, and equal to their values in the non-stochastic steady state for this economy (this steady state does not depend on λ). Since the productivity process is symmetric, expected lifetime utility is equal across countries. We solve for the equilibrium λ as follows. Recall that given symmetry, the first order conditions for the optimal portfolio split imply that

$$(21) \quad \sum_{t=1}^{\infty} \sum_{s^t} \pi(s^t) \beta^t U_c(s^t) d(s^t) \geq (1 - \tau) \sum_{t=1}^{\infty} \sum_{s^t} \pi(s^t) \beta^t U_c(s^t) r x(s^t) d^*(s^t) \\ = \quad \text{if } \lambda^f > 0$$

Thus computing a competitive equilibrium given a particular calibration (which includes a choice for τ) amounts to finding a value for λ such that at the allocations corresponding to that particular value for λ , equation 21 is satisfied. Note that the equilibrium λ is not necessarily the λ that maximizes expected utility, since the welfare theorems do not apply to this economy.

In practice we proceed as follows. First we create a fine grid over values for λ from $\lambda = 0$ (indicating perfect foreign bias in stock holding) to $\lambda = 1$ (indicating perfect home bias). For each value for λ in this grid, we solve for equilibrium allocations. Since tax revenues are rebated lump-sum to the representative agents in each country, 21 is the only equation in the set of equations characterizing equilibrium that references τ . Thus we can solve for equilibrium for a given a value for λ ignoring τ , and then back out the value for τ that supports this equilibrium using eq. 21. Once we have a value for τ for each point in the grid on λ , we can count how many interior equilibria, if any, are supported by any particular choice for τ . For example, for sufficiently high values for τ we should expect that there will be no values for λ satisfying equation 21, and that the only equilibrium is a corner solution in which $\lambda = 1$ and there is 100 percent home bias. However, for small but positive values for τ we might expect to find (possibly non-unique) equilibria with some diversification. In the results section we discuss a numerical example in which two positive diversification equilibria

emerge for certain tax rates.

Note that if the optimal portfolio condition is satisfied for the domestic agent, then it is easy to verify that the corresponding condition

$$\begin{aligned} \sum_{t=1}^{\infty} \sum_{s_t} U_c^*(s^t) d^*(s^t) &\geq (1 - \tau) \sum_{t=1}^{\infty} \sum_{s_t} U_c^*(s^t) \frac{d(s^t)}{rx(s^t)} \\ &= \text{if } \lambda^{h^*} > 0 \end{aligned}$$

is also satisfied for the foreign agent.

7. Results

We now use the model to answer two key questions. First can an exogenous fall in the correlation of productivity shocks account for the magnitude of the observed increase in diversification? Second, is increased diversification important in accounting for the magnitude of the decline in observed business cycle correlations?

Our results are summarized in table 11 and figures 8 and 9.

A. Correlation of shocks and international diversification

To understand the equilibrium determination of λ , it is helpful to consider figure 8. The curves plot equilibrium levels of diversification given particular tax rates τ on foreign dividends. Recall that as part of the calibration procedure, the tax rate τ is set so that it intersects the first period curve at the average level of diversification observed in the first sub-sample of data. The picture shows that in the second period (characterized by less correlated shocks) the value of holding foreign stock increases and hence, given a constant tax rate, more international diversification is observed in equilibrium. The model predicts that the amount of foreign assets held by domestic consumers increases from 5.5 percent of the capital stock to 15 percent of the capital stock, suggesting that the change in correlation is a quantitatively important factor in determining the extent of international

diversification.

There are two other interesting features of the economy revealed by figure 8. The first is that even in absence of any taxes, diversification will not be complete; with a zero tax rate only about 20 percent of total assets are invested abroad. The reason why complete diversification is not observed (contrary to the simple model considered in section 3) can be understood as follows. First, recall that household consumption is now given by the sum of labor income (a fixed fraction of output), domestic dividend income, and foreign dividend income. When households decide their portfolio they not only consider the correlation between domestic and foreign dividends (as in the simple model) but also the correlation between dividend and labor income. Domestic dividends are given by capital income (also a fixed fraction of output) minus investment (which is positively correlated with and more volatile than output). It follows that domestic dividend income is negatively correlated with domestic output and thus negatively correlated with domestic labor income. Domestic dividends therefore provide a good hedge against labor income volatility, and domestic households are happy to hold a relatively large fraction of domestic capital.¹⁹

Notice that this result is very different from the finding of Baxter and Jermann (1997) who show that the presence of labor income risk should make individuals want to hold more than 100% of their wealth in foreign assets. One key difference between our model and theirs is the nature of investment. In their model investment is assumed to be constant, which generates a perfect correlation between labor and capital income and thus strong incentives to diversify.

The second interesting aspect revealed by the figure is that for certain tax rates the model has two equilibria corresponding to two different levels of diversification. We conjecture that this feature is due to a diversification externality. The specification of the firms' objective implies that the value to households of diversifying their asset holdings depends on the aggregate level of diversification,

¹⁹It is interesting to note that the correlation between aggregate labor income and this definition of aggregate dividend payments is strongly negative in the U.S.

since when aggregate diversification is higher, firms place a higher weight on the preferences of foreign shareholders. If this effect is sufficiently strong, it is possible to have a low diversification equilibrium in which agents do not diversify because foreign firms do not consider them when deciding dividends, and a high diversification equilibrium in which consumers do diversify because foreign firms now pay sufficient attention to their preferences when making investment, employment and dividend decisions. The picture suggests that for the calibrations corresponding to both subperiods there is a (small) range of taxes for which this phenomenon arises. To verify the conjecture regarding the source of multiplicity, we consider an alternative specification in which we eliminate the diversification externality by assuming that domestic firms care only about domestic consumers (regardless of the level of diversification). In this case, we find only one equilibrium for each level of the tax (see figure 9). Notice also that when firms only care about domestic consumers the value of international diversification is reduced, and for any given tax rate less diversification is observed in equilibrium. Naturally, the two varieties of the model coincide when there is perfect home bias.

