DISCUSSION PAPER SERIES

No. 2940

CONSUMPTION DYNAMICS AND REAL EXCHANGE RATES

Morten O Ravn

INTERNATIONAL MACROECONOMICS

Centre for Economic Policy Research

www.cepr.org

Available online at: **www.cepr.org/pubs/dps/DP2940.asp**

ISSN 0265-8003

CONSUMPTION DYNAMICS AND REAL EXCHANGE RATES

Morten O Ravn, London Business School and CEPR

Discussion Paper No. 2940
September 2001

Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR, UK
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: www.cepr.org

CEPR Discussion Paper No. 2940

September 2001

ABSTRACT

Consumption Dynamics and Real Exchange Rates*

The Paper investigates the role of the real exchange rate in relationships between consumption growth rates across countries when financial markets are integrated. The real exchange rate introduces a wedge between real marginal utilities of consumption in different countries and this wedge plays a prominent role in a number of new theories of international fluctuations. Yet, the role of the real exchange rate has been ignored in many previous studies of risk sharing and financial market integration. We find a limited role for the real exchange rate in these relationships. Special attention is also paid to the analysis of non-separabilities in the utility function including effects of money balances, leisure, government spending, and habit persistence. The results are also shown to be robust to decomposing consumption. The evidence may question the empirical plausibility of recent theories of international business cycles that associate a crucial role to the real exchange rate in breaking the direct link between consumption in different countries.

JEL Classification: E21, E32 and E41
Keywords: consumption risk sharing, habit persistence, non-separabilities and real exchange rates

Morten O Ravn
Department of Economics
London Business School
Sussex Place
Regent's Park
LONDON
NW1 4SA
Tel: (44 20) 7262 5050 x3717
Fax: (44 20) 7402 0718
Email: mravn@london.edu

* I am grateful for comments from seminar participants at the Bank of England, participants at the CBGR conference on Macroeconomics 2000, University of Manchester, participants at the CEPR ESSIM conference 2000, and especially to Dave Backus, Mick Devereux, Charles Engel, Philip Lane and Andrew Scott for detailed discussions and comments. The Paper is a part of the project 'Exchange Rates, International Relative Prices, and Macroeconomic Models' funded by the ESRC (grant no. L138 25 1043). This Paper is produced as part of a CEPR research network on 'The Analysis of International Capital Markets: Understanding Europe's Role in the Global Economy', funded by the European Commission under the Research Training Network Programme (Contract No. HPRN-CT-1999-00067).

Submitted 24 July 2001

NON-TECHNICAL SUMMARY

An important issue in international macroeconomics and finance is the degree to which international financial markets help countries insure their consumption streams against idiosyncratic fluctuations in the economy. When agents are risk-averse they would wish to smooth consumption over time and accessing international financial markets provides a means for facilitating such smoothing. When countries face few restrictions on international borrowing and lending, and when there are sufficiently many contingent claims contracts available, access to international financial markets can lead to risk sharing relationships. Risk sharing refers to situations in which a group of countries pool parts of or all of the idiosyncratic risk that they face. When there are fewer contingent claims contracts available, agents may still smooth their consumption but may not necessarily be able to pool all of the idiosyncratic risk. Nevertheless, even if there are only non-contingent bonds available, integration of financial markets will generally lead to equalization of expected marginal rates of substitution of consumption across countries and states of natures (or a subset of these).

This principle is now incorporated into most international macroeconomic models. This principle has been tested empirically in a number of papers that have at best found limited evidence in favour of the hypothesis of integrated financial markets. Consistent with these studies is the observation, and puzzle, in the international macroeconomic literature that cross-country consumption correlations are low in the data while most standard macroeconomic models imply very large and positive correlations.

This evidence has led researchers to develop new theories that can account for these features. One currently popular strand of literature in the international macroeconomics area stresses the importance of fluctuations in real exchange rates. Among others, Betts and Devereux (1996, 2000), Kollmann (1996), and Chari, Kehoe and McGrattan (1998) have constructed international business cycle models in which the Law of One Price (the LOP) for traded goods fails to hold because of so-called Pricing-to-Markets (PTM) – see Lane (1999) for an excellent survey. According to these theories, although countries can access international financial market, real intertemporal marginal rates of substitution of consumption fail to equalize across countries. The reason for that is that it is assumed that exporters set prices in the currency of purchaser and that these local currency prices are sticky. Hence, fluctuations in nominal exchange rates in these models give rise to temporary deviations from purchasing power parity (PPP). This gives rise to a modification of the risk-sharing condition because real exchange rate variations introduce a wedge between the real marginal rates of substitution of different countries. At the intuitive level, if all countries can borrow and lend at the same nominal interest rate, fluctuations in real exchange rates are

equivalent to variations in real interest rates across countries that are associated with intertemporal reallocations of marginal utility of consumption.

The purpose of this Paper is to look further into this mechanism (which holds more broadly in settings where PPP is violated). In particular, we investigate empirically the evidence on integrated financial markets allowing for violations of PPP through variations in real exchange rates. Given the overwhelming evidence of substantial and persistent fluctuations in real exchange rates it would seem important to take this aspect into account when testing for risk sharing. The central assumption that is made is that – although asset markets may be incomplete – all countries can borrow and lend at the same nominal interest rate. Given that we will focus on OECD economies in the empirical tests of the theory this assumption does not appear unrealistic. We do not assume that PPP holds, a feature that again is realistic given the overwhelming evidence of real exchange rate volatility. In this case the integration of financial markets implies that the expected nominal marginal rates of substitution in consumption are equalized across countries. The expected real marginal rates of substitution will in general not be equalized because of movements in real exchange rates. More precisely, real exchange rate movements introduce a wedge between different countries' expected real marginal rates of intertemporal substitution.

To test this hypothesis we follow the approach suggested by Obstfeld (1989) and make assumptions that allow for the use of an instrumental variables estimator. The risk financial markets integration hypothesis then amounts to a regression based test stating that (the rate of changes in) foreign consumption and the real exchange rate should be able to explain the movements in domestic consumption (growth). Furthermore, the regression errors should be orthogonal to the information set used when estimating these relationships. This extends the results reported by Obstfeld (1989) and by Kollmann (1995) in a number of directions. First, we analyse data for a large cross-section of OECD countries. Our data set involves 12 individual OECD countries as well as the aggregate OECD. Second, we look at the stability of the results across different types of sample periods, and the data period under consideration is substantially longer than in those earlier papers. Third, we devote special attention to the effects of non-separabilities in the utility function. As candidates for non-separabilities, we introduce leisure, government spending, and real money balances. Such non-separabilities are important to take into account because, if wrongly excluded from the analysis, one may falsely conclude against the risk-sharing hypothesis. We also check if the results are sensitive to non-separabilities between different types of consumption goods and separate consumption into durables, semi-durables, and services. Fourth, we also investigate the effects of habit persistence, a phenomenon that has attracted a great deal of attention in the closely related literature in empirical finance on asset pricing.

Our results provide mixed evidence on the relationship between consumption growth differentials and real exchange rate changes implied by integrated financial markets. We show that while foreign consumption growth is often significant in these relationships, the real exchange rate consistently lacks explanatory power. The latter result is shown to be robust to the various sensitivity analyses listed above. In particular, while we find empirical evidence indicating the importance of non-separabilities in the utility function and of habit persistence, these aspects do not lead one to change the conclusion against the risk-sharing hypothesis. Only when one imposed that preferences are identical across countries does one find a significant role for the real exchange rate, but the parameter restrictions that are imposed are strongly rejected by the data.

Thus, the role of the real exchange rate is crucial in testing for integration of financial markets, but rather than helping to bridge the gap between theory and data, it points towards rejection of the theoretical relationship. Given the crucial role that the real exchange rate plays in the newly developed international macroeconomic models built on deviations from PPP, this result casts some doubt on the empirical relevance of these theories. The result does not mean that there is no link between exchange rates and consumption. In particular, it is still possible that consumption might help in forecasting real exchange rates and, indeed, other researchers have found this to be the case. The results show that the parameter restrictions in the relationship between these variables imposed by integrated financial markets are rejected in the data.

1 Introduction

An important issue in international macroeconomics and finance is the degree to which international financial markets help countries insure their consumption streams against idiosyncratic fluctuations in the economy. When agents are risk averse they would wish to smooth consumption over time and accessing international financial markets provides a means for facilitating such smoothing. When countries face few restrictions on international borrowing and lending, access to international financial markets can lead to risk sharing relationships. Risk sharing refers to situations in which a group of countries pool parts of or all of the idiosyncratic risk that they face. The precise nature of such risk sharing relationships depends on the details of the asset markets, the constraints on the contracts that can be written etc., but will generally lead to equalization of expected marginal rates of substitution of consumption across countries and states of natures (or a subset of these). This principle is now incorporated into most international macroeconomic models.

Yet the empirical evidence in favor of the risk sharing principle is, at best, not convincing. A number of studies have examined the risk sharing proposition empirically (see among many others, Canova and Ravn, 1996, Crucini, 1999, Head, 1995, Kollmann, 1995, Lewis, 1996, 1999, Obstfeld 1989, 1994, Pakko, 1998, and Sorensen and Yosha, 1998).[1] While these studies differ in the data that is examined, in the precise nature of the risk sharing relations, and in the empirical techniques, the studies generally find evidence against the risk sharing hypothesis. Consistent with these studies is the observation, and puzzle, in the international macroeconomic literature that cross-country consumption correlations are low in the data while most standard macroeconomic models imply large and positive correlations, see e.g. Backus, Kehoe and Kydland (1992, 1995).

This evidence has lead researchers to develop new theories that can account for these features of the data. One currently popular strand of literature in the international macroeconomics area stresses the importance of fluctuations in real exchange rates. Among others, Betts and Devereux (1996, 2000), Kollmann (1996), and Chari, Kehoe and McGrattan (1998) have constructed international business cycle models in which the Law of One Price (the LOP) for traded goods fails to hold because of so-called Pricing-to-Markets (PTM), see Lane (1999) for an excellent survey.[2] Models with such features have claimed success in accounting for fluctuations in real exchanges and in accounting for the pattern of cross-country comovements of consumption and output. At the intuitive level, if all countries can borrow and lend at the same nominal interest rate, fluctuations in real exchange rates are equivalent to variations in real interest rates across countries that are associated with intertemporal re-allocations of marginal utility of consumption. Hence, such deviations from PPP introduce a wedge between the marginal utilities of consumption in different countries and therefore leads to modifications of the risk sharing relationships. This mechanism has important implication for many issues including monetary policy, see e.g. Devereux and Engel, 2000.

[1] Some studies have also analyzed the risk sharing hypothesis across regions, see e.g. Asdrubali, Sorensen and Yosha, 1996, or Hess and Shin, 2000.

[2] Other researchers have introduced similar features through non-traded goods and sticky wages, see e.g. Obstfeld and Rogoff, 1999.

The purpose of this paper is to look further into this mechanism. In particular, we investigate empirically the evidence on the risk sharing hypothesis allowing for violations of the LOP and PPP through variations in real exchange rates. Given the overwhelming evidence of substantial and persistent fluctuations in real exchange rates it would seem important to take this aspect into account when testing for risk sharing. Yet with the exception of Obstfeld (1989), Backus and Smith (1993), and Kollmann (1995) most tests of risk sharing have either implicitly assumed that PPP holds (e.g. Canova and Ravn, 1996, Crucini, 1999, Sorensen and Yosha, 1998) or have made corrections for real exchange rate fluctuations that may not appropriately take the effects of real exchange rate fluctuations into account. In particular, in some applications researchers have applied PPP-adjusted data when testing for risk sharing (see e.g. Lewis, 1996, 1999, or Obstfeld 1994), but such adjustments will only take the effects of real exchange rate fluctuations properly into account under special circumstances.

