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Macroeconomic Risk and International Financial Markets

by

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A Thesis Submitted for the Degree of

Doctor of Philosophy

Supervised by

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Summary

This thesis is composed of three essays addressing the use of financial markets to hedge or gain exposure to macroeconomic risk. The first essay examines the question of consumption risk sharing between countries. Theory predicts that greater international financial integration should allow a higher degree of idiosyncratic consumption risk to be shared, so that domestic consumption in any given country should respond more to aggregate output shocks and less to domestic shocks. This prediction has never held true in an empirical study of developing or emerging countries, and the first essay of the thesis presents a number of reasons why this may be so.

The most important reason for the observed failure of consumption risk sharing is omitted variable bias in the testing framework. The method most often used to test the consumption risk sharing hypothesis is a regression of a country's consumption on domestic output and aggregate output, where these terms are interacted with a measure of financial integration. Theory predicts that the interaction terms should be negative for domestic output, and positive for aggregate output. The use of a single indicator of financial integration in the literature is a simplification which may have biased the results. In reality, there is evidence that financial integration could affect domestic consumption through several channels. One channel not previously considered in this type of test is the use by consumers of debt markets to increase consumption at a time when output is growing, perhaps in anticipation of a movement to a permanently higher level of output. This effect would bias against finding risk sharing, as it would increase the correlation between domestic consumption and output. Allowing for this and several other estimation issues leads to a finding of statistically and economically significant consumption risk sharing by developed and developing countries alike.

The second essay continues the theme of the sharing of idiosyncratic risk, by asking whether carry trade investors are exposed to such risk. The carry trade is the strategy of buying debt instruments in a high interest rate country and selling them in a low, thus reaping the interest differential ("carry") at the expense of currency risk. This trade typically earns high returns, which cannot be entirely explained by currency risk. The second essay asks whether, in addition to currency and global risk factors, carry trade investors are exposed to idiosyncratic macroeconomic risk, here proxied by equity returns of the countries in the investor's portfolio. Portfolio equity returns are found to be significantly priced in a Fama-Macbeth testing framework, controlling for conventional risk factors. This test proceeds in two stages, where the first stage provides estimates

of the level of exposure to the risk factors within a given portfolio of high or low interest rate countries, and the second stage regresses average returns across the estimated risk exposures to determine if the risk factor is priced in the cross section.

The idiosyncratic risk exposure identified in this test could occur via debt instruments or exchange rates, with some indicative evidence presented to support both channels. A negative signal regarding macroeconomic risk in a country could lead to a portfolio rebalancing from equity into debt, which would affect the carry trade investor. We can think of the consumer from the first essay, who invests in foreign assets in order to diversify risk, as a kind of carry trade investor. The carry trade appears to reward this investor for taking on some of the idiosyncratic macroeconomic risk of the countries in her portfolio.

The third essay is concerned with a particular type of aggregate risk, the existence of which is consistent with the theoretical prediction that aggregate risk will comprise an increasing share of overall risk as countries become more financially integrated. The aggregate risk in question is funding liquidity risk, which is defined as asset price risk arising from the level of funding availability, here proxied by the interest rate. Low interest rates may lead to excessive credit and excessive leverage of investment positions, increasing the risk of an asset price crash due to a tightening of credit conditions. Since liquidity risk is a global risk that is common across assets and asset classes, common volatility from one asset class may be used to proxy liquidity risk in a test using a second asset class. The proxy asset class chosen here is exchange rates, and the test class is equities.

Estimated liquidity risk appears to be priced in the United States and in some international equity markets, controlling for conventional risk factors. This finding highlights one kind of risk inherent in increasing financial integration, namely that liquidity conditions and the monetary policy stance in one country may have implications for asset prices in other countries, which, as the financial crisis of the late 2000's demonstrates, can contribute to macroeconomic risk. This is one way in which the consumer of the first essay, who tries to decrease idiosyncratic consumption risk by buying foreign assets, faces diminishing returns to her financial integration.

Chapter 1

Introduction

The dramatic increase in cross-border asset holdings since the mid 1980's has had an equally dramatic impact on the macroeconomic risk faced by consumers. Macroeconomic risk has become more correlated across countries as exposure to domestic risk decreases, however the reduction in domestic exposure comes at the price of increased exposure to aggregate risk, which, as the financial crisis and recession of the late 2000's shows, can be severe. This thesis attempts to demonstrate and quantify some of the risks and benefits of international financial integration.

The reduced exposure to domestic sources of risk that should occur with increasing financial integration has proven elusive in empirical studies of consumption risk sharing, with the early literature finding insignificant risk sharing for all countries, while more recent studies find significant risk sharing for developed countries only. This is a disappointing finding for the champions of financial integration, since emerging and developing countries who opened their capital accounts were expected to be among the main beneficiaries. One contribution of this thesis is to show that the observed lack of consumption risk sharing among emerging and developing countries is due to several estimation biases.

The most important bias identified is the failure to allow for pro-cyclical financial integration. Taking the example of a rapidly growing country, consumers may access debt markets in order to increase their consumption in anticipation of a movement to a permanently higher output level, which would mean that debt market integration increases the correlation of consumption with domestic output, instead of decreasing it. Allowing for separate effects of equity and debt market integration controls for this effect, and leads to a finding of significant risk sharing by emerging and developing markets, with a marginal benefit of financial integration which is comparable to that achieved by developed countries.

A secondary contribution to the question of consumption risk sharing is that the choice of deflator, which has been contentious in the literature, is not of major importance empirically. The risk sharing results are robust to the choice of deflator, as well as to the inclusion of several control variables.

Having examined the sharing of macroeconomic risk from the consumer's perspective, the thesis next examines the investor's perspective. The hypothesis advanced in Chapter 3 is that carry trade investors take on macroeconomic risk of the countries in their portfolio. A carry trade investor buys government debt in a foreign country, and has historically achieved significant excess returns which cannot be explained entirely as compensation for exchange rate risk. Macroeconomic risk of the portfolio countries (proxied by equity returns) appears to be significantly priced in carry trade returns, controlling for global equity returns and exchange rate crash risk. One way in which this could occur is via T-Bill returns covarying with equity returns, either through changes in the domestic discount factor or through changes in the perceived macroeconomic risk which lead to rebalancing between equity and safer government debt. Correlation analysis provides indicative evidence that both of these channels may be at work. Inflation could also provide the link from equity to carry returns, since a negative supply shock, for example, would affect equity returns and possibly the exchange rate, via the law of one price for goods markets. Again, correlation analysis suggests this channel may be at work.

The finding that carry trade returns reflect macroeconomic risk suggests that this trade may be viewed as a channel of risk sharing. This finding is robust to a number of different empirical specifications, including estimation at monthly in place of annual frequency. Volatility in the correlation of carry with portfolio equity returns suggests that this method of risk sharing is not always effective, in particular, periods of high global risk aversion weaken the link to idiosyncratic macroeconomic risk.