B. Correlation of shocks and international business cycles

In table 11 we report empirical business cycle statistics along with the predictions of the calibrated model economies. Reported statistics for the models are the averages across 200 simulations, each of which is 58 periods long. In the first subperiod, the equilibrium level of international diversification is equal to 5.5 percent. Simulation results given this level of diversification and the first period shock correlation are in the second row of table 11. For the second subperiod we report results for our two alternative experiments. In the first (constant diversification), although the shock correlation is reduced to the estimated second period level, households are not permitted to reoptimize their portfolios. In the second experiment (endogenous diversification) households re-optimize when the shock process is changed, and diversification increases to 15 percent (see the previous section).

Table 11. Simulation results

		International correlations				%	
		Y	C	X	L	Std(RX)	$E(\frac{NX}{Y})$
Period I	Data	0.76	0.51	0.63	0.66	5.34	1.10
72.1-86.2	Model	0.70	0.76	0.62	0.66	0.66	0.04
Period II	Data	0.26	0.13	-0.07	0.03	4.00	1.64
86.3-00.4	Constant Div.	0.38	0.50	0.26	0.32	0.86	0.05
	Endog. Div.	0.21	0.29	-0.08	0.15	0.56	0.18

For the first sub-period the cross-country correlations predicted by the model are very similar to those observed in the data. On the negative side, in the data output is more strongly correlated across countries than consumption, while the model predicts the reverse. Moreover, the real exchange rate is too smooth, and there is too little intertemporal trade.²⁰

When diversification is held constant and the shock correlation is reduced from 0.4 to -0.03 , the model-implied correlations fall, but all correlations remain positive and larger than 0.25. However, the correlations of consumption, investment and employment between the U.S. and the rest of the world were all close to zero over the second sub-period. Moreover, the model predicts a roughly uniform decline in correlation for all variables, whereas in the data the decline correlation for investment and employment was more pronounced than for consumption. Thus reducing the correlation of shocks alone cannot account for the observed change in business cycle comovement.

In contrast, the model in which both the shock process and the level of diversification change across sub-periods can account for many of the observed changes in international business cycle

²⁰These shortcomings of this class of models have been noted by many authors, beginning with Backus, Kehoe and Kydland 1994.

statistics. The model is consistent with the magnitude of the overall reduction in correlations and generates a particularly large fall in the correlation of investment. The model is also qualitatively consistent with the observed reduction in real exchange rate volatility, and the increase in the average absolute value of net exports, facts that cannot be accounted for by the constant diversification model. Thus allowing for more international asset trade in response to a change in the shock process has the effect of further reducing model-predicted correlations in factor supplies, such that the combined effects of less correlated shocks and more asset trade can jointly account for the magnitude of the changes in correlations seen in the data.

Why does increasing portfolio diversification reduce international co-movement in investment and employment? Consider the problem of a firm that is entirely owned by domestic shareholders. If firm productivity rises, the firm would like to respond by increasing investment, but the firm recognizes that more current investment implies lower current dividend income and consumption for its shareholders. Thus the firm does not adjust investment much in response to temporary shocks. If a large fraction of the firm's stock is held by foreigners, however, the firm is much more willing to increase investment given the same shock. The firm recognizes that domestic households have dividend income from abroad, and this income is not going to be much affected if the domestic country is hit by a relatively good shock. The overall effect is that firms will be willing to invest heavily when productivity is relatively high (and to cut back investment when productivity is relatively low) rather than to smooth investment through time. Thus the international correlation in investment falls as international diversification increases. To summarize, diversification allows countries to specialize intertemporally and to more efficiently exploit international differences in productivity.

8. Conclusion

Financial markets are becoming increasingly integrated internationally. A trend towards portfolio diversification has left asset holders less exposed to country-specific risk, and the flow of capital to its most productive location is increasingly unhindered by restrictions on international borrowing and lending.

This paper explores the implications of the ongoing growth in international asset trade for the real economy. We find that the trend towards financial globalization has been accompanied by a trend towards real regionalization. In particular, while output, employment and investment in the United States were strongly correlated with their foreign counterparts in the immediate post Bretton-Woods period, these correlations have since fallen dramatically.

Within a model in which the volume of assets traded internationally is determined endogenously, we are able to simultaneously account for both trends. Our conclusions are threefold. First, there is evidence of increasing country-specific risk, which is consistent with observed growth in international asset trade. Second, in models which quantitatively capture this growth in asset trade, financial integration has large implications for the real side of the international business cycle. Third, observed changes in the international business cycle are difficult to account for when the extent to which countries are linked via international financial markets is assumed constant, but are readily reconciled in a model which allows for endogenous international diversification.