We make the assumption that asset market are incomplete but that all countries can borrow and lend at the same nominal interest rate. In this case the risk sharing condition implies that the expected nominal marginal rates of substitution in consumption are equalized across countries. However, the real marginal rates of substitution will in general not be equalized because of movements in real exchange rates. We test the hypothesis empirically following Obstfeld (1989) and the results extend those reported by Obstfeld (1989) and by Kollmann (1995) in a number of directions. First, we analyze data for a large cross-section of OECD countries. Secondly, we look at the stability of the results across different types of sample periods, and the data period under consideration is substantially longer than in those earlier papers. Thirdly, we devote special attention to the effects of non-separabilities in the utility function. As candidates for non-separabilities, we introduce leisure, government spending, and real money balances. We also check if the results are sensitive to non-separabilities between different types of consumption goods and separate consumption into durables, semi-durables, and services. Fourthly, we also investigate the effects of habit persistence, a phenomenon that has attracted a great deal of attention in the closely related literature in empirical finance on asset pricing.

Our results provide relatively strong evidence against the risk sharing hypothesis. In particular, the risk sharing relationships relate consumption growth in one country to consumption growth in another country and to the change in the real exchange rate. We show that while foreign consumption growth is often significant in these relationships, the real exchange rate consistently lacks explanatory power. The latter result is shown to be robust. Only when one imposed that preferences are identical across countries does one find a significant role for the real exchange rate, but the parameter restrictions that are imposed by this restriction are strongly rejected by the data. It is also interesting to notice that the significance of foreign consumption in the risk sharing relationships would have lead one wrongly to conclude in favor of the risk sharing hypothesis had one assumed PPP to hold.

Thus, the role of the real exchange rate is crucial in testing for risk sharing, but rather than helping bridging the gap between theory and data, it allows for a stronger rejection of the theory. Given the crucial role that the real exchange rate plays in the newly developed international macroeconomic models built on deviations from PPP, this result puts some doubt on the empirical relevance of these theories. However, the result does not mean that

there is no link between exchange rates and consumption. In particular, it is still possible that consumption might help forecasting real exchange rates and, indeed, other researchers have found this to be the case, see e.g. Apte, Sercu and Uppal (2000) or Head, Mattina, and Smith (2000). However, the results show that the parameter restrictions in the relationship between these variables imposed by the risk sharing hypothesis are rejected in the data.

The paper is organized as follows. In the next section we outline a simple model of consumers' choices meant to highlight the link between consumption and real exchange rates. In Section 3 we examine the empirical evidence on international risk sharing. Section 4 carries out an extensive sensitivity analysis. Finally, Section 5 concludes and summarizes.

2 Some Theory

We start by deriving the risk sharing conditions that will be tested empirically in the next section using a set-up that is sufficiently rich that we can derive fairly general results.

The economy consists of N countries indexed by $i = 1, .., N$. For ease of presentation we initially set $N = 2$ but all results extend to any number of countries. Each country is inhabited by a single infinitely lived representative consumer with rational expectations that maximizes expected discounted lifetime utility. The intertemporal preferences are given by:

$$V_{it} = E_t \sum_{s=t}^{\infty} \beta^{s-t} U\left(C_{is}, X_{is}\right) \tag{1}$$

where β is the subjective discount factor, U is increasing and concave, and C_{is} is a consumption index and X_{is} denotes all non-consumption components that affect utility. The consumption index is made up of consumption of at least two different goods:

$$C_{is} = C\left(C_{is}^1, C_{is}^2\right) \tag{2}$$

where C is an increasing, homogeneous, and concave function. Any number of goods can be allowed but two suffices for our purposes. Good j is sold in i at the price P_i^j in currency i in country i. From the consumption index we can define a consumer price index for each country, $Q_{is}\left(P_i^1, P_i^2\right)$ and the bilateral real exchange rate as $R_s^{ij} = e_{js} Q_{js} / \left(e_{is} Q_{is}\right)$.

The consumers face a sequence of budget constraints:

$$\frac{1}{e_{is}} P_s^B B_{is+1} + Q_{is} C_{is} + M_{is+1} \leq \frac{1}{e_{is}} B_{is} + M_{is} + Y_{is} \tag{3}$$

where P_s^B is the price of a one-period zero coupon non-contingent nominal bond denominated in the currency of country 1 (the numeraire currency), B_{is} is the number of nominal bonds held at the start of period s, e_{is} is the nominal exchange rate between currency i and currency 1, M_{is} is beginning of period money holdings, and Y_{is} is nominal net income.

Consumers maximize (1) subject to the sequence of constraints given by (3). The intertemporal problem involves finding the solution to:

$$V\left(B_{is}, M_{is}\right) = \max\left(U\left(C_{is}, X_{is}\right) + \beta E_s V\left(B_{it+1}, M_{is+1}\right)\right) \tag{4}$$

subject to (3). Solving this problem leads to the following Euler equation for the consumer in country i:

$$\frac{1}{e_{is}} P_s^B \frac{U_c\left(C_{is}, X_{is}\right)}{Q_{is}} = \beta E_s \frac{1}{e_{is+1}} \frac{U_c\left(C_{is+1}, X_{is+1}\right)}{Q_{is+1}} \tag{5}$$

where $U_c \equiv \partial U / \partial C$ is the marginal utility of consumption. Since all countries face the same nominal interest rate, we find that:

$$\beta E_s \frac{e_{is}}{e_{is+1}} \frac{Q_{is}}{Q_{is+1}} \frac{U_c\left(C_{is+1}, X_{is+1}\right)}{U_c\left(C_{is}, X_{is}\right)} = \beta E_s \frac{e_{js}}{e_{js+1}} \frac{Q_{js}}{Q_{js+1}} \frac{U_c\left(C_{js+1}, X_{js+1}\right)}{U_c\left(C_{js}, X_{js}\right)} \tag{6}$$

This is the risk sharing condition which states that expected nominal marginal rates of substitution are equalized across locations. Here we have derived it from the properties of the competitive equilibrium but it can equally easy be derived from the planner's problem or using club theory. One interesting twist to this condition is that it may even hold if asset markets do not allow for intertemporal borrowing. Engel (2000) shows in a setting with no international borrowing and lending that consumption growth differentials will equal real exchange rate differentials which is observational equivalent to the risk sharing condition if utility is logarithmic (see also Cole and Obstfeld, 1991). However, the observational equivalence hinges on a number of assumptions including the absense of trade in capital goods and the lack of any international loans markets.

It is worth noting that to derive the condition we require only that there are no restrictions on borrowing and lending, and that consumers maximize intertemporally. Notice also that we have not assumed the law of one price or purchasing power parity to hold. Prices of identical traded goods may differ across countries due to e.g. transactions costs or pricing to market so that the law of one price is violated. Alternatively PPP may be violated because consumer price indices are country specific, or one of the two goods in question might represent non-traded goods. In any of these cases PPP would be violated but the risk sharing condition still applies.

In cases where PPP is violated, *real* marginal rates of substitution will **not** equalize across countries. Thus, real consumption growth rates will in general differ across countries since expected *real* interest rates - which determine real marginal utility growth - differ internationally when PPP is violated.

To come up with easily testable implications we make functional assumptions. We assume that the intertemporal utility function is given by:

$$U\left(C_i, X_i\right) = \frac{1}{1-\sigma_i}\left(\left[W\left(C_i, X_i\right)^{1-\sigma_i} - 1\right]\right) \tag{7}$$

where $\sigma_i > 0$ (to assure concavity) and W is assumed to be given by:

$$W\left(C_i^1, C_i^2\right) = \left[\omega_1 \left(C_i^i\right)^{(\tau-1)/\tau} + \omega_2 \left(C_i^j\right)^{(\tau-1)/\tau}\right]^{\tau/(\tau-1)} X_i^{\gamma_i} + A\left(X_i\right) \tag{8}$$

where τ is the (constant) elasticity of substitution between C^1 and C^2 and ω_i is a preference weight.

Given the assumptions made on preferences, equation (6) can be formulated as:

$$\beta E_t \frac{Q_{it}}{Q_{it+1}} \frac{C_{it+1}^{-\sigma_i} X_{it+1}^{\gamma_i(1-\sigma_i)}}{C_{it}^{-\sigma_i} X_{it}^{\gamma_i(1-\sigma_i)}} = \beta E_t \frac{e_{jt}}{e_{jt+1}} \frac{Q_{jt}}{Q_{jt+1}} \frac{C_{jt+1}^{-\sigma_j} X_{jt+1}^{\gamma_j(1-\sigma_j)}}{C_{jt}^{-\sigma_j} X_{jt}^{\gamma_j(1-\sigma_j)}} \tag{9}$$

Since this is a non-linear equation, a test would require us to use a non-linear estimator, for example GMM as in Kollmann (1995) or Canova and Ravn (1996). We take an alternative approach and make further statistical assumptions that allow for a more standard estimator.

Specifically, we follow Obstfeld (1989). Denote the econometrician's information set by I_t^z and assume that this information set consists of present and past values of observation of the vector $z_t = \left(\triangle c_{it}, \triangle c_{jt}, \triangle x_{it}, \triangle x_{jt}, \triangle q_{it}, \triangle \left(q_{jt} + e_t^{ij}\right)\right)'$, where lower case letters denote logarithms, $e_t^{ij} = e_{jt} - e_{it}$, and $\triangle$ is the first difference operator. Next, define the conditional expectation $E_t^z x_s$ as $E\left(x_s | I_t^z\right)$ where I_t^z is a subset of the agents' information sets. Due to the law of iterated expectations, the condition in (9) holds also conditional on the information set I_t^z. The vector of stochastic variables z_t is assumed to be generated by the following vector stochastic process:

$$z_{t+1} = A_0 + A(L) z_t + \mu_{t+1} \tag{10}$$

where A_0 is a vector of constants, $A\left(L\right)$ is a lag polynomial, and μ_{t+1} is a vector of covariance stationary normally distributed stochastic variables.

From this it follows that z_t is normally distributed and, thus, that the "growth" components are log normally distributed. Using this assumption and defining for any variable m_t the "expectational error": $\eta_{t+1}^m = E_t^z \triangle m_{t+1} - \triangle m_{t+1}$ (which by construction is uncorrelated with the econometrician's information set) we get that:

$$\begin{aligned} \triangle c_{it+1} &= \lambda_{ij} + \frac{\sigma_j}{\sigma_i} \triangle c_{jt+1} + \frac{1}{\sigma_i} \triangle r_{t+1}^{ij} \\ &\quad + \frac{1}{\sigma_i} \left(\left(1 - \sigma_i\right) \gamma_i \triangle x_{it+1} - \left(1 - \sigma_j\right) \gamma_j \triangle x_{jt+1} \right) + \eta_{t+1}^{ij} \end{aligned} \tag{11}$$

where $\triangle r_t^{ij} = \triangle e_t^{ij} + \triangle q_{jt+1} - \triangle q_{it+1}$ is the real depreciation of the bilateral exchange rate and $\eta_{t+1}^{ij} = \eta_{t+1}^{c_j} - \eta_{t+1}^{c_i} + \eta_{t+1}^{r^{ij}} + \eta_{t+1}^{x_i} - \eta_{t+1}^{x_j}$. This relationship forms the basis for our empirical tests. It states that the expected growth rate of consumption is equalized across countries apart from: (i) Effects of differences in the elasticity of intertemporal substitution in consumption, (ii) real exchange rate fluctuations, and (iii) cross-country variations in the growth rate of the component X_{it}.

Notice that the coefficient on "foreign" consumption growth is the ratio of domestic to foreign intertemporal elasticity of substitution in consumption and that the coefficient on the real exchange rate is simply the domestic intertemporal elasticity of substitution (hence, both σ_i and σ_j are identified). Given that we require the utility function to be concave, both parameters must be positive.

The tests, thus, include the following conditions: (i) The conditional expectation of η_{t+1} should be orthogonal to the information set, and (ii) the real exchange rate and the "foreign" consumption growth rate should both be significantly positive. Rejection of any of these conditions is formally a rejection of the hypothesis.