This volatility in the sharing of macroeconomic risk suggests that financial integration may engender risks that are absent under financial autarkey, and this is the subject of Chapter 4. As they become more integrated, countries increase their exposure to aggregate risks, one of which is liquidity risk. Liquidity risk is the risk inherent in asset prices due to the ease or difficulty of obtaining credit. If credit conditions suddenly worsen, asset prices can collapse. If the overall level of leverage is higher, this collapse will be more severe. Chapter 4 focuses on the relationship between credit availability and the perceived severity of a potential crash. Since excess leverage may take time to develop, the link between liquidity conditions and perceived crash risk is examined over months and years, a longer horizon than in the financial literature, where the focus is on the short term dynamics of liquidity crashes.

Taking interest rate levels as an indicator of the ease of credit availability, the results suggest that liquidity risk is priced in equities in the United States and in several other countries. The testing strategy relies on the integrated nature of global credit markets, taking the liquidity risk inherent in exchange rates and testing if this risk is priced in equities. Since the same liquidity risk affects many types of assets, this strategy should help to isolate the liquidity component of interest rate levels from the cyclical component, which could be correlated with equity returns. Aggregate liquidity risk represents a disadvantage of financial market integration that appears to be economically significant in magnitude.

The thesis thus draws together several facets of the relationship between financial integration and macroeconomic risk. Chapter 2 proceeds by examining consumption risk sharing, while Chapter 3 considers the macroeconomic risk exposure of international investors. Chapter 4 examines aggregate liquidity risk, and Chapter 5 concludes.

Chapter 2

International Financial Integration and Consumption Risk Sharing

2.1 Introduction

The expected risk sharing benefits of financial integration have proven difficult to substantiate empirically. This essay attempts to establish the degree of consumption risk sharing that is due to cross border debt and equity assets and liabilities by running panel regressions on a large sample of developed and developing countries over the period 1970-2004, in a framework which relaxes some of the assumptions that have been maintained in the literature.

As pointed out by Backus and Smith (1993), in the presence of segmented goods markets, perfect financial markets need not imply perfect cross-country consumption correlations. For this reason this essay focuses mainly on the marginal effect of debt and equity (foreign direct investment and portfolio equity) assets and liabilities on consumption correlations, rather than testing the level of these correlations. Previous studies have often measured financial integration via a single variable, sometimes combining equity and debt openness into one financial openness indicator. In contrast, it is argued that financial integration affects macroeconomic risk along a number of dimensions, necessitating a more refined measure of financial integration. Strong empirical support is found for this contention.

The practice of netting out aggregate values of consumption and output from their domestic counterparts rests on the assumption that the response of consumers to a shock in output does not depend on the source of the shock. Alternatively, it may be that different levels of persistence in domestic and aggregate shocks lead to varying responses in consumption. Some support is found for this contention, however a more general risk sharing framework which allows differing responses depending on the source of the shock yields no new results.

The regression setup used allows for a real exchange rate role in consumption dynamics, consistent with many open economy macroeconomic models. The estimation also controls for the possible effects of habit formation in consumption, whereby current consumption may depend on previous values of consumption. The results arising from alternative methods of deflating current price data as well as alternative data sources are compared. The conclusion that financial integration does facilitate risk sharing in the period 1987-2003/4, including by emerging and developing countries, appears robust across data sources.

Section 2.2 reviews the main empirical approaches to testing risk sharing. Section 2.3 develops the framework used to test for the effect of financial integration on risk sharing. Section 2.4 describes the data sources and empirical methodology, while Section 2.5 presents the results. Section 2.6 summarises the essay.

2.2 Empirical Tests of Risk Sharing

A classic question in international macroeconomics is whether financial integration leads to consumption risk sharing. Trade in contingent claims should enable risk sharing and the decoupling of consumption and output. Such trade should lead to an increase in cross country consumption correlations, as consumption would respond increasingly to common (aggregate) output risk rather than domestic risk. A model in the International Real Business Cycle literature which has this implication is that of Backus, Kehoe and Kydland (1992), who also establish the lack of empirical evidence to support this prediction.

The main approaches to measuring consumption risk sharing and the associated empirical results are summarized in Table 2.1. In the setting of Kose, Prasad and Terrones (2007), aggregate values are subtracted from the domestic series, giving "idiosyncratic" values, as the common risk represented by aggregate values is assumed to be uninsurable. The aggregate values are calculated as the average over the sample of OECD countries examined. The authors' approach allows the dependence of idiosyncratic consumption on idiosyncratic GDP to be a function of financial openness. If risk sharing occurs, increased cross-border financial openness should allow the two idiosyncratic series to become decoupled, which should lead to a negative β_1.

This is closely related to the approach of Sorensen et al (2007), where the coefficient of idiosyncratic output is allowed to depend on a country's equity home bias and a time trend, among other measures. Equity Home Bias is measured as 1 - (share of country i's holdings of foreign equity in country i's total equity portfolio / the share of foreign equity in the world portfolio). Home bias is therefore zero for a country that shows no preference for equity issued domestically, and one for a country whose equity is completely domestically invested. Kose et al examine a set of 72 countries, including 51 developing countries, whereas Sorensen et al concentrate on the OECD countries. Kose et al find that financial flows help improve risk sharing by industrial countries in the globalization period (1987-2004), although the magnitude of the effect would appear small: an increase in the stock of foreign assets and liabilities equal to 100% of GDP is seen to decrease the dependence of idiosyncratic consumption on idiosyncratic output from 0.744 to 0.725. To put this in context, the average value of the stock of foreign assets and liabilities for the industrial countries is 265% of GDP. Cross-border financial openness does not appear to facilitate risk sharing for emerging countries or over other periods than the globalization era.

Other studies examine variants of the above regression equation. Artis and Hoffmann (2007) run a regression in log levels instead of log differences on OECD countries over the period 1960-2000, which should capture more long term risk sharing. They find an increase in risk sharing by OECD countries in the globalization period, but also find that international financial holdings do not completely explain this increase. Bai and Zhang (2005), following Cochrane (1991), run two cross-section regressions on a sample of 40 countries from 1973-1985 and 1986-1996, and find that risk sharing remained static between these two periods. Following a study by Mace (1991) that examined household level data, Bai and Zhang also run a panel regression with aggregate consumption as an explanatory variable and again find no improvement in risk sharing. The introduction of aggregate consumption on the right hand side allows a second test of risk sharing based on this coefficient, with the prediction under perfect risk sharing being a unitary coefficient. Crucini (1999) examines a similar equation to that of Bai and Zhang (2005), which has the growth rate of permanent income in place of that of output. Crucini finds significantly more risk sharing among the Canadian and United States than among G7 countries. Huizinga and Zhu (2004) also test an equation similar to that of Bai and Zhang, where aggregate consumption is omitted and the coefficient of GDP is allowed to depend on domestic and international equity and debt market development. They find that development of the domestic debt market is important for OECD countries, whereas development of the international market is important for non-OECD countries. Moser et al (2004) run a panel regression on a sample of EU countries and test for break points in the coefficients. They conclude that the increasing financial links among EU countries between 1960 and 2002 have not lead to more efficient consumption risk sharing.