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Data Appendix

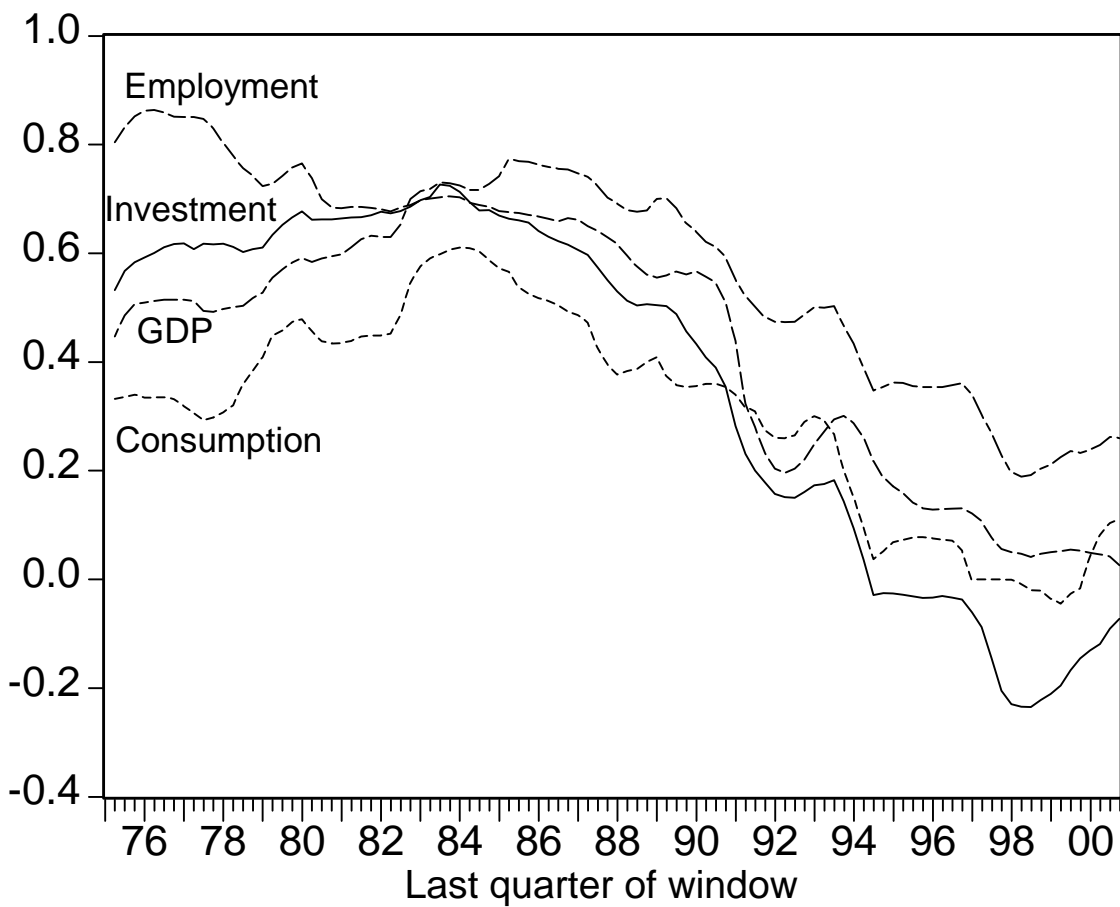
The data series for U.S. GDP, consumption, investment are from the OECD Quarterly National Accounts (QNA) and they are Gross Domestic Product, Private plus Government Final Consumption Expenditure, Gross Fixed Capital Formation (all at constant prices). For GDP, consumption and investment in the rest of the world, we constructed an aggregate of Canada, Japan, and Europe 15 (an OECD aggregate of the following countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Norway, Netherlands, Portugal, Spain, Sweden and United Kingdom). The original series are from the OECD-QNA, the same source we used for the U.S. We aggregated to create a single fictional non-U.S. country by first rebasing each series in 1996 national currency constant prices (using series specific deflators from the OECD, QNA) and then expressing everything in 1996 U.S. dollars using PPP exchange rates (from the OECD). Employment for the U.S., Canada, Japan and Europe 15 is the (deseasonalized) civilian employment index series from the OECD, Main Economic Indicators. Employment for the rest of the world is aggregated using constant weights, from the OECD, that are proportional to the number of employed persons in each area in 1995. Since before 1983 employment series for Europe 15 is not available, for the period 1972.1 1983.4 we use employment (aggregated using OECD weights) for Austria, Finland, France, Germany, Italy, Norway, Spain, Sweden and the United Kingdom, while for the period 1962.1 1971.4 we use employment (aggregated using OECD weights) of Finland, Germany, Italy, Sweden and United Kingdom. These were the only European countries for which we could find consistent and comparable employment series.

U.S. holdings of foreign stocks, and foreign holdings of U.S. stocks by country and in aggregate are reported in ‘The International Investment Position of the United States’ published in various issues of the Survey of Current Business (SCB) by the Bureau of Economic Analysis (BEA). The U.S. direct investment position abroad, and the foreign direct investment position in the U.S. by

country are reported on a historical-cost basis in ‘Direct Investment Positions for [year]: Country and Industry Detail’ in various issues of the SCB by the BEA. Aggregate measures of foreign direct investment at current cost and at market value are from ‘The International Investment Position of the United States’. The U.S. capital stock is the net stock at current cost of private nonresidential fixed assets as reported by the BEA. We estimate FDI (inward and outward) at current cost (market value) for Europe Canada and Japan by first computing the share of total FDI on a historical cost basis accounted for by these countries, and then multiplying this fraction by aggregate FDI at current cost (market value). For the period 1972 to 1975 we take direct investment position figures at market value from Lane and Milesi-Ferretti (2000), and use ratios of market capitalization to the current-cost replacement value of the capital to stock to estimate FDI at current cost.