In estimating and testing these relationships equation (11) can be estimated on a country-by-country basis using an instrumental variables estimator (using as instrument lagged values of the dependant and the independent variables as instruments given the assumption in equation (10)). However, when dealing with more than two countries we see that the error terms will be correlated across equations. Hence, one can gain efficiency by applying a SURE estimator. We will use both country-by-country estimations and system estimations since one problem with the latter is that the number of instruments quickly becomes very large thus giving rise to a very limited number of degrees of freedom. In particular, we apply the SURE estimator (with instrumental variables) only for the set of countries for which we have sufficiently long sample periods.

Another empirical issue is the choice of partner country. In particular, if the non-consumption variable represents non-observable taste shocks then Obstfeld (1994) have earlier proposed to estimate these relationships using aggregate "world" consumption as the right hand side variable. Assuming that there is a complete set of asset markets and that all countries have identical preferences, Obstfeld (1994) shows that this specification lowers the negative bias on the slope coefficient on foreign consumption. It is straightforward to show that a similar negative bias can occur under the incomplete markets, and that the slope parameters on foreign consumption and the real exchange rate will be negatively biased in country-by-country regressions but consistent in regressions involving aggregate consumption.[3] However, it is worth stressing that this result relies on the assumption of identical preferences across countries. Furthermore, in the case of real exchange rate fluctuations, this approach faces the problem that while it is simple to define "world" or "aggregate" consumption, it is hard to define a corresponding measure for the real exchange rate. Nevertheless, we will also experiment with such specifications.

2.1 Discussion

The large majority of papers that have empirically tested international risk sharing have implicitly or explicitly assumed that PPP holds and most of these studies have concluded against the risk sharing hypothesis, see e.g. Canova and Ravn (1996), Sorensen and Yosha (1998)[4], or Crucini (1999). Such conclusions have been drawn using many different empirical techniques and a variety of different data sets. However, given the large amount of evidence that have documented large and persistent fluctuations in real exchange rates, the analysis above indicates that many of those tests may have suffered from serious problems of misspecification.

Some studies have implicitly allowed for deviations from PPP in empirical tests of the risk sharing hypothesis by using "PPP-adjusted data" (see e.g. Lewis, 1996, 1999, or Obstfeld, 1994). PPP-adjustments of the data amounts to a linear correction for real exchange rate variations implemented by measuring different countries' consumption in a common price level.[5] It is interesting to note from above that such PPP-adjustments would fail to take the

[3]Derivations of these results are available upon request.

[4]These authors use a base year PPP adjustment but apply first differences in most of their analysis.

[5]If we let country 1 be the base country, a PPP-adjustment would imply that real consumption of other countries would be measured as nominal consumption divided by the bilateral real exchange rate (the nominal

effects of real exchange rate fluctuations correctly into account unless utility is logarithmic ($\sigma = 1$).

As far as we know, Obstfeld (1989) was the first to derive and test the risk sharing hypothesis in settings where PPP does not hold and the derivation above is parallel his. We also follow Obstfeld's (1989) empirical approach in deriving the instrumental variables estimator although he formally estimated the relationships using the real exchange rate as the left hand side variables while we formulate the relationship instead in terms of the risk sharing hypothesis. More importantly, our study extends Obstfeld's (1989) earlier study by extending the length of the data set, the number of countries under consideration, and by rigorously checking for robustness of the results.

Perhaps the paper is most closely related to Kollmann (1995) who studied exactly the implications from the relationship between consumption and real exchange rates that we have derived above. Kollmann (1995) looked at two types of tests of the risk sharing condition. First, making the auxiliary assumption that asset markets are complete, he tested whether there is a co-integrating relationship between the real exchange rate, domestic consumption, and foreign consumption and found evidence against this using various alternative data sets (for a panel of 6 OECD economies).[6] Kollmann also tested condition (9) using a GMM estimator but imposing that the non-consumption factor is constant. He found that this relationship cannot be rejected. However, the tests performed in Kollmann (1995) impose a unitary coefficient on the real exchange rate and its significance can therefore not be examined separately. Furthermore, he found that the concavity condition was rejected in a number of the country pairs that he looked at.

Our approach differs from Kollmann's (1995) approach in several dimensions. First, we use a different estimation technique which has better small sample properties. Secondly, due to the formulation of the empirical tests proposed above, we can evaluate separately the significance of the real exchange rate. Thirdly, we look thoroughly at the effects of introducing natural candidates for the non-consumption factor. Fourthly, we investigate a broader data set than that considered by Kollmann (1995).

The paper is also closely related to a an intriguing paper by Backus and Smith (1993). These authors look at the relationship between consumption and real exchange rates in a dynamic general equilibrium exchange economy with non-traded goods and derive essentially the same risk sharing relationship as in the above section with two differences. First, Backus and Smith (1993) assume complete asset markets. Secondly, these authors assume that the law of one price holds for tradable goods but introduce real exchange rate movements through non-traded goods. Backus and Smith (1993) examine the link between real exchange rates and marginal utilities by graphically comparing the moments of real exchange rates and the ratio of domestic to foreign marginal utilities. They find no clear cross-sectional relationship between the moments of real exchange rates and marginal utilities in the data that they examine and thus conclude against the theory. Our approach differs from theirs in several dimensions. First, we adopt a more statistically founded approach than Backus and Smith (1993) and we test formally whether the data supports the predictions of the theoretical model. Furthermore, Backus and Smith (along with Head, Mattina, and Smith, 2000) assume

exchange rate times the ratio of foreign to domestic prices).

[6]Canova and Ravn (1996) find similar results but their tests ignore the real exchange rate.

that countries have identical attitudes towards risk. We do not impose this restriction but test it empirically instead. Secondly, the "tests" for equality of moments that Backus and Smith (1993) focus upon, rest on the assumption that the non-consumption factor X is either constant or enters into the preferences in additively separable manner. We examine this point in great detail since there are good reasons to believe that non-consumption factors are important. Thirdly, we examine a larger set of data covering longer periods of time and a larger set of countries. Fourthly, we examine also a number of extensions of the basic model.

Apte, Sercu and Uppal (2000) and Head, Mattina, and Smith (2000) follow in the lines of Obstfeld (1989) and test whether marginal utility helps forecasting real (or nominal) exchange rates. The former of these paper do not relate the empirical tests too closely with theory but finds that marginal utility helps forecasting the nominal exchange rate. Head, Mattina, and Smith (2000) link their empirical analysis more closely with the theoretical relationship as derived above. Head, Mattina, and Smith (2000) also find that real exchange rates can be forecasted by marginal utilities.

3 Empirical Results: Basic Tests

We examine the risk sharing relationship derived above using quarterly data for 12 OECD economies, Australia, Canada, Denmark, France, Italy, Japan, the Netherlands, New Zealand, Norway, Switzerland, the UK and the US. The sample periods vary somewhat across countries and depends also on the variable of interest. Details of the sample periods and measurements are given in the data appendix. However, for all cases the earliest we start the sample period is 1960 quarter 1 and in almost all cases the sample ends at 2000 quarter 1. Initially we measure consumption by per capita private consumption in constant prices and real exchange rates by the bilateral exchange times the ratio of foreign to domestic prices where prices are measured by the implicit consumption deflators.[7] The consumption data are taken from the OECD quarterly accounts; Exchange rates and population data are from the International Financial Statistics published by the IMF.

As mentioned in the previous section we also examine the risk sharing hypothesis using aggregate OECD data. In this case we measure aggregate consumption as aggregate OECD consumption in constant prices (and with a base year PPP adjustment). As for the above data, we define the real exchange rate from the nominal exchange rate and the implicit consumption deflators. However, in this application, there is no natural definition of the nominal exchange rate. We use the nominal effective exchange rate as defined by the IMF using trade weights. An alternative would be to use the real effective exchange rate rather than the nominal effective exchange rate times the ratio of implicit consumption deflators. However, results are practically identical and we report only results based on the latter measure.

[7]The results are practically identical if one uses consumer price indices rather than implicit consumption deflators. Results are available from the author upon request.

3.1 Moments of the Data

Table 1 lists the sample cross-country correlations of the growth rates of per capita real consumption. We find moderate cross-country correlations of consumption growth rates. The highest correlations are in general observed between neighboring countries with close links in trade in goods and financial assets such as Denmark-Norway or Switzerland-Italy, where correlations are equal to 0.43 and 0.52, respectively. The finding of generally low correlations square well with the conclusions in previous studies (see e.g. Backus, Kehoe and Kydland, 1992, 1995, or Ravn, 1997). However, the present numbers do tend to be slightly higher than those found in previous studies. The correlations with aggregate OECD consumption growth are in general higher than those for the individual country pairs and tend to indicate a quite close relationship with aggregate OECD consumption.

As we highlighted in the previous section, consumption correlations need not be perfect even if countries can fully insure their consumption streams if there are fluctuations in real exchange rates or in factors that affect the marginal utility of consumption. A simple way to examine the role played by the real exchange rate is to check whether there is an obvious (negative) relationship between the strength of the cross-country consumption correlation and real exchange rate variability. Figure 1 illustrates the consumption correlations plotted against the percentage standard deviation of the bilateral real exchange rate for the 66 individual country pairs in the sample. This plot does not give any clear answers since there does seem to be a negative relationship between these moments but the rank correlation is no higher than -0.24. Backus and Smith (1993) report a similar plot and find an even less clear relationship in their data.

Table 2 reports percentage standard deviations of log first differences of real exchange rates, nominal exchange rates, the price ratio, consumption levels and the ratio of domestic to foreign consumption. We split the sample into the pre-1973 and the post-1972 period since this coincides roughly with the end of the Bretton-Woods system (which affected exchange rate behavior) and since Obstfeld (1994) has earlier found that risk sharing has increased after 1973.

In the full sample real and nominal exchange rates defined against the US dollar have been very volatile with standard deviations from 2 per cent per quarter (for the real Canadian dollar) to above 6.5 per cent per quarter (for the real Swiss Franc and the New Zealand Dollar). Consumption growth variability differs substantially across countries (with Switzerland having very smooth consumption growth rates and New Zealand being in the other extreme). We also notice that relative price variability has increased substantially in the post 1972 period but that consumption growth does not uniformly display higher or lower variability in the post 1972 period.

For most of the countries in the sample the variability of the real effective exchange rate is substantially smaller than that of the bilateral exchange rate vis-a-vis the US dollar and the differences are substantial in some cases (e.g. Denmark, France, and the Netherlands). Associated with the general tendency for lower variability of relative prices when defined more broadly is also tendency for greater stability of the consumption growth differential.

Table 3 examines some correlations between these variables. For our purposes the most interesting moments refer to the link between relative prices and consumption. Based upon

the previous section we would expect to see large positive correlations, but with the exception of Australia and Japan in the Bretton-Woods period, we do not find any large positive correlations.

3.2 Basic Tests of Risk Sharing and Real Exchange Rates

The above evidence indicates that the risk sharing hypothesis may not be supported by the data. However, the correlation analysis does not constitute a real test because it makes a number of implicit assumptions that may not be hold in the data. Thus, we now proceed to the formal tests of (11). We first assume that utility is additively separable in consumption and other factors, i.e. that $\gamma_i = 0$, so that our regressions take the form:

$$\triangle c_{it+1} = \lambda^{ij} + \alpha^{ij} \triangle c_{jt+1} + \beta^{ij} \triangle r^{j}_{it+1} + \eta^{ij}_{t+1}$$

Given the structure of the errors, we estimate this relationship using instrumental variables. We recall that the estimate of β^{ij} should give us an estimate of country i's intertemporal elasticity of substitution and the estimate of α^{ij} should be equal to the ratio of domestic to foreign elasticities of intertemporal substitution in consumption. Furthermore, these parameters must be positive and the risk sharing hypothesis implies that the regression errors should be orthogonal to the information set. We use as instruments lags 2 to 5 of domestic consumption growth, foreign consumption growth, and the real exchange rate[8]. We lag the instruments by two periods in order to take temporal aggregation into account. Furthermore, to correct for residual serial correlation and heteroscedasticity we use robust standard errors. Given that we employ 13 instruments to estimate the 3 structural parameters, we have 10 over-identifying restrictions that can be used to test the orthogonality conditions implied by the theory (we compute $T * R^2$ for the regression of the estimated errors on the instruments; This test statistic is χ^2 with $N_x - N_k$ degrees of freedom where N_x is the number of instruments and N_k the number of parameters that are estimated in the risk sharing condition).