The above studies primarily examine the dependence of personal consumption on GDP. Obstfeld (1995) examines the dependence of consumption on GDP net of government consumption and investment (hereinafter referred to as "net output"), rather than simply GDP. Yakhin (2004) also argues that net output is the more relevant measure for studying consumption risk. Yakhin examines G7 countries and runs cross-section regressions of consumption correlation on GDP and net GDP. The author finds that netting out government consumption and investment reverses the rank of the consumption and net output correlation coefficients for many pairs of countries, suggesting that examining net output may be important.

Several hypotheses have attempted to explain the weak empirical evidence for the risk sharing benefits of financial integration. The presence of non-tradable and durable goods may help to explain the discrepancy. Stockman and Tesar (1995) present a model with non-traded goods, but find that this cannot reduce predicted consumption correlations to a realistic level. Lewis (1995) finds that allowing for non-tradable goods in conjunction with capital market restrictions leads to the finding of some risk sharing among OECD countries. Heathcote and Perri (2000) examine the role of market incompleteness and conclude that observed correlations match those expected under financial autarkey better than other asset structures. Kose, Prasad and Terrones (2007), among others, suggest that the absence of financial derivatives based on a broad measure of national output may partly explain the low observed correlations, however it seems possible that such "Shiller securities" could be adequately proxied by a portfolio of currently available securities (Shiller, 1993, Sorensen et al, 2007).

If purchasing power parity does not hold, consumption may be expected to depend on the real exchange rate. Obstfeld and Rogoff (2000) claim that segmented goods markets can account for low observed consumption correlations, which is one of the reasons why the present essay concentrates on finding a marginal risk sharing effect of financial integration. Ravn (2001) points out that allowing for the possible effect of the real exchange rate is necessary in consumption risk sharing regressions, since if countries face the same nominal interest rate then real exchange rate movements are equivalent to real interest rate differentials, and will lead to intertemporal substitution of consumption. Ravn regresses consumption growth on aggregate consumption growth and the growth in the real exchange rate, and finds that the real exchange rate is rarely a significant predictor, which casts doubt on the role given to it in a number of international macroeconomic models. He concludes that the data do not consistently support a role for financial markets in risk sharing, based on a sample of twelve OECD countries. His results are robust to non-separabilities in the utility function and the decomposing of consumption goods into durables, non-durables and services. Ravn also finds evidence in favour of habit persistence, although introducing lagged consumption growth to allow for this does not alter the results. Fuhrer and Klein (2006) develop a model incorporating habit persistence and show that habit formation can generate positive consumption correlation in the absence of risk sharing, suggesting that the evidence in favour of international portfolio diversification may be even weaker than it appears.

The model developed below incorporates many of the features mentioned in this review, while relaxing some of the assumptions. The empirical focus in the existing literature has mainly fallen on industrialized countries. None of the above studies find risk sharing by non-OECD countries. The use of a more refined measure of financial integration contributes to a reversal of this finding.

Study	*Sample*	*Findings and Remarks*
$\Delta c_{it} - \Delta c_{at} = \alpha_i + \delta_t + (\beta_0 + \beta_1 fo_{it})(\Delta y_{it} - \Delta y_{at}) + \varepsilon_{it}$		
Kose et al (2007)	21 OECD + 51 Developing Countries	Risk sharing only by OECD countries during the period 1987-2004. Financial Openness is measured in a number of alternative ways, including as equity and debt stocks and flows.
$\Delta c_{it} - \Delta c_{at} = \alpha_i + (\beta_0 + \beta_1(EHB_{it} - \overline{EHB_t}) + \beta_2(t - \bar{t}))(\Delta y_{it} - \Delta y_{at}) + \varepsilon_{it}$		
Sorensen et al (2007)	OECD Countries, 1993-2003	Strong equity home bias effect on consumption smoothing.
$c_{it} - c_{at} = \beta_i(y_{it} - y_{at}) + \varepsilon_{it}$		
Artis and Hoffmann (2007)	23 OECD Countries and US States	Large increase in consumption risk sharing, which international capital income flows cannot completely explain. β_i is allowed to depend on a country's cumulative asset and equity trade relative to its total financial wealth.
$\Delta c_i = \alpha + \gamma \Delta y_i + \varepsilon_i$ $\Delta c_{it} = \alpha + \eta \Delta c_{at} + \gamma \Delta y_{it} + \varepsilon_{it}$		
Bai and Zhang (2005)	21 Developed and 19 Developing Countries	Panel and cross-section regressions were run over 1973-85 and 1986-1996. In both cases there was no increase in risk sharing despite the increase in financial integration.
$\Delta c_{it} = \alpha_i + \eta_i \Delta c_{at} + \gamma_i(\Delta y_{it} - \Delta y_{at}) + \varepsilon_{it}$		
Moser et al (2004)	Sample of EU Countries	Coefficients were tested for structural breaks. No improvement in risk sharing was found.
$\Delta c_t = \alpha + \eta \Delta c_{at} + \gamma(\Delta y_t - \Delta i_t - \Delta g_t) + \varepsilon_t$		
Obstfeld (1995)	Germany and Japan	Increasing comovement with aggregate net output in the period 1973-1988.

Table 2.1: The main estimating equations used to test for consumption risk sharing. c stands for per capita private consumption, y for per capita GDP, the i subscript indicates country, a indicates aggregate, and fo stands for financial openness. EHB is Equity Home Bias, i is investment and g is government expenditure, both per capita.

2.3 Risk Sharing Model

As pointed out by Backus and Smith (1993), perfect consumption correlation is not expected in the presence of non-traded goods. This essay focuses therefore on the marginal effect of financial openness on consumption correlations and hence risk sharing. Mace (1991) derived the equation

$$\Delta c_{it} = \alpha_i + \eta \Delta c_{at} + \gamma \Delta y_{it} + \varepsilon_{it} \tag{2.1}$$

where $\Delta c_{at} = \sum_{i \neq j} \frac{\Delta c_{it}}{n-1}$ and y_{it} stands for household i's income at time t, as the solution to a social planning problem in the presence of common endowment shocks. In Mace's case the sum was over all households in an economy, here it is over all *other* countries in a sample. Aggregate consumption (and output) thus vary by country, however the country index is omitted for clarity. Under the null hypothesis of perfect risk sharing $\eta = 1$ and $\gamma = 0$. As Mace points out, the errors include preference shocks and measurement errors. The risk sharing implications were shown to hold under general conditions for the number, separability and durability of goods. Kose, Prasad and Terrones (2007), among others, have tested this equation on international data with output substituted for income. This substitution is necessary because income may already be smoothed by risk sharing.

Aggregate consumption and output risk, to which every country is exposed, cannot be hedged. These variables can therefore be subtracted from their domestic counterparts, giving idiosyncratic variables:

$$\Delta c_{it} - \Delta c_{at} = \alpha_i + \beta(\Delta y_{it} - \Delta y_{at}) + \varepsilon_{it} \tag{2.2}$$

One situation in which the response of consumption to aggregate and domestic variables might differ, in which case the subtraction of aggregate values would not be valid, is if shocks to aggregate and domestic output have differing levels of persistence. Under the permanent income hypothesis, for example, consumers would respond only to permanent changes in income. The validity of the assumption of an identical response to domestic and aggregate shocks is discussed in Section 2.3.3 below.