The series for U.S. market capitalization is the combined NYSE, AMEX and NASDAQ capitalization series from the Center for Research on Stock Prices (CRSP). A series for foreign market capitalization is created by (i) using International Federation of Stock Exchanges data to weight the relative capitalizations of the stock markets corresponding to the U.S. and the set of countries included in the Morgan Stanley MSCI World (developed economies) excluding USA Price Index series in 2000 and (ii) using the ratio of the MSCI World excluding USA series to the MSCI USA series to estimate a series for foreign market. The series for the U.S. real exchange rate is a trade-weighted measure of the real value of the U.S. dollar reported by the Board of Governors (Major Currencies Index). The series for net exports is constructed by taking the ratio between exports minus imports and GDP, all at current prices, from the OECD, QNA. The current account series is the ratio between the current account from the IMF, International Financial Statistics and GDP, all at current prices. Stock prices indexes for the U.S. are from MSCI USA and for the rest of the world are from MSCI World excluding USA. All indexes are in quarterly averages and in dollars. The complete dataset is available at www.stern.nyu.edu/~fperri/research.

Figure 1. International correlations (rolling window estimates)



Each window is 58 quarters long. Correlations are between the US variable and the corresponding variable for Europe, Canada and Japan

Figure 2. US stock of assets in Europe, Canada and Japan

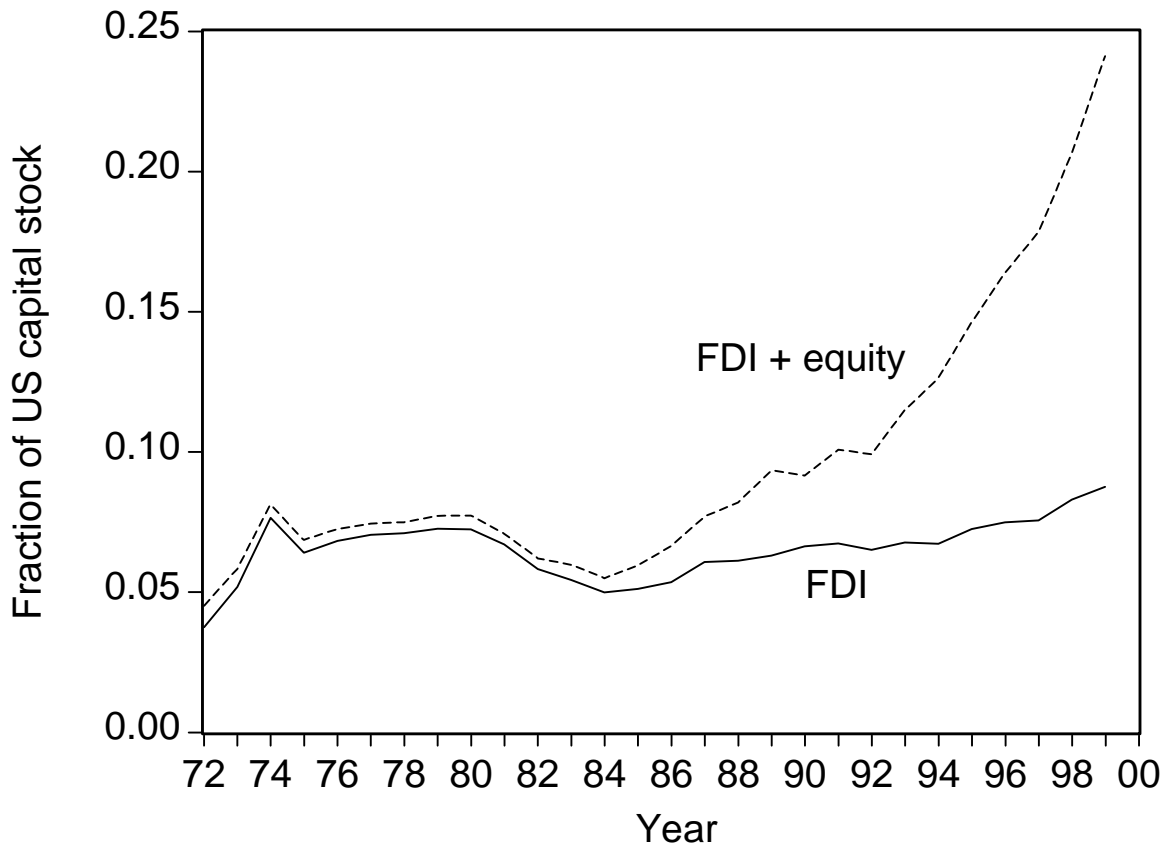


Figure 3. Stock of US assets held by Europe, Canada and Japan

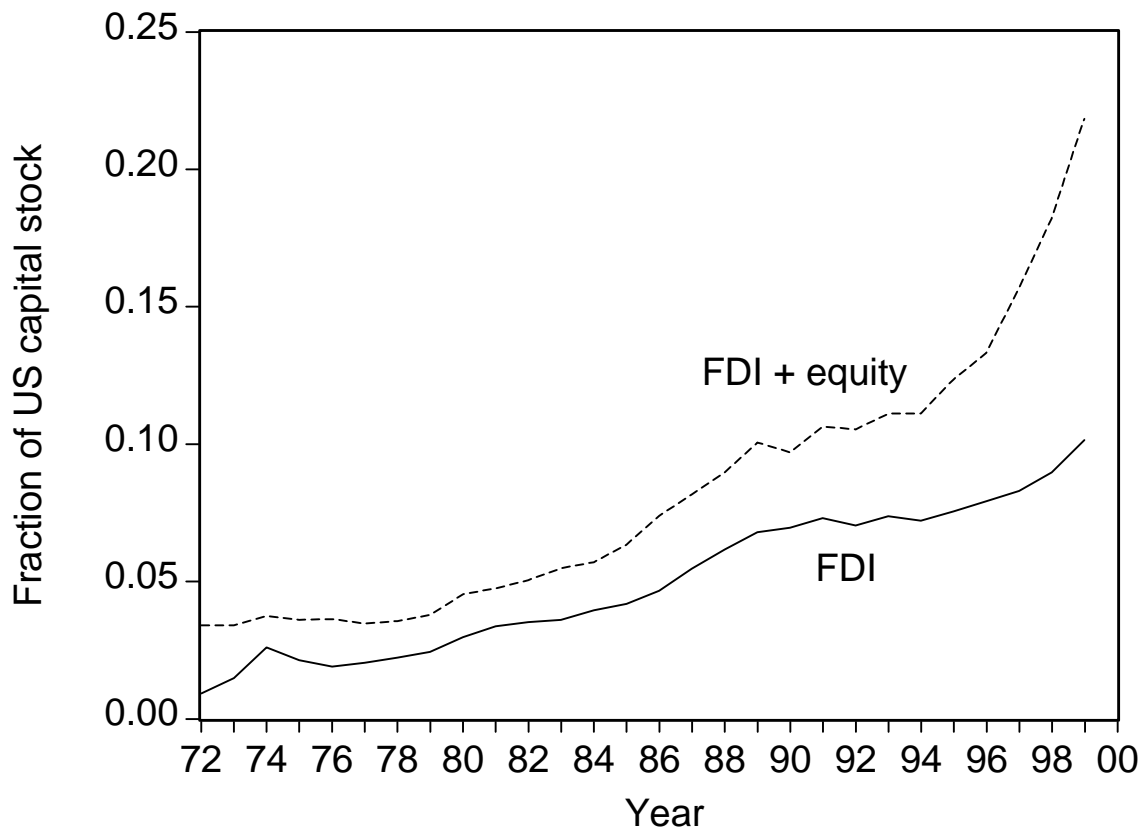
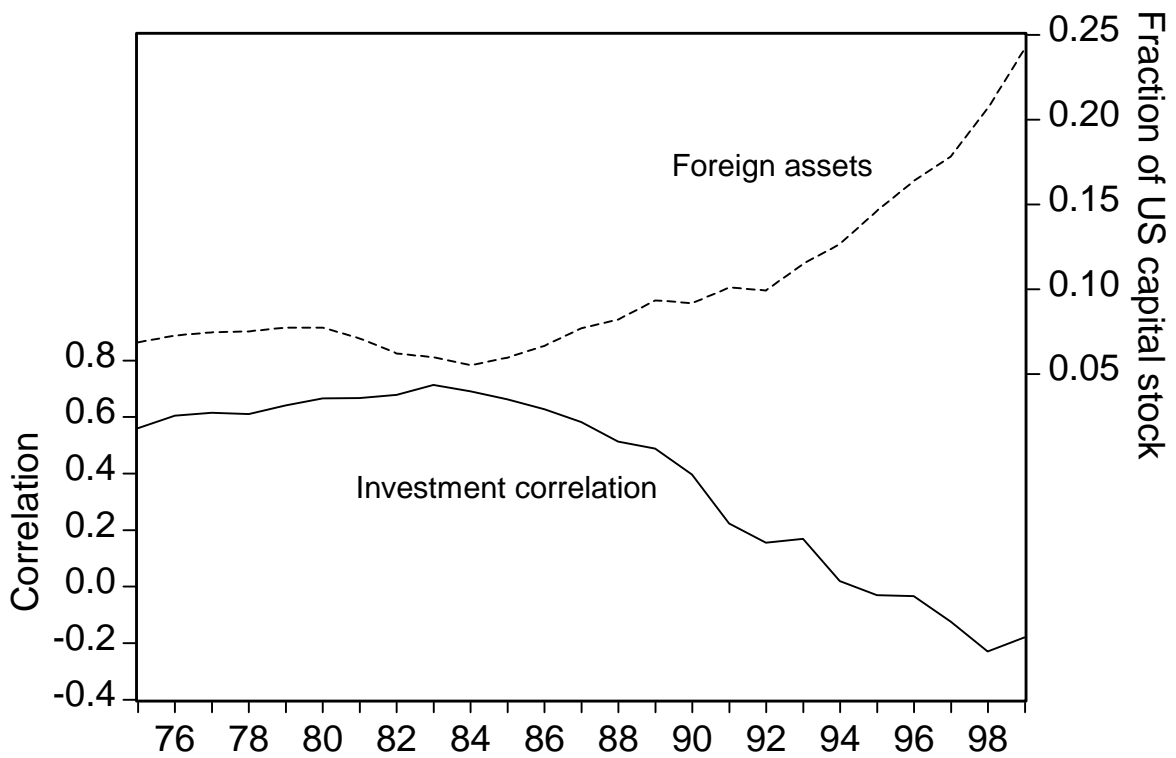


Figure 4. Financial globalization and real regionalization



Foreign assets are stocks of US FDI and equity investment in Europe, Canada and Japan. Investment correlation is the correlation between US investment and investment in Europe, Canada and Japan over the previous 58 quarters.