The results are listed in Table 4. The table reports the coefficients on foreign consumption growth and the real exchange rate and the significance of the orthogonality tests. We report results both for $j = US$ and for $j = World$, and we also look at sub-sample results (splitting the sample at 1972 quarter 4). Finally, we report results for both country-by-country regressions and for SURE regressions (the last 6 rows of the table) which takes into account the cross-relation correlation structure in the regression errors. For the latter results we focus upon the countries for which we have the longest sample periods due to the large number of instruments that are used in these regressions.[9] For the country-by-country regressions this implies that we look at data for Australia, Canada, Japan and the

[8]Results based on using instruments lagged 2 to 9 periods are almost identical to those reported here. These results are available from the author upon request.

[9]When estimating the relations with the SUR estimators we use lags 2 to 5 of the consumption growth rates and of the real exchange rates for all the countries which the system is estimated. Thus, with 4 countries in the system, we have 37 variables in the instrument list. This naturally leads to the requirement that the number of observations is relatively large.

UK (against the US), while for the regressions involving aggregate OECD consumption, the system include Canada, Japan, the UK and the US.

We turn first to the country-by-country regressions. We find relatively strong evidence against the risk sharing hypothesis in the full sample: Although US consumption is significant at the 1 percent level for Switzerland, at the 5 percent level for Canada and Japan, and at the 10 percent level for New Zealand and the UK, the real exchange rate is insignificant in 9 out of the 11 cases and significantly negative in one case. Only for the country-pair Denmark-US do we find a positive and significant estimate of β and here US consumption is insignificant. The orthogonality conditions can in most cases not be rejected although this condition is rejected very strongly for Japan and the Netherlands.

When instead setting $j = World$, we find a greater tendency for significance of foreign consumption, but again the real exchange rate is significant only for one country (in this case the Netherlands). This result is interesting in its own right since standard tests of the risk sharing hypothesis would ignore the role of the real exchange rate and thus could have concluded positively in favor of the hypothesis. The lack of significance of the real exchange rate goes against such conclusions and this insight is in line with the evidence just presented for the bilateral regression against the US. We also notice that the coefficient on aggregate OECD consumption tends to be substantially larger than the coefficient on US consumption in the bilateral regression which may indicate the negative bias in β induced by endogeneity of the regressor highlighted by Obstfeld (1994).

When we investigate the stability of these findings over time we find mixed evidence in favor of increased risk sharing since 1973. For the bilateral regressions, we find that US consumption is significant at the 10 percent level only for the US-Canada pair in the early sub-sample, but significant at the 10 percent level for the US-Japan pair and at the 5 percent level for UK-US in the later sub-sample. This indicates, as documented by Obstfeld (1994) evidence in favor of increased risk sharing. Nevertheless, while the real exchange rate is estimated to be positive and significant for the US-Australia pair in the early sub-sample, we find no significant positive estimates of β in the later sub-sample. This contradicts the evidence on increased capital market integration. The evidence from the regression involving aggregate OECD consumption growth are similar since we find significance of α for all countries in the post-1972 period but in no case do we find a positive and significant estimate of β is this sub-sample.

The results just discussed ignore the increase in efficiency that can be gained form taking into account that the regressions errors are correlated across country-pairs. In the lower part of the table we report the results from taking this correlation structure into account by using a SURE estimator (in this case a three stage least squares estimator). As mentioned above, we estimate the system for the set of countries for which we have sufficiently many observations.

This gives rise to an increase in the significance of foreign consumption both in the regressions involving the US and in the regressions involving the aggregate OECD. Specifically, we now find significance of aggregate OECD consumption growth at the 1 percent level for all four countries that we look at and at the 5 percent level or better for three out of the four countries in the bilateral regressions against the US. Nevertheless, the real exchange rate still remains insignificant.

It is worth recalling from the previous section that in order to go from the bilateral regressions to the regressions involving aggregate world activity (meant to minimize the endogeneity problem), we must impose that all countries have the same attitudes towards risk. This restriction has also been imposed in other studies of the relationship between real exchange rates and consumption, see e.g. Head, Mattina, and Smith (2000). To examine this case we impose that the slope coefficients involving foreign consumption are equal to 1 ($\alpha^{ij} = 1$) and that the slope coefficients on the real exchange rates are identical for all countries ($\beta^{ij} = \beta^{sj}$). We can test these restrictions using a likelihood ratio test (with 7 degrees of freedom). We report the results of estimating these restricted systems of equations for the full sample and the two sub-samples in the last three rows of the table.

The results are interesting. Imposing these restrictions leads to significance of the real exchange rate in all three samples in the regressions involving the US. Furthermore, the implied degree of relative risk aversion is not too unreasonable with a point estimate of around 11 in the early sub-sample and 28 in the full sample and in the later sub-sample. For the regressions involving aggregate OECD consumption, we find significance of β only in the first sub-sample (with an implied risk aversion coefficient of around 6) but the point coefficient estimate is positive in all three sub-samples. These results thus indicate much more positive evidence in favor of the risk sharing hypothesis. However, the problem with this is that the parameter restrictions are very strongly rejected.

Thus, on this basis, the overwhelming evidence is that the risk sharing hypothesis is rejected. The simple version of the theory which ignores other factors than consumption in the utility function is not supported by the theory. More importantly, the potentially important role of the real exchange rate in the risk sharing relations does not seem to be present in the data.

4 Sensitivity Analysis

We now proceed to examine the robustness of the results of the previous section. First, we examine whether non-separabilities in the utility function may be important to take into account. Secondly, we check if the results are due to the aggregation over different types of goods. Thirdly, it is investigated whether the results are special to the choice of partner country. Fourthly, we look at the specification of preferences and we introduce habit persistence.

4.1 Non-Separabilities

The tests of Section 3 are potentially subject to the criticism that they ignore non-separabilities in the utility function: If the factor X is important but ignored in the empirical tests, we might falsely have concluded against the theory. Thus, in this section we look at several candidates for this variable and see whether this matters for the results. This requires us to specify which variables we think might affect the marginal utility of consumption.

We look at the following candidates: Real money holdings, government consumption, and leisure. Real money holdings have been stressed as important in many holdings and are also

key in some recent models of international business cycles (see e.g. Chari, Kehoe and McGrattan, 1998). Government consumption is another natural candidate because large parts of government consumption may practically substitute for private households' spending. Finally, leisure is a standard variable of interest and non-separabilities with consumption play a key role in many macroeconomic theories.

4.1.1 Money and Risk Sharing

With a non-separability between consumption and real money balances the risk sharing condition that we estimate is specified as:

$$\triangle c_{it+1} = \lambda + \alpha^{ij} \triangle c_{jt+1} + \beta^{ij} \triangle r^{j}_{it+1} + \gamma^{ij}_{1} \triangle m_{it+1} - \gamma^{ij}_{2} \triangle m_{jt+1} + \eta^{ij}_{t+1}$$

where m denotes the logarithm of real money holdings. The coefficients on real money holdings are here combinations of the weight of real money balances in the utility function, the elasticity of substitution between real money balances and consumption, and of the relative risk aversion coefficient. This parameter may be positive or negative depending on the degree of risk aversion.[10] In the data we measure real money holdings as M1 per capita divided by the implicit consumption deflator apart from the UK for which we use M2. We also extend the instrument list to include lags 2-5 of real money balances.

The top part of Table 5 reports the results this specification. We do find some evidence in favor of non-separabilities between real money balances and consumption since either γ_1 or γ_2 is significant in approximately half of the regressions. Nevertheless, the impact on the risk sharing tests is limited. We find a slight improvement in the significance level of α (the slope parameter of foreign consumption growth) but the estimates of β remain insignificantly different from zero or negative. Furthermore, the orthogonality conditions are now rejected in a number of cases for the bilateral regressions.

Thus, although there are signs that there are non-separabilities in the utility function, this does not lead us to change the conclusions on the lack of support for the risk sharing hypothesis and the importance of the real exchange rate.

4.1.2 Leisure

Non-separabilities between consumption and leisure play a key role in many macroeconomic theories. We look at this issue by now estimating:

$$\triangle c_{it+1} = \lambda + \alpha^{ij} \triangle c_{jt+1} + \beta^{ij} \triangle r^{j}_{it+1} + \gamma^{ij}_{1} \triangle n_{it+1} - \gamma^{ij}_{2} \triangle n_{jt+1} + \eta^{ij}_{t+1}$$

where n denotes the logarithm of employment per capita. The most common assumption in the literature is that the elasticity of substitution between consumption and leisure is equal to 1. In this case theory predicts that $\gamma^{ij}_{1} > 0$ if $\sigma_i > 1$ and $\gamma^{ij}_{1} < 0$ if $0 < \sigma_i < 1$. The use of employment rather than hours worked may, of course, be associated with serious measurement errors so it is important to interpret the results with care.

[10] For example when $U\left(C_i, M_i/Q_i\right) = \frac{1}{1-\sigma_i}\left(\left[\left(C_i\left(M_i/Q_i\right)^{\gamma_i}\right)^{1-\sigma_i} - 1\right]\right)$, the risk sharing condition is given by $\triangle c_{it+1} = \lambda_{ij} + \frac{\sigma_j}{\sigma_i}\triangle c_{jt+1} + \frac{1}{\sigma_i}\triangle r^{ij}_{t+1} + \frac{1}{\sigma_i}\left(\left(1-\sigma_i\right)\gamma_i \triangle m_{it+1} - \left(1-\sigma_j\right)\gamma_j \triangle m_{jt+1}\right) + \eta_{t+1}$

Results from this exercise are reported in the second section of Table 5. As for real money balances, we find that employment growth enters significantly into the regressions in a number of cases and that the great majority of the significant estimates of γ are significantly positive. For the bilateral regressions involving US variables, we find that the implications for the risk sharing hypothesis are limited since the real exchange rate remains insignificant or negative while the significance level of US consumption is approximately unaltered.

For the regressions involving aggregate OECD variables, however, the results, if anything, are even worse than those listed in Table 4. In particular, the significance of aggregate OECD consumption decreases for almost all countries. This may indicate that the significance of the aggregate OECD consumption is due more to an omitted variables problem than to risk sharing. Regardless of this, it seems fair to conclude that this extension does not rescue the risk sharing hypothesis.

4.1.3 Government Spending

The final candidate for non-separabilities that we examine is government spending. Parts of government consumption may substitute for private consumption and the level of government spending may affect the marginal utility of private consumption. Christiano and Eichenbaum (1992) have earlier investigated the importance of such non-separabilities between private and government consumption and specify the utility function as:

$$W(C,G) = \left((C+\theta G)^{1-\sigma} - 1\right)/(1-\sigma)$$

These authors find significantly positive estimates of θ using quarterly post war US data. Hence, this variable could potentially be important to take into account. We now estimate the following relationships:

$$\triangle c_{it+1} = \lambda + \alpha^{ij}\triangle c_{jt+1} + \beta^{ij}\triangle r^{j}_{it+1} + \gamma_1^{ij}\triangle g_{it+1} - \gamma_2^{ij}\triangle g_{jt+1} + \eta^{ij}_{t+1}$$

where g denotes the logarithm of per capita real government consumption. In this case the estimate of γ_1 is given by $-(\theta g/c)/\sigma$ which should be negative. It should also be noted that the coefficients on α and β now will be modified by $\alpha^{ij} = \left(\sigma^j c^i/(\sigma^i c^j)\right)\left(c^j + \theta^j g^j\right)/\left(c^i + \theta^i g^i\right)$ and $\beta^{ij} = \left(c^i/\sigma^i\right)/\left(c^i + \theta^i g^i\right)$.[11]

The results from including government spending in the risk sharing condition are reported in the final rows of Table 5. The results are similar to what we found in the preceding sensitivity analyses. Domestic and foreign government consumption are significantly different from zero in a number of cases but, as above, the introduction of a new variable into the risk sharing relationships affects the estimates α and the significance of this variable. However, as we have seen in the other cases as well, the introduction of government spending does not lead to the emergence of the real exchange rate which remains insignificant in most of the regressions.