Comovement of consumption with GDP may depend on financial integration. This can be tested by allowing the GDP coefficient to depend on the level of financial integration.

$$\Delta c_{it} - \Delta c_{at} = \alpha_i + (\beta_0 + \beta_1 eo_{it} + \beta_2 do_{it})(\Delta y_{it} - \Delta y_{at}) + \beta_3 eo_{it} + \beta_4 do_{it} + \Gamma Z_{it} + \varepsilon_{it}, \tag{2.3}$$

where eo_{it} and do_{it} designate equity (portfolio equity and FDI) and debt openness (assets plus liabilities as a proportion of GDP), respectively, and Z_{it} represents a vector of other explanatory and control variables, discussed below. To avoid endogeneity bias the financial openness variables have been lagged, so that the t subscript indicates the end-of-year $t-1$ value, appropriate for measuring risk sharing in year t. This is similar to the setup used by Kose, Prasad & Terrones (2007). One important difference is that it allows for separate channels through which financial integration can affect consumption, through the inclusion of two risk sharing interaction terms.

The expectations regarding the signs of the financial interaction variable coefficients are not necessarily clear. Equity holdings imply state contingent returns. If a portion of the returns to output is not available to domestic consumers because it is claimed by foreign equity liability holders, this should decrease the dependence of domestic consumption on domestic output. The same is true of foreign equity assets held by domestic investors to the extent that an increase in such assets indicates less exposure to domestic equity. Whereas equity openness may provide insurance against domestic output risk, debt assets and liabilities may allow buffer lending and saving, respectively. This would also decrease the dependence of consumption on domestic output. The returns to debt assets are also state contingent since default may occur and because the returns to longer term debt assets may vary with a country's monetary policy. These considerations would lead to negative β_1, β_2. Since the mechanisms affecting the predictions for β_1 and β_2 are different, it appears necessary to allow separate terms for equity and debt openness. A number of previous studies have examined both equity and debt openness, but this is the first large scale study of which the author is aware which includes both variables simultaneously. Given the potential correlation in these explanatory variables, this would appear to be an important step. While high debt openness indicates access to international debt markets, low openness does not necessarily imply low access, but perhaps only low utilization, which would not rule out use of debt to buffer risk in bad times. Equity openness could also be an effective indicator of access to debt markets, which highlights the difficulty of separating the effects of debt and equity. These effects could confound the interpretation of the coefficients, and may help to explain the absence of support for risk sharing in previous studies.

2.3.1 Procyclical Financial Integration

Under perfect risk sharing, and abstracting from problems such as market frictions and non-traded goods, the expectation is for $(\beta_0 + \beta_1 eo_{it} + \beta_2 do_{it}) = 0$, implying that domestic consumption moves one for one with aggregate consumption. However the estimation of the risk sharing effects of financial openness may be subject to a number of biases. It is possible that debt and equity openness may appear to increase the dependence of domestic consumption on GDP. Suppose during some period GDP growth in excess of the long term rate (the constant should remove the long term rate from consumption growth) follows an autoregressive process. If not all consumers are forward looking, then comovement between consumption and GDP will increase during this period. More precisely, if GDP does not follow a random walk, so that $E[\Delta y_{it+1}|I_{it}]$ need not equal long term growth, where I_{it} is some information set, then in the presence of "rule of thumb" consumers

(consumers who are not forward looking, in other words whose consumption varies with income), it may be expected that comovement with domestic GDP increases during periods when growth exceeds long term trend growth, and vice versa. Equity and debt openness may also respond to such short or medium term trends, in other words $eo_{it} = e^{+}(E[\Delta\tilde{y}_{it}])$ and $do_{it} = d^{+}(E[\Delta\tilde{y}_{it}])$, where the tilde indicates the excess over the long term growth rate and E is the expectation operator. This could occur as companies seek funding for expansion during the boom, or in a similar fashion, consumers access debt markets to facilitate an increase in consumption. Under perfect risk sharing, consumption would remain steady during a period of strong output growth, unless consumers access debt markets in this way. These two mechanisms would lead to a positive association between comovement and financial asset openness, and hence positive β_1, β_2.

Kose et al (2007) note that financial flows may be procyclical, and suggest that this procyclicality could prevent consumption smoothing, presumably by the simple mechanism that there are less financial assets available for insurance when insurance is most needed. The concern here is rather with the potential bias caused by the procyclicality of both financial openness and domestic comovement. In previous studies the motivation for increased financial integration is unequivocally to engage in risk sharing. The use of international debt markets by consumers to procyclically increase consumption, or likewise increasing foreign investment during a domestic boom, have received little attention, and could significantly affect the risk sharing measure. If these alternative motivations for financial integration are important, it may be necessary to include a plurality of risk sharing measures and consider their joint significance.

2.3.2 Net Output

It seems plausible that net output (output net of government consumption and investment) is more appropriate than output in consumption risk sharing regressions, since consumers can only share the output remaining after government consumption and investment, as Obstfeld and Rogoff (2000) argue. Yakhin (2004) provides an alternative intuition: net exports can be thought of as a shock absorber for smoothing private consumption. Regressing consumption on consumption plus the shock absorber will give a measure of the degree of risk sharing. In order to facilitate comparison with the existing literature, which has primarily examined "gross output", this essay compares the results using the two measures.

2.3.3 The Idiosyncratic Variable Assumption

Supposing a negative β_1, β_2, Equation (2.3) assumes that, under risk sharing, financial openness increases dependence on aggregate GDP to the same extent to which it decreases dependence on domestic GDP. An alternative approach is to allow a varying effect:

$$\Delta c_{it} = \alpha_i + (\gamma_0 + \gamma_1 eo_{it} + \gamma_2 do_{it})\Delta y_{it} + (\beta_0 + \beta_1 eo_{it} + \beta_2 do_{it})\Delta y_{at} + \Gamma Z_{it} + \varepsilon_{it} \tag{2.4}$$

The main reason this may be of interest is if domestic and aggregate shocks are different in nature, aggregate shocks may for instance be more permanent (Sorensen et al, 2007). This would imply variation in the coefficients of aggregate and domestic output, making the assumption $(\gamma_0+\gamma_1 eo_{it}+\gamma_2 do_{it}) = -(\beta_0 + \beta_1 eo_{it} + \beta_2 do_{it})$ invalid.

There are other arguments in favour of the unconstrained equation. A period of high domestic macroeconomic volatility could affect both comovement with aggregate values and investment from abroad (financial integration), which would affect the measure of risk sharing. Two measures of the effect of financial integration would be needed to account for the two opposing effects (the effect of this procyclicality bias and the risk sharing effect). Secondly, consumers in an economy experiencing rapid growth may use debt markets to help smooth their consumption growth, potentially leading to higher debt market integration during a period of high comovement in domestic consumption and output. This would bias against finding risk sharing. A second risk sharing measure based on comovement with an aggregate variable would not suffer this bias.