Figure 5. International diversification and shock correlation

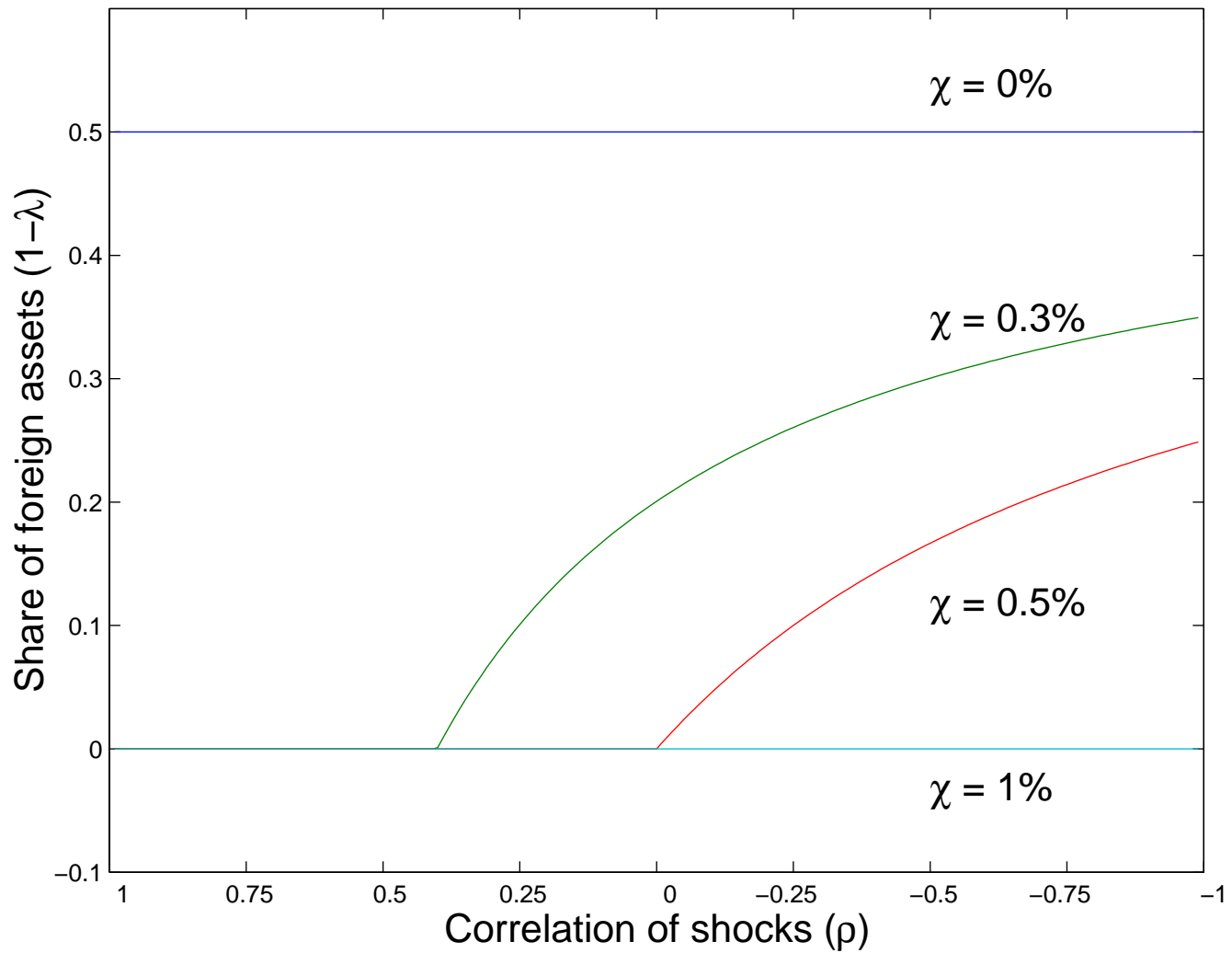


Figure 6. Consumption correlation and shock correlation