[11] Variables without time subscripts here denote steady-state values.

4.2 Good Specific Results

The second type of sensitivity analysis that we carry out is to look at good specific results. The above results all refer to total private sector consumption. Previously a number of papers have suggested that non-traded goods might be an important component in accounting for the low cross-country correlations of consumption (see e.g. Tesar, 1995, or Stockman and Tesar, 1995). Lewis (1996, 1999) examines the role of non-tradables in tests fo risk sharing in detail. However, the existence of non-traded goods does not mean that the tests above are invalid. In fact, Backus and Smith (1993) show how the relationship between marginal utilities and real exchange rates can be derived in a model with traded and non-traded goods assuming that the law of one price holds for traded goods. The reason for this is that the effects of non-traded goods enter into the consumption aggregate and into the real exchange variable. In fact, the analysis of Section 2 can be re-interpreted to a setting with non-traded goods letting one of the goods in question denote non-traded goods. Hence, the analysis is robust to this aspect. The one disclaimer to this result is situations in which utility is additively separable between different types of consumption goods. Assume, for example, that the utility function can be written as:

$$W(C) = \sum_{s=1}^{S} W_s(C^s)$$

where s denotes a given "type" of goods. In this case, and assuming that the sub-utility functions, W_s, are of the form assumed in equations (7), the risk sharing conditions, equations (7)−(8), would hold for each "type" of good separately, but not necessarily for an "aggregate" consumption good.

In order to investigate this issue we separate aggregate consumption into three types of goods, "durables", "non-durables" and "services". This does not necessarily match well with non-traded goods, but the above point is valid even in settings with different types of traded goods and would rely less on the appropriateness of aggregate price deflators than the tests carried out above. The national government section of the OECD statistics reports such numbers for all countries in our sample except Australia, Netherlands, Norway, and Switzerland.[12] Table 6 reports the results of estimating

$$\triangle c^s_{it+1} = \lambda + \alpha^{ij} \triangle c^s_{jt+1} + \beta^{ij} \triangle r^{js}_{it+1} + \eta^{ijs}_{t+1}$$

for each of these different types of goods and using $j = US$. We also report the correlation of the growth rate of each type of good with the corresponding US number and we report the standard deviation of the goods specific real exchange rates. The latter are measured as the aggregate real exchange rate but using the goods specific implicit price deflators.

Table 6 reports the results of this exercise which indicate that the conclusions drawn on the risk sharing relationships are not sensitive to the aggregation of consumption. The bilateral correlation of the consumption growth rates are similar across different types of goods and so are the standard deviations of the disaggregated real exchange rates. The

[12] For some of these countries, we can also look at even more dis-aggregated data such as "food", "furniture" "clothing" etc. Nevertheless, the geographical and temporal coverage of these data are more limited.

only exception to this is for Canada for which we observe a substantially larger and more positive correlation with the US for consumption of durables than for the two other types of goods. The estimates of α and β differ across countries and types of goods, but there is no specific pattern to this variation and we do not uncover any significant and positive estimate of β. Furthermore, there is a slight increased tendency for rejection of the orthogonality conditions.

Thus, in summary, the results for goods specific versions of the tests do not indicate that the results are qualitatively sensitive to the use of aggregate consumption.

4.3 Partner Country

The analysis so far has focused on bilateral regressions involving the Unites States as the partner country or the aggregate OECD as the partner country. As we have already discussed, the appropriateness of the latter specification hinges on some auxiliary assumptions that do not seem to be supported by the data. The issue is whether the choice of the US as the partner country might affect the results. As is clear from Table 1, cross-country consumption correlations do vary across countries and this may indicate that some sub-groups of countries are better insured.

In order to investigate this, Table 7 reports the results of carrying out the risk sharing tests for all other combinations of countries in the sample. The estimates of α and β are sensitive to the choice of partner countries. However, out of the 55 country pairs, we find α to be significant and positive (at the 10 percent level) in only 8 country pairs. Furthermore, β is significant in 9 of the country pairs but positively so in only 5 of these cases. The only country pair for which we find positive and significant estimates of both α and β and where we cannot reject the orthogonality conditions is UK-Switzerland (although the implied value for the risk aversion coefficient is quite large with a point estimate of 28.5). Disappointingly, we also find that the risk sharing hypothesis is rejected in the country pairs where we observe a high cross-country consumption growth correlation (such as Denmark-Norway or Italy-Switzerland). In sum, we find that the negative results do not hinge on the choice of the US as the partner country.

4.4 Habit Persistence

In the empirical finance literature, and in many macroeconomic analysis the importance of preferences is often stressed as key in bridging the gap between theory and data. Some of these extensions (non-separabilities) have been covered above, but here we now introduce habit persistence. The effects of habit persistence have been heavily investigated in the empirical literature on the equity premium and the risk free rate puzzle (see e.g. Abel, 1990, 1999, Campbell and Cochrane, 1999, 2000, or Heaton, 1995) and, although conclusions on the effects of habit persistence have not been uniformly positive, this aspect has been shown to be important. This insight could potentially be important for the present subject as well because preferences are at the center of attention (like in the empirical finance literature).

There are several different ways in which to model habit persistence. Here we choose to follow Abel (1990, 1999) and model the habit as exogenous and we use the so-called ratio

model. In particular, we now specify preferences as:

$$U\left(C_i, X_i\right) = \frac{1}{1-\sigma_i}\left(\left[W\left(C_i/X_i\right)^{1-\sigma_i} - 1\right]\right)$$

where $X_{it} = \widetilde{C}_{it-1}^{\mu_i}$ where $\widetilde{C}_i$ denotes aggregate per capita consumption in country i. Alternatives to this specification include models with endogenous habits and "difference" habit models possibly allowing for non-linearities such as in Campbell and Cochrane (1999, 2000). The above specification leads to the following risk sharing condition:

$$\triangle c_{it+1} = \lambda + \alpha^{ij} \triangle c_{jt+1} + \beta^{ij} \triangle r_{it+1}^{j} + \gamma_1^i \triangle c_{it} - \gamma_2^{ij} \triangle c_{jt} + \eta_{t+1}^{ij}$$

where $\gamma_1^i = \mu_i\left(\sigma_i - 1\right)/\sigma_i$ and $\gamma_1^i = \mu_j\left(\sigma_j - 1\right)/\sigma_i$. Thus, introducing habit in this manner simply introduces another term into the Euler equation and when the habit is exogenous (and includes only lagged consumption) this term is simply current consumption growth. We estimate this relationship as the basic relationship in Table 4 but using lags 3-6 of the regressors and the regressand as instruments (since current consumption growth now enters the Euler equation).

The results are reported in Table 8. The habit formation parameters are significant in a number of country-pairs and in some cases at very high levels of confidence. However, the introduction of habit persistence, if anything, worsens the case in favor of risk sharing rending the slope parameters α less significant in many cases and leaving β insignificant in the great majority of regressions. These results are independent of the choice of partner country and the sample period under consideration. When estimating the system with the SUR estimator and imposing that preferences are identical across countries, we find that the habit persistence appears only to be significant in the pre-1973 sample. Furthermore, in this period we also find a significant and positive estimate of β for both the regressions involving US consumption growth and the regressions involving aggregate OECD consumption growth. However, the parameter restrictions are rejected (although less strongly for the regressions involving aggregate OECD consumption growth). Thus, although the evidence is mildly in favor of the presence of habit formation, the introduction of this phenomenon does not lead to a radical change in the negative evidence on the risk sharing hypothesis.

5 Summary and Conclusions

This paper have looked into the link between consumption risk sharing and real exchange rates. Making the assumption that countries can borrow and lend freely at the same nominal interest rate leads to a risk sharing relationship that links the cross-country difference of the expected marginal rate of substitutions of consumption to the expected change in the real exchange rate. The reason is simple: When purchasing power parity does not hold but countries can borrow and lend at the same nominal interest rate, real exchange rate movements are equivalent to real interest rate differentials, and such real interest rate differentials give rise to intertemporal substitution of consumption. This mechanism is important in many new theories that have been developed to address the empirical shortcomings of international business cycle models and has been applied to important economic policy issues.

Furthermore, given the large and persistent movements in real exchange rates that have been observed, especially since the downfall of the Bretton-Woods system, this mechanism might potentially be an important factor in explaining why previous tests of risk sharing have concluded against this hypothesis.

Testing the risk sharing on a panel of OECD countries we found very robust results that indicate evidence against the risk sharing hypothesis. The real exchange rate plays a crucial role in reaching this conclusions. In fact, since foreign consumption is often statistically significant in the risk sharing relations, it is the inclusion of the real exchange rate that allows one to reach the negative conclusion. Furthermore, we showed that the results are robust to the introduction of non-separabilities in the utility function, to decomposing consumption, to changes in the choice of partner countries, and to the introduction of habit persistence. We only find evidence in favor of a significant role for the real exchange rate when imposing the conditions that preferences are identical across countries and this restriction is rejected by the data. Hence, the papers findings put some doubts on the crucial role played by real exchange rates in a number of recent international macroeconomic models.

The evidence, of course, does not imply that exchange rates and consumption are not connected. It is perfectly possible that consumption growth differentials can help forecast exchange rates and indeed some authors do find evidence of this (see e.g. Apte, Sercu and Uppal, 2000, or Head, Mattina and Smith, 2000). However, the paper shows that it is unlikely that the restrictions imposed by theory are supported by the data.

References

[1] Abel, Andrew B., 1990, "Asset Prices under Habit Formation and Catching Up with the Joneses", *American Economic Review*, 80(2), 38-42.

[2] Abel, Andrew B., 1999, "Risk Premia and Term Premia in General Equilibrium", *Journal of Monetary Economics*, 43(1), 3-33.

[3] Apte, Prakash, Piet Secu and Raman Uppal, 2000, "The Exchange Rate in Complete Markets: Theory and Tests", mimeo.

[4] Asdrubali, Pierfederico, Bent E. Sorensen, and Oved Yosh, 1996, "Channels of Interstate Risk Sharing: United States 1963-90", *Quarterly Journal of Economics*, 111(4), 1081-1110.

[5] Backus, David K., Patrick J. Kehoe, and Finn E. Kydland, 1992, "International Real Business Cycles", *Journal of Political Economy*, 100(4), 745-75.

[6] Backus, David K., Patrick J. Kehoe and Finn E. Kydland, 1995, " International Business Cycles: Theory and Evidence", in: Tom Cooley (ed.), **Frontiers of Business Cycle Research**, Princeton University Press: New Jersey.

[7] Backus, David K., and Gregor W. Smith, 1993, "Consumption and Real Exchange Rates in Dynamic Economies with Non-Traded Goods", *Journal of International Economics*, 35, 297-316.

[8] Betts, Caroline, and Michael Devereux, 1996, "The Exchange Rate in a Model of Pricing-to-Markets", *European Economic Review*, 40, 1007-22.

[9] Betts, Caroline, and Michael Devereux, 2000, "Exchange Rate Dynamics in a Model of Pricing to Markets", *Journal of International Economics* vol.50, 215-44.

[10] Campbell, John Y., and John H. Cochrane, 1999, "By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior", *Journal of Political Economy*, 107(2), 205-51.

[11] Campbell, John Y., and John H. Cochrane, 2000, "Explaining the Poor Performance of Consumption-Based Asset Pricing Models", *Journal of Finance*, 55(6), 2863-78.

[12] Canova, Fabio, and Morten O. Ravn, 1996, "International Consumption Risk Sharing", *International Economic Review*, 37(3), 573-601.

[13] Chari, V., Patrick Kehoe, P. and Ellen McGrattan, 1998, Monetary Shocks and Real Exchange Rates in Sticky Price Models of the International Business Cycle, Fed of Minneapolis, Staff Report 223.