It should be noted that an "adding up constraint" may apply to the coefficient of aggregate net output. As mentioned above, y_{at} and c_{at} both vary by country. The constraint can be expressed as $\sum_i \frac{\Delta c_{at}^i}{n} = \sum_i \frac{\Delta c_{it}}{n}$. A simple linear regression of consumption on aggregate consumption calculated in this way would be trivial, giving a coefficient of one. This constraint may also apply to some extent to aggregate net output, since aggregate net output is correlated with aggregate consumption. In interaction with aggregate variables, the financial openness variables still explain deviations from average comovement, but average comovement is constrained to be unity for OECD countries. The implications of this constraint are discussed in Section 2.13.

2.3.4 Other Explanatory Variables

The growth rate of the real exchange rate (Δr_{it}, the Purchasing Power Parity exchange rate) is incorporated to allow for the possibility (suggested by Giannone & Reichlin (2005) and Ravn (2001), among others) that consumption depends on the real exchange rate.

In the presence of risk sharing, consumption should be high in countries where prices are low. One model with this implication is that of Obstfeld and Rogoff (2000), where the first order condition

$$\frac{C_{it+1}^{-\rho}/P_{it+1}}{C_{it}^{-\rho}/P_{it}} = \frac{C_{at+1}^{-\rho}/P_{at+1}}{C_{at}^{-\rho}/P_{at}} \tag{2.5}$$

is derived, with ρ standing for the coefficient of relative risk aversion and P representing the price in a common currency. This condition becomes $\Delta c_{it} = \Delta c_{at} + \frac{1}{\rho}\Delta r_{it}$ when expressed in growth rates. Because of this relation the rate of growth of the real exchange rate is added linearly to the baseline regression equations.

In order to test whether consumption in more financially integrated economies shows stronger positive dependence on the growth in the real exchange rate, which would occur if international payments allow countries to take advantage of cheap prices, the coefficient of the growth in the real exchange rate is allowed to depend on financial openness. The risk sharing coefficients are also allowed to depend on the real exchange rate, as suggested by Sorensen in comments appended to Giannone & Reichlin (2005).

It may be the case that equity and debt provide alternative and not complementary methods of decoupling consumption from output. If a large portion of the returns to domestic output are claimed by foreign investors, the marginal risk sharing and buffering benefits of debt assets and liabilities may be less than for a country with low equity liabilities. Similarly, a country which can effectively buffer domestic risk may benefit less from equity portfolio diversification. For these reasons the interaction term $eo_{it}do_{it}(\Delta y_{it} - \Delta y_{at})$ is also examined in the empirical analysis. The specification is

$$\begin{aligned} \Delta c_{it} - \Delta c_{at} = \alpha_i + (\beta_0 + \beta_1 eo_{it} + \beta_1 do_{it} + \beta_3 eo_{it} do_{it})(\Delta y_{it} - \Delta y_{at}) \\ + \beta_3 eo_{it} + \beta_4 do_{it} + \beta_5 eo_{it} do_{it} + \Gamma Z_{it} + \varepsilon_{it}. \end{aligned} \tag{2.6}$$

It would be expected that this term would enter with a positive coefficient, decreasing the decoupling of consumption and net output caused by the risk sharing terms.

2.3.5 Control Variables

The following variables are included as controls:

1. The levels of the equity and debt openness to net GDP ratios are included since the interaction model would be misspecified in their absence, as explained in Brambor et al (2006), among others. These variables are included in all regressions, whereas the remaining two control variables are not.

2. The first lag of the dependent variable is included to control for the possible effects of habit formation, as Fuhrer and Klein (2006) show that such a habit process could by itself lead to consumption correlation.

3. Trade openness is included individually and in interaction with net output as it could be a predictor of a country's ability to buffer and smooth against output fluctuations, to the extent

that it proxies for a country's creditworthiness. A country that is highly integrated into the world goods market may find it easier to adjust its balance of payments to allow it to borrow in order to stabilise consumption in the face of a domestic output shock. Thus a finding that trade openness leads to decreased dependence on domestic GDP could be partly due to the use of international financial markets to buffer or hedge domestic risk.

2.4 Data Sources and Empirical Methodology

This essay follows Kose et al (2007) in dividing the period 1970-2004 into 1970-1986 and 1987-2004 (period of high financial integration). The models are estimated via OLS regression. Aggregate values are calculated over the (rest-of-)OECD21.

2.4.1 Data Sources

- *International Price Data:* Consumption, investment, output and the purchasing power parity exchange rate (the real exchange rate) are taken from the Penn World Tables 6.2 (Heston et al, 2006).
- *CPI Deflated Data:* Current price output, consumption (household consumption), investment (gross fixed capital formation), government consumption, imports and exports are taken from UNSTATS (2007). Consumption and (net) output are made per capita using population data from Penn World Tables 6.2, then deflated to 2000 prices using national consumer price indices, taken from the IMF's International Financial Statistics, then converted to dollars using the 2000 purchasing power parity exchange rate, taken from the Penn World Tables 6.2. This approach follows Sorensen et al (2007). Trade openness is calculated as the sum of imports and exports of goods and services divided by GDP, taken from UNSTATS.
- *Financial Data:* Data on financial openness are taken from Lane and Milesi-Ferretti's (2007) External Wealth of Nations II (EWN) dataset. Financial openness ratios are calculated based on GDP from the EWN, which is taken from the World Bank's World Development Indicators, rather than UNSTATS. The financial openness data refer to end of year values and so have been lagged by one year. The t subscript in these variables refers to the end of year $t-1$ value, which is appropriate for measuring risk sharing in year t. The financial openness variables have been centered by subtracting their mean values over the relevant samples (e.g. Non-OECD 1987-2004).

Aggregate values of consumption and output are calculated by summing over all OECD countries for non-OECD countries and all other OECD countries for OECD countries, then dividing by total (remaining) OECD population.

2.4.2 Price Deflators

Sorensen and Yosha (2002) argue for the use of the CPI to deflate not only consumption but also output. Deflating output by the output deflator would eliminate changes in the purchasing power of output in terms of consumption goods. This is undesirable since the possible response of consumption to such changes is of interest here. The disadvantage of this approach is that it does not allow for adjustment to an output shock via a change in the internal terms of trade, in other words diverging consumer and producer prices (Hoffmann, 2007). Not allowing for this channel could lead to an artificially high observed dependence of consumption on output.

Hoffmann (2007) points out that the use of an idiosyncratic price series as the deflator may be inappropriate as it fails to account for international price differentials. The author observes that regional risk sharing studies generally deflate consumption and output by a common (national) consumption price deflator, whereas international studies generally deflate the series using an idiosyncratic (also national) price deflator. The first type of regression examines comovement in the values of the series, the second in the quantities. There are arguments in favour of each approach. Deflating by idiosyncratic prices fails to account for the possibility that comovement in idiosyncratic price deflated data could be due to the existence of international price differentials, and not the absence of risk sharing (and vice versa). On the other hand, deflating by a common price series may retain national price differentials that affect the degree of comovement but are not caused by and do not facilitate risk sharing. Hoffmann runs a regression using aggregate prices as the deflator, and finds that the results are closer to those seen among regional regressions.