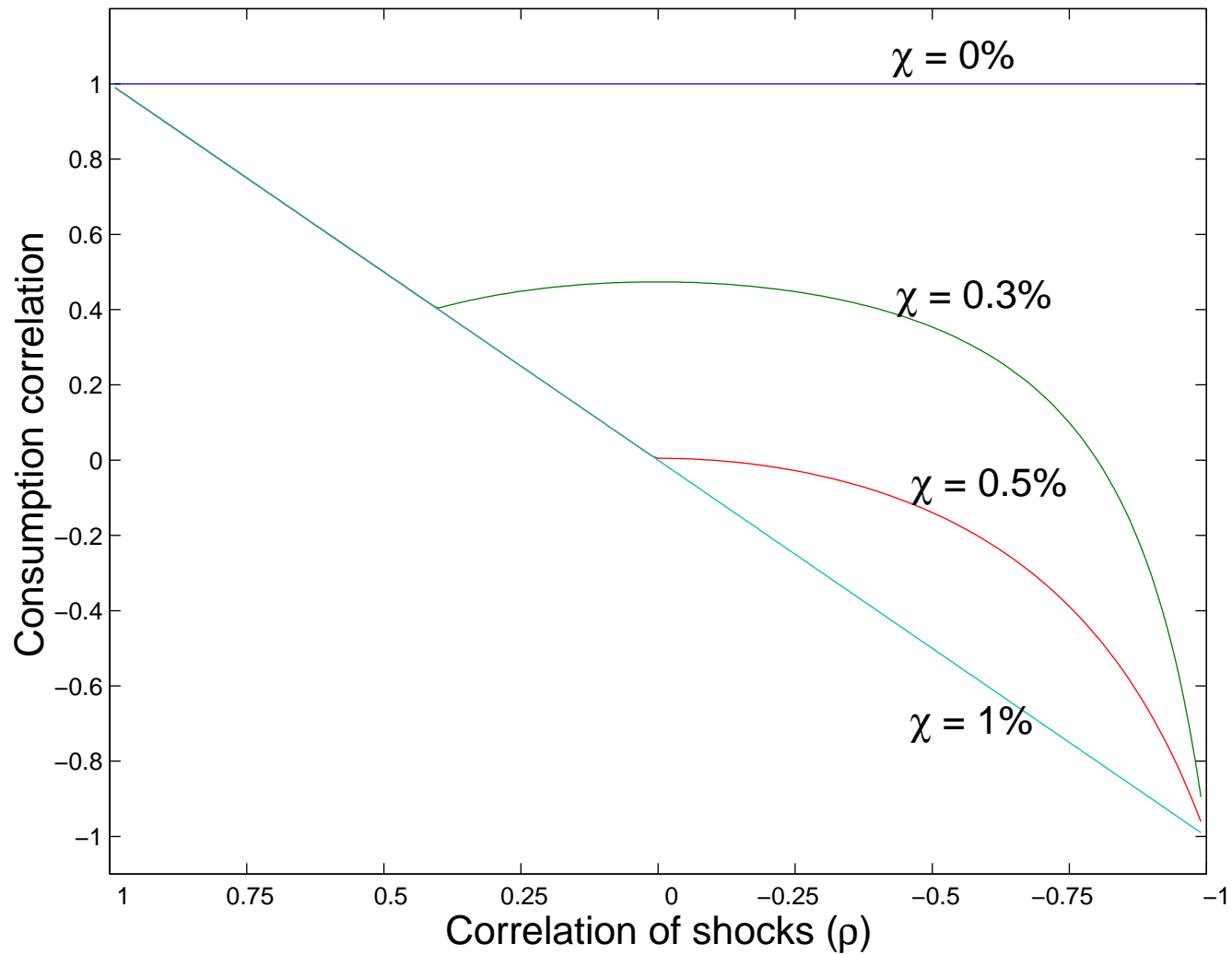


Figure 7. Volatility of net exports and shock correlation