[14] Christiano, Lawrence J., and Martin Eichenbaum, 1992, "Current Real Business Cycle Theories and Aggregate Labor Market Fluctuations", *American Economic Review*, vol.82(3), 430-50.

[15] Cole, Harold L., and Maurice Obstfeld, 1991, "Commodity Trade and International Risk Sharing: How Much Do International Financial Markets Matter?", *Journal of Monetary Economics*, vol.28(1), 3-24.

[16] Crucini, Mario J., 1999, "On International and National Dimensions of Risk Sharing", *Review of Economics and Statistics*, 81(1), 73-84.

[17] Michael B. Devereux, and Engel, Charles M., 2000, "Monetary Policy in the Open Economy: Price Setting and Exchange Rate Flexibility", working paper, University of Wisconsin.

[18] Engel, Charles M., 2000, "Optimal Exchange Rate Policy: The influence of Price Setting and Exchange Rates", forthcoming, *Journal of Money, Credit and Banking.*

[19] Head, Allen C., 1995, "Country Size, Aggregate Fluctuations, and International Risk Sharing", *Canadian Journal of Economics*, 28(4B), 1096-1119.

[20] Head, Allen C., Todd D. Mattina, and Gregor W. Smith, 2000, "Marginal Utility and International Relative Prices", working paper, Queen's University.

[21] Heaton, Jonathan, 1995, "An Empirical Investigation of Asset Pricing with Temporally Dependent Preference Specifications", *Econometrica*, 681-717.

[22] Hess, Gregory, and K. Shin, 2000, "Risk Sharing by Households Within and Across Regions and Industries", *Journal of Monetary Economics*, 45(3), 533-60.

[23] Kollmann, Robert, 1995, "Consumption, Real Exchange Rates, and the Structure of International Capital Markets", *Journal of International Money and Finance,* 14, 191-211.

[24] Kollmann, Robert, 1996, "The Exchange Rate in a Dynamic Optimizing Current Account Model with Nominal Rigidities", CentER Discussion Paper no.9667.

[25] Lane, Philip R., 1999, "The New Open Economy Macroeconomics: A Survey", CEPR Discussion Paper no. 2115.

[26] Lewis, Karen K., 1996, "What Can Explain the Apparent Lack of International Consumption Risk Sharing?", *Journal of Political Economy* 104, 267-97.

[27] Lewis, Karen K., 1999, "Trying to Explain Home Bias in Equities and Consumption", *Journal of Economic Literature*, 37 (June), 571-608.

[28] Obstfeld, Maurice, 1989, "How Integrated are World Capital Markets? Some New Tests", in: Guillermo Calvo, Ronald Findlay, Pentti Kouri, and Jorge Braga de Macedo (eds.), **Debt, Stabilization and Development: Essays in Memory of Carlos Diaz-Alejandro**, Oxford, UK: Basil Blackwell.

[29] Obstfeld, 1994, "Are Industrial-Country Consumption Risks Globally Diversified?", in: Leonardo Leiderman and Assaf Razin (eds.): **Capital Mobility: The Impact on Consumption, Investment and Growth**, Cambridge, UK: Cambridge University Press.

[30] Obstfeld, Maurice and Kenneth Rogoff, 1999, "New Directions for Stochastic Open Economy Models", NBER working paper no. 7313.

[31] Pakko, Michael, R., 1998, "Characterizing Cross-Country Consumption Correlations", *Review of Economics and Statistics*, 80(1), 169-74.

[32] Ravn, Morten O., 1997, "International Business Cycles in Theory and in Practise", *Journal of International Money and Finance*, 16(2), 255-83.

[33] Stockman, Alan C., and Linda L. Tesar, 1995, "Tastes and Technology in a Two-Country Model of the Business Cycle", *American Economic Review*, 85, 168-85.

[34] Sorensen, Bent E., and Oved Yosha, 1998, "International Risk Sharing and European Monetary Unification", *Journal of International Economics*, 45(2), 211-38.

[35] Tesar, Linda L., 1995, "International Risk Sharing and Non-Traded Goods", *Journal of International Economics*, 35, 69-89.

6 Appendix: Data Description

The data used in the paper are sampled at the quarterly frequency. Unless mentioned, the data were deseasonalized from the source. All data were collected either from the OECD or the IMF.

A. Data used in Tables 1-4 and Table 7-9.

Consumption is defined as private final consumption expenditure in constant prices divided by population. Consumption data were obtained from the OECD while population numbers at the annual frequency were obtained from the IMF International Financial Statistics (IFS) and converted into quarterly numbers by interpolation. Real exchange rates are defined as the nominal exchange rate times the ratio of foreign to domestic prices. Nominal exchange rates were obtained from the IFS and prices are defined as the implicit deflators for the consumption variables. World consumption is defined as aggregate OECD consumption in constant prices divided by aggregate OECD population. Real effective exchange rates were defined as the nominal effective exchange rate times the ratio of aggregate OECD prices to domestic prices. The nominal effective rates are from the IFS and the price variables are defined as the implicit consumption deflators. In all regressions we used the longest available sample period unless otherwise indicated in the Tables. Sample periods and notes on these data are summarized in the following table:

	Sample Period		
	Start	End	Notes
Australia	1960.1	2000.1	-
Canada	1961.1	2000.1	Nominal effective rate available for 1979.1-2000.1
Denmark	1988.1	1999.3	-
France	1978.1	2000.1	-
Italy	1982.1	2000.1	-
Japan	1960.1	2000.1	-
Netherlands	1977.1	2000.1	-
New Zealand	1982.2	2000.1	-
Norway	1978.1	1999.4	Seasonally adjusted using an exponential filter
Switzerland	1980.1	2000.1	-
UK	1960.1	2000.1	-
US	1960.1	2000.1	-
OECD	1960.1	2000.1	-

B. Data used in Table 5.

Real money balances are defined as the nominal money stock divided by the implicit price deflator and by population. The nominal money stock is defined as nominal M1 for all countries except the UK for which we use M2 since M1 is not available. These data were obtained from the OECD. In the section "Leisure" we use employment per capita. Employment data were obtained from the OECD and are index numbers. In the section "government spending" we use government consumption expenditure in constant prices (obtained from the OECD) divided by population. Most of the data were seasonally adjusted from the source; seasonally unadjusted data was transformed into logarithms and seasonally adjusted with an exponential filter assuming a linear trend and additive seasonality. Sample periods and seasonal adjustments are summarized in the following table.

	Money Stocks			Employment			Government Spending		
	Sample Period			Sample Period			Sample Period		
	Start	End	SA	Start	End	SA	Start	End	SA
Australia	1975.1	2000.1	Source	1964.1	2000.1	Exp.	1960.1	2000.1	Source
Canada	1960.1	2000.1	Source	1960.1	2000.1	Exp.	1961.1	2000.1	Source
Denmark	1970.1	2000.1	Source	1980.1	1998.4	Exp.	1988.1	1999.3	Source
France	1978.1	2000.1	Source	1960.1	2000.1	Exp.	1978.1	2000.1	Source
Italy	1974.1	2000.1	Source	1960.1	2000.1	Exp.	1970.1	2000.1	Source
Japan	1960.1	2000.1	Source	1960.1	2000.1	Exp.	1960.1	2000.1	Source
Netherlands	1960.1	2000.1	Source	1987.1	2000.1	Exp.	1977.1	2000.1	Source
New Zealand	1977.2	2000.1	Source	1960.1	2000.1	Exp.	1982.2	2000.1	Source
Norway	1960.1	2000.1	Source	1972.1	2000.1	Exp.	1978.1	1999.4	Source
Switzerland	1960.1	2000.1	Source	1966.3	2000.1	Exp.	1980.1	2000.1	Source
UK	1982.1	2000.1	Source	1960.1	2000.1	Exp.	1960.1	2000.1	Source
US	1960.1	2000.1	Source	1960.1	2000.1	Exp.	1960.1	2000.1	Source
OECD	1982.3	2000.1	Source	1983.1	1999.1	Exp.	1960.1	2000.1	Source

where SA denotes seasonal adjustment, Source denotes from the source, Exp. denotes seasonally adjusted with an exponential filter.

B. Data used in Table 6.

The data in Table 6 are obtained from the OECD. These data decomposes the aggregate consumption data into "durables", "non-durables" and "services". Each component is measured in constant prices and converted into per capita terms. For this application the real exchange rate for component is measured as the exchange rate times the ratio of foreign to domestic prices where prices for each component correspond to the goods specific implicit consumption deflator. All data were seasonally adjusted from the source except the Japanese data which were converted into logarithms and de-seasonalized using an exponential filter with a linear trend and an additive seasonality component. Sample periods are the same as in part A above apart from Italy where we have data for the period 1970.1-2000.1.

Figure 1. Risk Sharing and Relative Prices

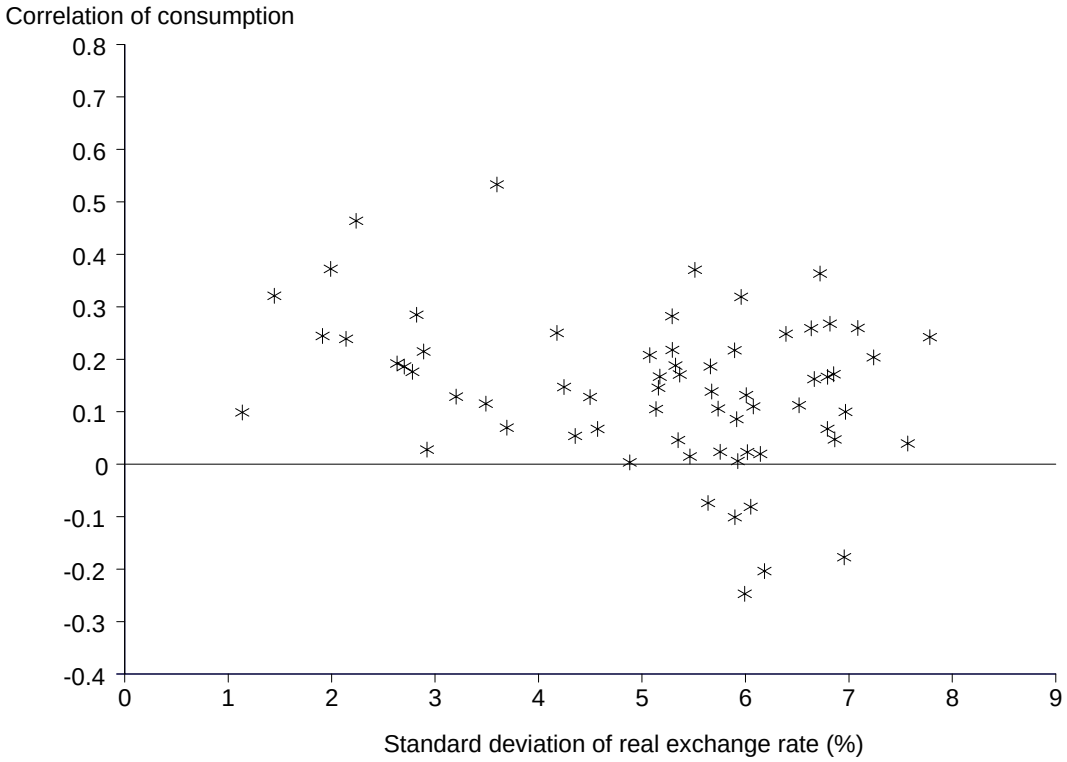

Table 1. Cross Country Consumption Correlations

	CAN	DEN	FRA	ITA	JAP	NL	NZ	NOR	SWI	U.K.	U.S.	OECD	Average
AUS	0.24	0.17	0.37	0.14	-0.03	0.14	0.21	0.12	0.22	0.13	0.13	0.17	0.17
CAN		-0.07	0.00	0.19	0.06	0.01	0.32	0.15	0.26	0.17	0.37	0.42	0.15
DEN			0.11	0.07	-0.23	0.34	0.37	0.43	0.17	0.02	0.18	0.10	0.14
FRA				0.22	0.21	0.25	0.10	0.09	0.29	0.21	0.11	0.43	0.17
ITA					0.01	0.12	0.04	0.08	0.52	0.15	0.05	0.30	0.15
JAP						0.05	-0.13	-0.14	-0.03	0.11	0.22	0.57	0.01
NL							0.26	0.19	0.23	-0.01	0.22	0.32	0.16
NZ								0.09	0.20	0.26	0.11	0.14	0.11
NOR									0.06	0.10	0.14	0.09	0.12
SWI										0.28	0.16	0.34	0.21
U.K.											0.19	0.37	0.15
U.S.												0.79	0.17
OECD													0.37

The numbers in the table are cross country consumption correlations of first differences of the logarithms of the consumption per capita measured in constant prices.