To control for the above considerations, the analysis is run on data from the Penn World Tables 6.2, which uses aggregate price series, as well as national CPI deflated data. The real exchange rate is also added as a control.

2.5 Empirical Results

Table 2.3 shows strong evidence that financial openness leads to risk sharing as measured by the comovement of consumption and net GDP (GDP net of government consumption and investment) in the period 1987-2004 for both OECD and Non-OECD countries. The four financial openness related variables are jointly significant at the 1% level for both samples over the later period.

The findings are presented according to sample. The 21 country subsample of OECD countries are referred to as "the OECD countries". "Non-OECD" refers to the sample excluding the Persian Gulf countries and Overseas Financial Centres. The countries comprising the samples analyzed here are listed in Section 2.7.

Figure 2.2 shows the coefficient of idiosyncratic net GDP from Regression 1:

$$\Delta c_{it} - \Delta c_{at} = \alpha_i + (\beta_0 + \beta_1 eo_{it} + \beta_2 do_{it})(\Delta y_{it} - \Delta y_{at}) + \beta_3 eo_{it} + \beta_4 do_{it} + \Gamma Z_{it} + \varepsilon_{it} \quad (2.7)$$

The values shown are $\beta_0 + \beta_1 eo_{it} + \beta_2 do_{it}$ for levels of equity openness between 200% of GDP below and above the average level, and for debt openness equal to the average (the dark line) and to 100% of GDP above the average (the blue/lightly shaded line) over the relevant sample. Under perfect risk sharing, the coefficient should be zero. Under no risk sharing (or buffering), it should be one. The graphs also show confidence intervals of the coefficients. These are equal to plus or minus twice the standard error of the coefficient, calculated as the square root of:

$$\begin{aligned} var(\beta_0 + \beta_1 eo_{it} + \beta_2 do_{it}) = var(\beta_0) + eo_{it}^2 var(\beta_1) + do_{it}^2 var(\beta_2) + \\ 2eo_{it} cov(\beta_0\beta_1) + 2do_{it} cov(\beta_0\beta_2) + 2eo_{it} do_{it} cov(\beta_1\beta_2). \end{aligned} \quad (2.8)$$

This method of analysis follows the suggestions of Brambor et al (2006).

Where the growth rate of the real exchange rate is significant the sign of the estimated coefficient is negative. An increase in the domestic price level relative to the US level will, ceteris paribus, decrease R_{it}.[1] Inflation thus appears to be associated with increasing consumption. This result may be driven by the nominal exchange rate. An increase in the nominal exchange rate could lead to higher import prices, which could affect consumption. Interaction variables involving the real exchange rate ($eo_{it}R_{it}$ and $do_{it}R_{it}$) may be of greater interest. Under risk sharing, higher domestic prices should lead to lower consumption, since the marginal benefit of a dollar of consumption is higher in a country with cheaper prices. These interaction variables are discussed under the heading Non-OECD countries, 1987-2003.

20 OECD countries, 1973-1986

As seen in Figure 2.2, for most values of equity and debt openness, the 95% confidence intervals of the estimated coefficient encompass the x-axis. It may be that the biases discussed in Section 2.3.1 or the lower degree of financial integration over this period make risk sharing difficult to detect.

21 OECD countries, 1987-2004

The coefficient of equity openness in Column 2 of Table 2.3 implies that an increase in equity openness equal to 100% of GDP with no accompanying change in debt openness would lead to a 96% decrease in the dependence of idiosyncratic consumption on idiosyncratic GDP. This is a

[1] The purchasing power parity exchange rate is taken as the measure of the real exchange rate (RER). The definition of RER used is $R_{it} = e_{it}\frac{p_{USt}}{p_{it}}$, where e_{it} is the number of foreign currency units per dollar, p_{USt} is the dollar price level and p_{it} is the foreign price level.

larger effect than is usually found in the literature. Kose et al (2007) find that an increase in equity openness equal to 100% of GDP would decrease the dependence of idiosyncratic consumption on idiosyncratic gross output by only 12%, although Sorensen et al (2006) find a much larger effect of equity home bias on consumption risk sharing. Their results suggest that a 100% decrease in equity home bias would lead to a greater than proportionate increase in consumption risk sharing. The authors note, however, that the equity home bias coefficient they find may not be applicable to such a large change. The debt coefficient implies that the same increase in debt openness would lead to a 59% increase in the dependence of idiosyncratic consumption on idiosyncratic GDP. It should be borne in mind that equity and debt openness are correlated, so that a large increase in one while the other remains constant may be unlikely.

The debt effect is dependent on Ireland's inclusion in the sample. This appears to support the view advanced in Section 2.3.1 above, that consumers may access international debt markets to increase the cyclicality of consumption expenditure during a boom. In view of the high level of Irish equity liabilities (FDI liabilities averaged 63% of GDP over 1987-2004), the rapid growth in Ireland's GDP in the late nineties should have been shared with other countries. The results suggest this did occur, but instead of consumption growing slowly along with aggregate consumption, which is the prediction in classical risk sharing models, Irish consumers used debt markets to increase consumption along with GDP.

Figure 2.2 shows the strong risk sharing effect of equity openness, as predicted by theory. Debt shows an opposing effect. The implications for individual countries in the year 2003 are presented in Table 2.11 and Figure 2.3.

35 Non-OECD Countries, 1971-1986

Figure 2.2 shows that, as in the OECD sample, over the earlier period the confidence intervals of the coefficient encompass the x-axis, regardless of the equity and debt openness values considered. No evidence of risk sharing is found. This is not surprising given the relatively low levels of financial integration during this period (2.2).

49 Non-OECD Countries, 1987-2003

Figure 2.2 shows a strong risk sharing effect of equity openness, similar to that found for the OECD countries over the same period. This is consistent with theory but contrasts with the findings of previous studies. The debt effect is insignificant, possibly due to the various roles debt plays in this sample of countries, as financing expansion during good times, as facilitating buffer saving and lending, and as foreign aid – however the debt effect is significant and procyclical (as in the OECD case), when regressions are run on CPI deflated data (Table 2.4). The implications of these findings for individual countries in 2003 are reported in Table 2.12.

Table 2.5 presents the results from the regression including control variables and with financial integration variables broken down by type (FDI vs portfolio equity vs debt) and direction of the investment (assets vs liabilities). The risk sharing finding appears robust to the inclusion of the lagged dependent variable, trade openness (*co*) and the real exchange rate, as well as interaction terms with the latter two variables. The negative and significant coefficient of the trade openness interaction variable, which implies that increasing goods market integration decreases dependence of consumption on domestic output, could occur because goods market integration is an indicator of access to debt markets. Access to debt markets could be a better indicator of a country's ability to smooth consumption than actual use of debt markets (*do*). The correlation between trade and debt openness for this sample is .17 (p-value$<$ .01).