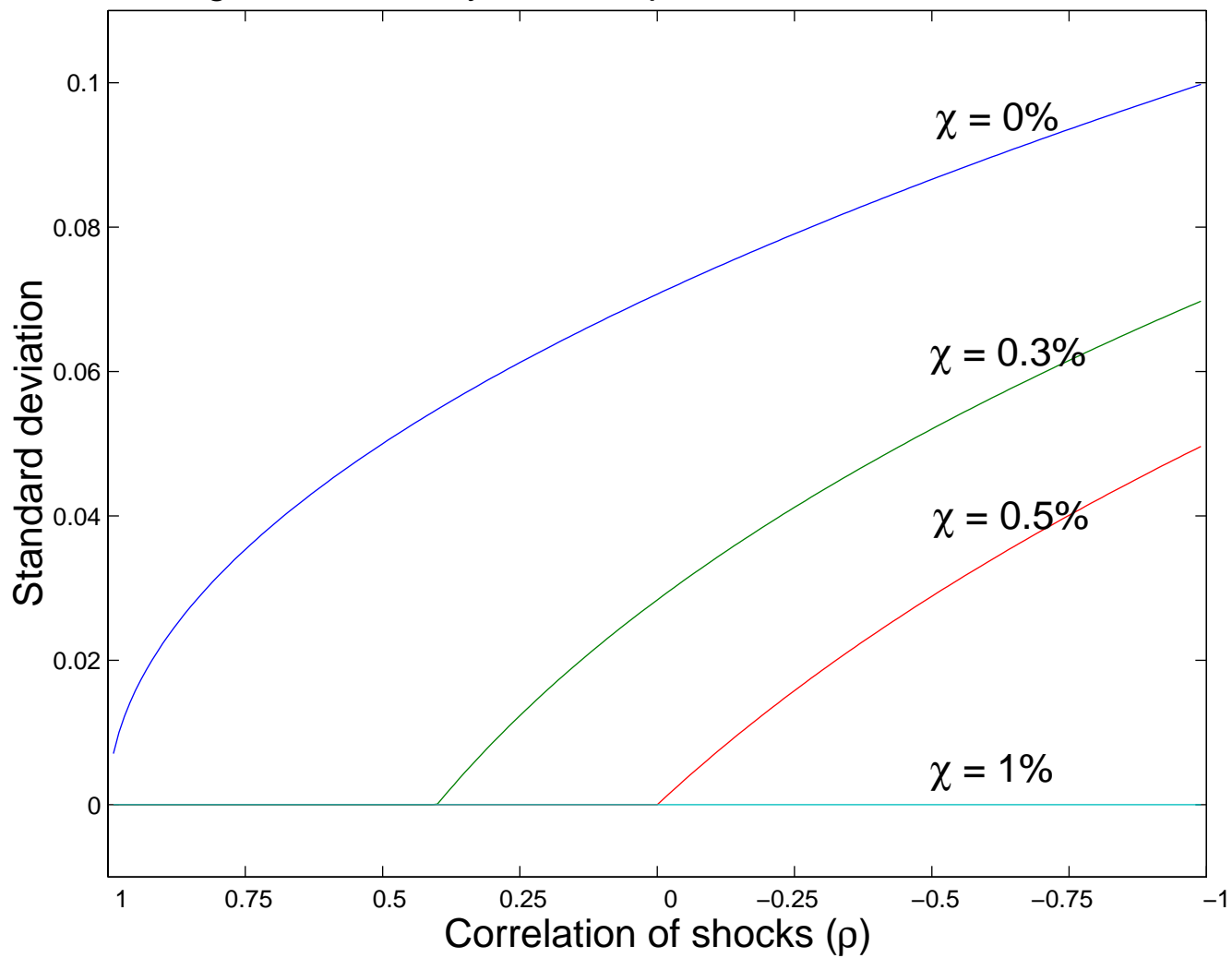


Figure 8. Equilibrium diversification

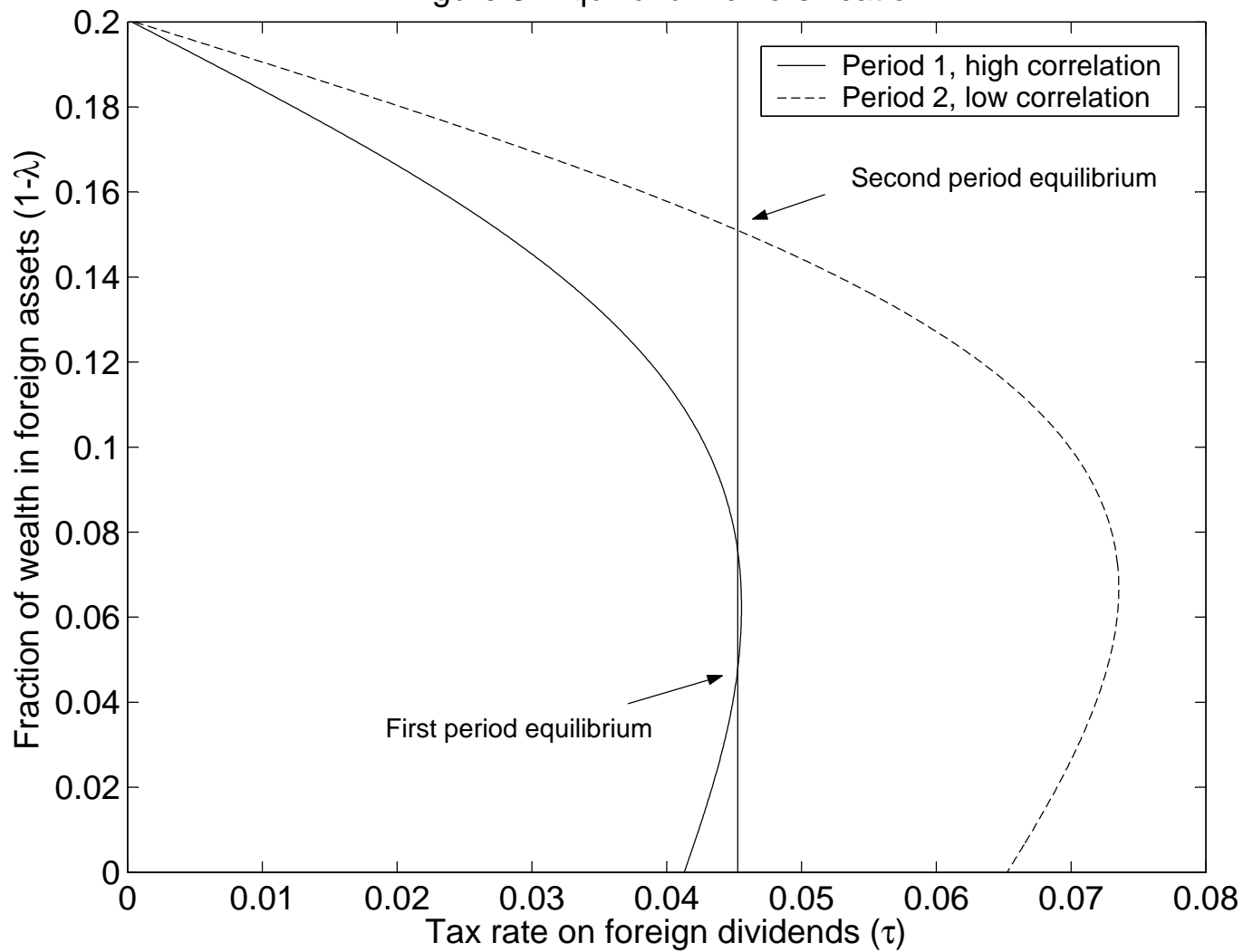


Figure 9. Equilibrium diversification