Table 2. Percentage Standard Deviations

	r^{us}	e^{us}	p^{us}/p^i	c^i	c^i/c^{us}	r^{eff}	e^{eff}	p^w/p^i	c^i/c^w
I. Full sample									
Australia	4.48	4.51	0.75	0.80	1.01	4.58	4.66	0.69	0.70
Canada	1.92	1.90	0.47	0.92	0.93	1.86	1.83	0.48	0.84
Denmark	5.77	5.84	0.58	1.18	1.18	1.62	1.69	0.66	1.34
France	5.77	5.87	0.62	0.69	0.91	1.80	1.76	0.61	0.64
Italy	6.24	6.37	0.69	0.65	0.83	2.47	2.48	0.66	0.63
Japan	5.08	5.05	0.99	1.27	1.32	4.49	4.43	1.01	1.07
Netherlands	5.92	5.98	0.70	0.99	1.05	1.46	1.32	0.73	0.96
New Zealand	6.43	6.34	1.22	1.81	1.83	4.57	4.48	1.24	1.79
Norway	5.11	5.19	0.65	0.80	0.98	1.74	1.71	0.65	0.86
Switzerland	6.75	6.74	0.45	0.33	0.70	2.79	2.72	0.48	0.44
UK	5.17	5.15	0.90	1.19	1.27	3.44	3.40	0.89	1.10
US	-	-	-	0.73	-	3.03	3.08	0.23	0.45
II. 1960-1972.4									
Australia	0.91	0.60	0.55	0.83	1.09	-	-	-	-
Canada	1.29	1.29	0.40	0.99	1.04	1.19	1.19	0.40	0.91
Japan	1.45	1.38	0.84	0.96	1.12	1.48	1.32	0.84	0.92
UK	2.40	2.36	0.60	1.17	1.36	1.75	1.68	0.54	1.11
US	-	-	-	0.72	-	0.94	0.90	0.24	0.47
III. 1973.1-2000.1									
Australia	5.39	5.45	0.81	0.79	0.98	-	-	-	-
Canada	2.14	2.10	0.50	0.88	0.89	2.08	2.04	0.51	0.81
Japan	6.08	6.05	0.89	1.22	1.30	5.35	5.28	0.92	1.05
UK	6.05	6.04	1.01	1.20	1.22	4.00	3.96	1.00	1.07
US	-	-	-	0.72	-	3.62	3.68	0.23	0.43

r^{us} denotes the bilateral real US$ exchange rate defined as the log of $R_i^{US} = E_i^{US}\left(P^{US}/P^i\right)$ where E_i^{US} is the nominal bilateral US$ exchange rate and P^j is the CPI of country j. e^{us} is the log of the nominal exchange rate and p^{us}/p^i is the log of the price ratio. c^i is the log of consumption in country i in constant prices, c^i/c^{us} is the log of the ratio of country i consumption and US consumption (all in constant prices). r^{eff} is the log of the real effective exchange rate, e^{eff} is the log of the nominal effective exchange rate, p^{us}/p^i is the log of the price ratio and c^i/c^{wo} is the log of country i consumption divided by aggregate OECD consumption. All moments refers to first differenced data.

Table 3. Unconditional Correlations

	With real US$ rate				With real effective exch. rate			
	e^{us}	p^{US}/p^i	c^i	c^i/c^{us}	e^{eff}	p^w/p^i	c^i	c^i/c^w
I. First differences, full sample								
Australia	0.99	0.03	-0.03	-0.02	0.99	0.04	-0.03	-0.03
Canada	0.97	0.18	0.07	-0.01	0.97	0.18	0.02	0.05
Denmark	0.99	-0.07	0.09	-0.01	0.92	0.10	0.07	0.04
France	0.99	-0.12	-0.22	-0.28	0.94	0.24	-0.11	-0.12
Italy	0.99	-0.13	-0.34	-0.40	0.96	0.12	-0.30	-0.26
Japan	0.98	0.12	0.12	0.02	0.97	0.17	0.07	0.09
Netherlands	0.99	0.00	-0.09	-0.20	0.87	0.43	0.03	-0.01
New Zealand	0.98	0.23	0.12	0.11	0.96	0.18	0.11	0.13
Norway	0.98	0.17	0.02	-0.11	0.93	0.23	0.23	0.19
Switzerland	0.99	-0.06	-0.07	-0.21	0.97	0.22	0.04	0.01
UK	0.99	0.04	0.03	-0.04	0.99	0.18	0.12	0.11
US	-	-	-	-	0.99	-0.16	-0.05	-0.13
II. First differences, 1960-1972.4								
Australia	0.81	0.77	0.39	0.34	-	-	-	-
Canada	0.95	0.15	0.06	0.12	0.94	0.17	0.09	0.13
Japan	0.82	0.37	0.25	0.24	0.83	0.47	0.22	0.26
UK	0.97	0.18	0.08	0.10	0.95	0.27	0.32	0.27
US	-	-	-	-	0.97	0.24	0.19	0.19
III. First differences, 1973.1-1998.4								
Australia	0.99	0.00	-0.06	-0.06	-	-	-	-
Canada	0.97	0.19	0.09	-0.05	0.97	0.19	0.02	0.02
Japan	0.99	0.10	0.04	0.02	0.99	0.16	0.09	0.10
UK	0.99	0.10	0.03	-0.07	0.97	0.16	0.10	0.10
US	-	-	-	-	0.99	-0.22	-0.10	-0.18

See notes to Table 2.

Table 4. Instrumental Variables Tests of Risk Sharing

	US bilateral real exchange rates			Real effective exchange rates		
country	$\widehat{\alpha}$	$\widehat{\beta}$	J	$\widehat{\alpha}$	$\widehat{\beta}$	J
I. Full sample						
Australia	0.088	-0.022	0.174	-0.211	0.075	0.604
Canada	0.595**	-0.092	0.290	0.691**	-0.061	0.204
Denmark	0.896	0.054*	0.427	-0.559	0.163	0.444
France	-0.072	-0.098**	0.715	0.379	-0.162	0.228
Italy	0.275	-0.023	0.343	1.409**	-0.048	0.390
Japan	0.849**	0.008	0.003	1.952***	0.058	0.239
Netherlands	0.443	-0.064	0.013	1.998*	0.514***	0.947
New Zealand	0.170*	0.067	0.105	1.352	0.117	0.291
Norway	0.518	-0.195	0.434	0.016	0.176	0.002
Switzerland	0.450***	-0.013	0.230	0.763***	0.031	0.795
UK	0.503*	-0.114	0.243	0.575	0.075	0.047
US	-	-	-	0.792***	0.018	0.001
II. 1960-1972.4						
Australia	0.149	0.650**	0.955	-	-	-
Canada	0.658*	-0.211	0.517	1.560***	-0.241	0.799
Japan	-0.024	0.078	0.456	0.765	0.263	0.312
UK	-0.131	0.023	0.006	0.408	-0.029	0.649
US	-	-	-	1.408***	0.179*	0.907
III. 1973.1-1998.4						
Australia	0.013	-0.029	0.104	-	-	-
Canada	0.377	0.044	0.067	0.708**	-0.060	0.117
Japan	0.545*	0.019	0.241	1.428***	0.062	0.595
UK	0.618**	-0.062	0.046	1.401**	0.021	0.044
US	-	-	-	1.482***	-0.078**	0.027
SURE RESULTS						
Australia	0.073	0.033	0.633	-	-	-
Canada	0.494***	-0.086	0.619	0.621***	-0.007	0.671
Japan	0.734***	0.052	0.170	1.830***	0.051	0.926
UK	0.496**	-0.024	0.494	0.649***	0.030	0.363
US	-	-	-	1.059***	-0.025	0.017
Restricted FS^A	1	0.036*	0.000^D	1	0.010	0.000^D
Restricted ES^B	1	0.086**	0.000^D	1	0.151***	0.000^D
Restricted LS^C	1	0.036*	0.000^D	1	0.005	0.000^D

$\widehat{\alpha}$ is the estimate of the coefficient on foreign consumption and $\widehat{\beta}$ is the coefficient on the real exchange rate estimated using instrumental variables with lags 2-5 of the left hand side and right hand side variables as instruments. J is the significance level of a test of the overidentifying restrictions.

A: In this regression we impose that $\alpha^i = 1$ and $\beta^i = \beta^j$ for all countries in the system. B: As A but estimated for the sample 1960-1972.4. C: As A but estimated for the sample 1973.1-2000.1. D: This is the significance level of a likelihood ratio test of the hypothesis $\alpha^i = 1$ and $\beta^i = \beta^j$.

Table 5. Effects of Non-Separabilities

	US bilateral real exchange rates					Real effective exchange rates				
country	$\widehat{\alpha}$	$\widehat{\beta}$	$\widehat{\gamma}_i$	$\widehat{\gamma}_{US}$	J	$\widehat{\alpha}$	$\widehat{\beta}$	$\widehat{\gamma}_i$	$\widehat{\gamma}_w$	J
	Real Money Balances									
Austr.	0.001	0.035	0.113***	0.128	0.160	0.956***	0.015	0.127**	0.291**	0.417
Canada	0.608***	-0.047	0.062	0.186**	0.313	1.553***	0.010	0.114*	0.090	0.660
Denmark	0.756	0.011	0.132	-0.123	0.413	0.015	0.067	0.055	0.195	0.164
France	-0.290	-0.047**	0.162	-0.098	0.332	0.759**	-0.157	0.199**	0.138	0.314
Italy	0.298	-0.016	0.036	0.094	0.562	1.207**	-0.066	-0.060	-0.021	0.300
Japan	0.605**	-0.034	0.154*	0.156	0.008	0.988**	0.012	-0.127	0.133	0.452
Netherl.	0.388	-0.037	0.009	0.101	0.013	-0.667	0.070	-0.020	0.036	0.602
New Zea.	0.321	0.021	0.107*	0.003	0.015	1.103	0.111	-0.048	0.048	0.207
Norway	0.586*	-0.091*	0.016	-0.022	0.037	-0.402	0.034	-0.087	0.503***	0.003
Switzerl.	0.372***	-0.015	-0.007	0.079	0.068	0.525***	0.006	0.001	-0.114*	0.236
UK	0.521*	0.005	0.503***	0.083*	0.779	1.028**	-0.026	0.570**	0.120	0.677
US	-	-	-	-	-	1.057***	0.003	0.002	-0.128	0.025
	Leisure									
Austr.	0.020	0.006	0.317*	-0.278	0.723	-0.219	0.093**	0.291	0.010	0.703
Canada	0.375*	-0.048	0.227	-0.245	0.233	1.134**	-0.136*	0.803***	1.513**	0.259
Denmark	0.947*	0.044*	0.012	0.052	0.883	0.316	0.190*	-0.916	-0.820	0.819
France	-0.148	-0.035**	0.722***	-0.270	0.182	0.703	-0.203**	0.671	-0.239	0.617
Italy	0.272	-0.025**	0.746***	-0.136	0.560	-0.038	-0.052	0.517**	-0.855*	0.386
Japan	0.685**	0.020	1.216*	-0.291	0.077	1.273***	0.024	1.327***	0.550	0.711
Netherl.	-0.007	-0.036	0.662**	-0.271	0.642	-0.155	0.146	0.133	-1.243**	0.290
New Zea.	0.790	0.009	0.416	-0.703	0.072	2.730	0.079	0.958**	0.911	0.578
Norway	0.142	-0.134	0.768***	0.093	0.730	0.073	-0.005	0.925***	1.011	0.234
Switzerl.	0.330***	-0.018	0.524***	-0.102	0.736	0.152	-0.023	0.299*	0.522	0.889
UK	0.347	-0.045	0.073	-0.319	0.234	0.569	0.025	1.074	1.831	0.090
US	-	-	-	-	-	1.357***	-0.011	0.755***	1.135***	0.227
	Government Consumption									
Austr.	0.173	-0.022	0.100	-0.198	0.189	0.103	0.067	0.112*	0.135	0.381
Canada	0.418*	-0.019	0.061	-0.225	0.075	0.759***	0.040	-0.080	-0.317	0.207
Denmark	-0.149	0.053	0.671***	-0.136**	0.159	-0.186	0.123	0.745	-0.534	0.252
France	0.208	-0.071**	0.217	-0.121	0.160	0.883***	-0.059	0.382	0.369	0.162
Italy	0.146	-0.034*	0.396***	-0.206	0.308	0.778	0.009	0.263	-0.630	0.755
Japan	0.622*	0.022	-0.071	-0.578***	0.110	1.691***	0.096**	0.097	0.823**	0.663
Netherl.	0.414	-0.017	-0.091	-0.072	0.009	1.324**	0.299***	-0.111	0.589	0.592
New Zea.	0.949**	0.050	0.096	-0.393	0.278	0.914	-0.003	0.017	0.520	0.422
Norway	0.807**	-0.075	0.117**	0.193	0.195	0.224	0.099	0.054	0.107	0.006
Switzerl.	0.269*	-0.030***	-0.048	-0.181**	0.485	0.597***	0.006	-0.058	0.207	0.483
UK	0.656**	-0.080	0.036	0.153	0.052	1.031**	0.054	-0.153	0.614	0.094
US	-	-	-	-	-	0.909***	-0.003	0.303*	0.669**	0.037