A possible interpretation of the $do_{it}\Delta r_{it}(\Delta ny_{it} - \Delta ny_{at})$ coefficient is that debt market integration mitigates the effect of a rise in domestic prices on the dependence of consumption on output. This is in line with the predictions of risk sharing models.

The results from a breakdown of financial integration variables are broadly in line with expectations, with FDI liabilities proving to be the main driver of consumption risk sharing. The coefficient of the FDI assets variable (significant only at the 10% level) is difficult to interpret. The high FDI assets coefficient is dependent on the inclusion of Malaysia. Removing one by one the insignificant terms leads to a more parsimonious model, shown in the final column.

Figure 2.1 shows why Malaysia exerts an influence on the coefficient of the FDI assets interaction variable. The large swings in financial integration and macroeconomic variables during the Asian financial crisis are responsible. The influence of this outlier suggests that sample error may have considerable effects on risk sharing estimates, and may help to explain the lack of empirical evidence for consumption risk sharing. Table 2.6 shows the equity openness coefficient and its t-statistic from the regression using international price data (corresponding to the coefficient of -.33 reported in Table 2.3, final Column), when each country in the sample is individually excluded. The only country exerting a significant influence on this coefficient is Chad, although the two risk sharing variables remain jointly significant with a p-value of .03 (.01 for gross GDP) on Chad's exclusion.

The subsequent tables and figures investigate a number of potential explanations for the lack of evidence in previous studies of risk sharing by emerging and developing countries.

GDP Gross of Investment and Government Consumption

Most empirical risk sharing studies consider GDP, instead of GDP net of investment and government consumption. The results of regressions using "Gross GDP" are presented in Tables 2.7 and 2.8. Table 2.7 finds evidence of risk sharing by Non-OECD countries only at the 10% level. Small sample errors could easily have reduced this significance level further. As can be seen in Table 2.8, the inclusion of the control variables discussed in Section 2.3.5 raises the significance of the equity openness interaction variable to the 1% level. This is due to the real exchange rate interaction variables. This may provide evidence that risk sharing is dependent on price movements, with greater risk sharing being seen when a country's price level increases. The explicit analysis of the financial integration variables expected to provide most efficient risk sharing and smoothing, FDI and debt liabilities, is also sufficient to increase the significance of risk sharing to the 5% level. The four financial variables in the final column of Table 2.8 are jointly significant at the 1% level, again underlining the correlation in the variables and the distinct motivations for different kinds of financial integration.

Persian Gulf States and Overseas Financial Centres

Over the period 1971-86 the debt openness interaction variable appears significant (Table 2.10) and consistent with buffering of output risk, but enters with a very small magnitude (the lines for the coefficients under average and 100% of GDP above average values of debt openness are indistinguishable in Figure 2.2). Cross-border financial openness does not appear to have facilitated risk sharing over the period 1987-2003.

The estimation of cross-border financial openness in these countries may be subject to greater measurement error than is associated with the other two samples studied. The confidence intervals in Figure 2.2 quickly blow up in the earlier panel, while in the later panel the resource coefficient as a function of equity openness is essentially a straight line.

2.5.1 CPI-Deflated Data

The results using CPI-deflated data (Table 2.4) are similar to those using the PWT data, however the CPI-deflated data show evidence of debt being used to buffer risk by non-OECD countries over 1971-86 and of debt increasing consumption dependence on net GDP among the same countries over 1987-2004, similar to the effect seen among OECD countries over this period. This supports the argument that consumers may use international debt markets to increase consumption when GDP is rising, leading to a positive coefficient for the debt interaction variable. This opposes the prediction in classical risk sharing models, and may help to explain the lack of empirical evidence for risk sharing, particularly by Non-OECD countries.

The results for Overseas Financial Centres and Gulf States using CPI-deflated data (not shown) are very similar to those using the PWT data.

2.5.2 Regression (2): Equity/Debt Interaction

Allowing the risk sharing effect of equity openness to depend on the level of debt openness (this variable could also be interpreted as the converse):

$$\begin{aligned}\Delta c_{it} - \Delta c_{at} = \alpha_i + (\beta_0 + \beta_1 eo_{it} + \beta_1 do_{it} + \beta_3 eo_{it} do_{it})(\Delta y_{it} - \Delta y_{at}) \\ + \beta_3 eo_{it} + \beta_4 do_{it} + \beta_5 eo_{it} do_{it} + \Gamma Z_{it} + \varepsilon_{it}\end{aligned} \tag{2.9}$$

does not appear to offer further insights into consumption risk sharing. The debt/equity interaction term is not significant using international price data.

2.5.3 Regression (3): Non-Idiosyncratic Variables

This regression relaxes the assumption of an equal and opposite effect of financial openness on the dependence of consumption on domestic and aggregate GDP:

$$\begin{aligned}\Delta c_{it} = \alpha_i + (\gamma_0 + \gamma_1 eo_{it} + \gamma_2 do_{it})\Delta y_{it} + (\beta_0 + \beta_1 eo_{it} + \beta_2 do_{it})\Delta y_{at} \\ + \beta_3 eo_{it} + \beta_4 do_{it} + \Gamma Z_{it} + \varepsilon_{it}\end{aligned} \tag{2.10}$$

The results are shown in Table 2.9 for the OECD sample over the later period. The assumption that financial openness increases the dependence on aggregate GDP to the same extent to which it decreases dependence on domestic GDP is formally rejected, however it does not interfere significantly with the results. The assumption that the aggregate resource movements are always reflected in the domestic resource movements is not supported, but empirically is of little concern, at least for the present samples. The similarity of the results with and without subtracting aggregate values from domestic values reflects the fact that the aggregate series are more stable than the domestic series. The majority of the variation in the data comes from the domestic series.

For Non-OECD countries over the later period, none of the aggregate variables are significant. The domestic variables (including the risk sharing interaction variables) are unaffected. The correlations of domestic net GDP and consumption with their aggregate counterparts are low and insignificant for this sample. Figure 2.4 shows that among non-OECD countries financial integration is concentrated on the liability side, which would not give domestic investors claims on aggregate net output (the graph shows average (uncentred) debt openness, but the same pattern is seen in equity openness). This may help to explain the fact that aggregate net output is not a significant predictor of domestic consumption for non-OECD countries.

2.5.4 Robustness

All regressions are based on the OLS estimator with country fixed effects and robust standard errors. Although the financial openness variables appear to have unit roots, the errors from the regressions are stationary.[2] All standard errors are robust to clustering of errors within countries (following Kose et al, 2006).

The risk sharing findings are not affected by the introduction of the lagged dependent variable, lagged trade openness (both separately and in interaction with idiosyncratic GDP), real exchange rate interaction variables or (in the case idiosyncratic variable regressions) year dummy variables (for Non-OECD countries over the later sample, the inclusion of year dummies raises the p-value of the equity interaction variables to .046. The four financial variables remain jointly significant at the 1% level). The lagged dependent variable is significant only in the OECD sample, where it alters the coefficients of significant variables very little. Including it leads to a higher dependence of consumption on net output in the steady state, but very nearly the same relative effect of equity and debt openness (since their coefficients and those of net output are inflated by the same factor), which are the variables of primary interest in this study.