See notes to Tables 2 and 4. $\widehat{\gamma}$ denotes the coefficient on the non-consumption variable, see Section 4.1.

Table 6. Goods Specific Results

country	$C\left(\triangle c_i, \triangle c_{US}\right)$	$std\left(q_i\right)$	$\widehat{\alpha}$	$\widehat{\beta}$	J
	Durable Goods				
Canada	0.431	2.09	0.853***	0.329	0.164
Denmark	0.066	6.31	0.157	0.208	0.117
France	0.096	6.22	0.311	-0.069***	0.263
Italy	0.055	5.57	-0.407	0.055	0.014
Japan	0.083	5.85	0.276	0.195	0.001
New Zealand	0.147	6.43	-0.188	0.555	0.404
UK	0.012	5.57	0.204	0.827	0.068
	Non-Durable Goods				
Canada	0.185	1.94	0.530	-0.016	0.034
Denmark	-0.017	5.88	0.265	0.047	0.996
France	-0.107	5.81	-0.098	-0.011	0.157
Italy	-0.003	5.46	-0.123	-0.138	0.048
Japan	0.128	6.11	0.507	-0.102	0.021
New Zealand	0.084	6.51	1.277**	0.100	0.123
UK	0.170	5.11	0.132	-0.020	0.442
	Services				
Canada	0.151	2.17	0.622**	-0.077	0.304
Denmark	0.119	5.76	1.219	-0.028	0.271
France	0.071	2.44	0.321	-0.015	0.526
Italy	-0.006	5.53	0.242	-0.072**	0.289
Japan	0.176	5.87	0.306	-0.051**	0.011
New Zealand	0.201	6.91	0.088	-0.027	0.392
UK	0.028	5.27	-0.826*	0.015	0.000

See notes to Table 4. $C\left(\triangle c_i, \triangle c_{US}\right)$ denotes the correlation between the first differences of the logarithms domestic and foreign consumption for each of the three different types of consumption goods. $std\left(q_i\right)$ denotes the standard deviation of the first difference of the logarithm of the goods specific real exchange rate defined against the US.

Table 7. Sensitivity to Partner Country

		CAN	DEN	FRA	ITA	JAP	NL	NZ	NOR	SWI	U.K.
Australia	α	0.266	0.218	0.289	0.091	0.143	0.000	0.054	-0.035	0.360	-0.189
	β	0.063	0.097***	-0.009	0.029	-0.026	0.007	0.075**	0.043	0.015	-0.005
	J	0.477	0.987	0.030	0.096	0.786	0.138	0.692	0.211	0.131	0.759
Canada	α	-	0.179	0.164	0.781	0.270**	0.281	0.286**	0.386	1.327	0.106
	β	-	0.059	0.012	-0.043	0.079	0.048	0.060	-0.021	0.020	0.140
	J	-	0.399	0.044	0.373	0.497	0.158	0.240	0.050	0.121	0.423
Denmark	α	-	-	0.038	0.171	0.075	0.126	0.311**	0.268	0.577	0.148
	β	-	-	0.172	0.041	-0.009	0.278	-0.000	0.180	0.183	-0.199*
	J	-	-	0.460	0.297	0.181	0.255	0.289	0.890	0.090	0.715
France	α	-	-	-	0.273	0.194	0.145	-0.052	-0.115	0.698*	0.160
	β	-	-	-	-0.105	-0.047**	0.066	-0.013	-0.138	-0.036	0.021
	J	-	-	-	0.156	0.200	0.021	0.600	0.189	0.143	0.189
Italy	α	-	-	-	-	-0.021	0.239	-0.022	-0.015	1.368**	0.368*
	β	-	-	-	-	-0.016	0.002	-0.036	-0.008	-0.129*	-0.112
	J	-	-	-	-	0.275	0.383	0.480	0.304	0.703	0.822
Japan	α	-	-	-	-	-	0.006	0.015	-0.184	0.713	0.151
	β	-	-	-	-	-	0.032	0.017	0.011	-0.076*	0.085
	J	-	-	-	-	-	0.366	0.480	0.832	0.831	0.000
Netherl.	α	-	-	-	-	-	-	0.036	0.170	1.094**	0.136
	β	-	-	-	-	-	-	-0.017	-0.048	-0.051	0.069
	J	-	-	-	-	-	-	0.702	0.008	0.083	0.046
NewZeal.	α	-	-	-	-	-	-	-	0.068	-0.584	0.746
	β	-	-	-	-	-	-	-	0.061	0.039	0.129***
	J	-	-	-	-	-	-	-	0.075	0.366	0.707
Norway	α	-	-	-	-	-	-	-	-	-0.159	0.129
	β	-	-	-	-	-	-	-	-	0.252**	0.025
	J	-	-	-	-	-	-	-	-	0.194	0.000
Switz.	α	-	-	-	-	-	-	-	-	-	0.381**
	β	-	-	-	-	-	-	-	-	-	0.035*
	J	-	-	-	-	-	-	-	-	-	0.332

See notes to Table 4. The results refer to the estimates from the regressions $\triangle c_{it} = \lambda^{ij} + \alpha^{ij} \triangle c_t^j + \beta^{ij} \triangle r_{it}^j + \eta_t^{ij}$ where i is given by the row entry and j is given by the column entry.

Table 8. Habit Persistence

	US bilateral real exchange rates					Real effective exchange rates				
country	$\widehat{\alpha}$	$\widehat{\beta}$	$\widehat{\gamma}_i$	$\widehat{\gamma}_{US}$	J	$\widehat{\alpha}$	$\widehat{\beta}$	$\widehat{\gamma}_i$	$\widehat{\gamma}_w$	J
Austr.	0.095	-0.034	0.256	-0.185	0.270	0.624	0.081	-0.300	0.929	0.622
Canada	0.526	-0.138	0.193	-0.094	0.157	0.668^{*}	-0.166	0.061	-0.036	0.247
Denmark	1.805^{**}	0.013	-0.079	1.330^{*}	0.775	0.241	-0.021	-0.274	2.410	0.803
France	-0.401	-0.015	-0.237	-0.630^{**}	0.816	0.492	-0.025	-0.467^{*}	-0.402	0.306
Italy	0.892^{**}	-0.032	0.132	0.352	0.933	0.361	-0.021	0.288	-0.499	0.136
Japan	1.332^{***}	-0.015	0.579^{***}	0.720	0.129	2.587^{***}	0.052	0.509	1.343	0.981
Netherl.	0.249	-0.076	0.060	0.726^{*}	0.106	1.371^{**}	0.169	-0.436^{*}	-1.413	0.324
N. Zeal.	1.780	0.139	-0.594	-0.433	0.206	2.313	0.209	-0.468	1.003	0.275
Norway	0.062	0.005	0.769^{***}	-0.408	0.674	0.271	0.077	0.714^{***}	0.378	0.384
Switzerl.	0.074	-0.012	0.820^{***}	0.063	0.090	0.600	-0.072	1.131^{*}	0.570	0.956
UK	0.602	-0.170	-0.542	-0.103	0.659	0.843^{*}	-0.111	-0.477	-0.116	0.215
US	-	-	-	-	-	1.016^{***}	-0.040	0.521^{***}	0.705^{***}	0.025
	1960-1973.4									
Austr.	-0.133	0.388^{*}	-0.317^{*}	0.137	0.609	-	-	-	-	-
Canada	0.804^{**}	-0.126	-0.279	-0.293	0.625	1.442^{***}	-0.162	-0.350	-0.641	0.387
Japan	0.266	0.169	0.351^{**}	-0.202	0.662	0.345	0.009	0.088	0.570	0.507
UK	0.276	0.093	-0.044	0.272	0.583	2.092^{***}	-0.254	0.342	1.899^{***}	0.990
US	-	-	-	-	-	1.448^{***}	0.161	-0.481	-1.158	0.867
	1973.1-2000.1									
Austr.	0.076	-0.033	0.150	0.024	0.089	-	-	-	-	-
Canada	0.338	-0.126	-0.279	-0.293	0.094	0.635	-0.140	0.189	-0.041	0.216
Japan	0.468	0.010	-0.153	0.105	0.092	2.032^{***}	0.038	0.476	1.380	0.942
UK	0.792^{**}	-0.133	-0.652^{*}	-0.248	0.268	1.696^{***}	-0.130	-0.512	-0.116	0.332
US	-	-	-	-	-	1.366^{***}	-0.086	0.344^{*}	0.408^{*}	0.076
SUR Results										
Austr.	0.108	0.037	0.216	-0.088	0.397	-	-	-	-	-
Canada	0.453^{**}	-0.075	0.081	-0.033	0.263	0.462^{*}	-0.015	-0.054	-0.332	0.590
Japan	0.739^{**}	0.046	0.151	-0.148	0.112	2.018^{***}	0.018	0.033	0.082	0.901
UK	0.257	-0.102^{**}	-0.328^{*}	-0.442	0.852	0.587	-0.013	-0.195	0.185	0.315
US	-	-	-	-	-	1.039^{***}	-0.024	0.435^{***}	0.654^{***}	0.576
R. FS^{A}	1	0.018	0.084	-0.084	0.000^{D}	1	-0.007	0.090	0.090	0.910^{L}
R. ES^{B}	1	0.148^{***}	-0.131^{*}	-0.131^{*}	0.000^{D}	1	0.140^{***}	-0.152^{*}	-0.152^{*}	0.041^{L}
R. LS^{C}	1	0.016	0.042	0.042	0.000^{D}	1	-0.012	0.088	0.088	0.066^{L}

See notes to Table 2 for definitions. A: In this regression we impose that $\alpha^i = 1$, $\beta^i = \beta^j$ and $\gamma_i = \gamma_{US}$ for all countries in the system. It is estimated for the full sample. B: As A but estimated for the sample 1960-1972.4. C: As A but estimated for the sample 1973.1-2000.1. D: This is the significance level of a likelihood ratio test of the hypothesis $\alpha^i = 1$, $\beta^i = \beta^j$ and $\gamma_i = \gamma_{US}$. This test statistic is distributed as a $\chi^2(10)$.