The results are generally unaffected by the exclusion of individual countries, as discussed in the section for the relevant sample. The exclusion of Ireland renders the debt interaction variable marginally insignificant, but does not affect the significance or magnitude of the equity interaction variable. Excluding Chad weakens but does not remove the finding of risk sharing by Non-OECD countries.

2.6 Summary

Integration into the international equity and debt markets facilitated consumption risk sharing by both OECD and non-OECD countries over the period 1987-2003/4. The finding that non-OECD countries use financial markets for risk sharing runs counter to previous empirical findings, and may have significant policy implications for countries considering their level of engagement in financial trade. The findings are robust to the data source, the method used to deflate current price series, outliers and a number of control variables.

The implication drawn from classical risk sharing models regarding financial integration is that it should unilaterally decrease consumers' dependence on domestic output. In contrast, evidence is presented that debt market access may be used by consumers to increase consumption pro-

[2]Referring to the results for the OECD, 1987-2004, and PWT data, the panel unit root test of Levin, Lin and Chu (2002) rejects the null of non stationarity under any plausible specification, for example with two lags and trend the t-star statistic is -7.19. The test of Im et al (2003) also strongly rejects the null hypothesis that all series are non-stationary, with a W[t-bar] statistic of -2.72 allowing two lags in the residual from the error process. The residuals from other regressions are similarly stationary, details are not reported.

cyclically. These contrasting effects of financial integration necessitate the use of a general risk sharing framework which allows for a multilateral effect of financial integration on consumption. It appears that the real exchange rate may also play a role in risk sharing for non-OECD countries. The risk sharing effect of financial integration is robust to the possibility of both international and internal (consumer vs producer) price differentials facilitating a smoothing of consumption in the face of output shocks.

Output net of investment and government consumption appears to be a more appropriate measure of resources available for consumption than output. Risk sharing by non-OECD countries can still be found when examining consumption dependence on output, but greater care is needed regarding control variables, the measure of financial integration, and the joint testing for multitudinous and contrasting (possibly offsetting) effects of integration, which include but are not limited to risk sharing.

The assumption, frequently maintained in the literature, that shocks to aggregate and domestic output elicit the same response from consumers is formally rejected for OECD countries over the period 1987-2004, although relaxing this assumption does not materially affect the measure of risk sharing. This may occur because of different levels of persistence in aggregate and domestic shocks. Aggregate variables (based on a subset of OECD countries) show no relation to domestic variables for non-OECD countries. This suggests the possibility of a market for trading aggregate risk, which is generally assumed to be uninsurable in the literature. Examining the nature of the macroeconomic risk that is common across non-OECD countries, if such risk exists, could shed further light on risk sharing by these countries.

2.7 Country Samples

2.7.1 21 Country OECD Sample

This sample of wealthy countries is the same as that used in Kose et al (2003).

Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Ireland (IRL), Italy (ITA), Japan (JPN), Netherlands (NLD), New Zealand (NZL), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), United Kingdom (GBR), and United States (USA).

For regressions over the period 1973-86, Greece is excluded due to missing equity data.

2.7.2 49 Country Non-OECD Sample

This sample includes all Non-OECD21 countries for which all data (from both the Penn World Tables 6.2 and the CPI deflated data) were available for all years from 1987-2003 (inclusive), excluding Persian Gulf states and countries that are designated by the IMF as Overseas Financial Centres.

Argentina (ARG), Burkina Faso (BFA), Bangladesh (BGD), Bolivia (BOL), Botswana (BWA), Chile (CHL), Cote d'Ivoire (CIV), Cameroon (CMR), Colombia (COL), Dominican Republic (DOM), Algeria (DZA), Ecuador (ECU), Egypt (EGY), Ethiopia (ETH), Gabon (GAB), Ghana (GHA), Guatemala (GTM), Honduras (HND), Hungary (HUN), Indonesia (IDN), India (IND), Iceland (ISL), Jamaica (JAM), Jordan (JOR), Kenya (KEN), Korea (KOR), Sri Lanka (LKA), Madagascar (MDG), Mexico (MEX), Malaysia (MYS), Nigeria (NGA), Nepal (NPL), Pakistan (PAK), Papua New Guinea (PNG), Poland (POL), Paraguay (PRY), Senegal (SEN), El Salvador (SLV), Swaziland (SWZ), Chad (TCD), Togo (TGO), Trinidad and Tobago (TTO), Tunisia (TUN), Turkey (TUR), Tanzania (TZA), Uganda (UGA), Venezuela, Rep. Bol. (VEN), South Africa (ZAF), Zambia (ZMB).

2.7.3 35 Country Non-OECD Sample

This sample includes all Non-OECD21 countries for which all data (from both the Penn World Tables 6.2 and the CPI deflated data) were available for all years from 1971-1986 (inclusive), excluding Persian Gulf states and countries that are designated by the IMF as Overseas Financial Centres.

Chile (CHL), Cote d'Ivoire (CIV), Cameroon (CMR), Colombia (COL), Dominican Republic (DOM), Algeria (DZA), Ecuador (ECU), Egypt (EGY), Ethiopia (ETH), Gabon (GAB), Ghana (GHA), Guatemala (GTM), Honduras (HND), India (IND), Iceland (ISL), Jamaica (JAM), Jordan (JOR), Kenya (KEN), Korea (KOR), Sri Lanka (LKA), Madagascar (MDG), Malaysia (MYS), Nigeria (NGA), Nepal (NPL), Pakistan (PAK), Paraguay (PRY), Senegal (SEN), El Salvador (SLV), Swaziland (SWZ), Togo (TGO), Trinidad and Tobago (TTO), Turkey (TUR), Tanzania (TZA), Venezuela, Rep. Bol. (VEN), South Africa (ZAF).

2.7.4 Persian Gulf States and Overseas Financial Centres

This sample is not exclusive of countries in the other two samples. It consists of all Persian Gulf states and countries that are designated by the IMF as Overseas Financial Centres for which all data were available over the relevant period. The 1987-2003 balanced sample consists of: Bahrain (BHR), Switzerland (CHE), Costa Rica (CRI), Cyprus (CYP), Hong Kong S.A.R. of China (HKG), Israel (ISR), Japan (JPN), Mauritius (MUS), Panama (PAN), Philippines (PHL), Qatar (QAT), Saudi Arabia (SAU), Singapore (SGP), Thailand (THA), Uruguay (URY).

The balanced sample from 1971-1986 consists of: Bahrain (BHR), Switzerland (CHE), Costa Rica (CRI), Israel (ISR), Japan (JPN), Mauritius (MUS), Singapore (SGP), Thailand (THA).

2.7.5 Average Financial Openness Values

	Observations	Equity Avg.	Debt Avg.
OECD 1973-86	336	0.19	0.66
OECD 1987-2004	378	0.82	1.57
Non-OECD 1971-1986	1664	0.12	0.46
Non-OECD 1987-2003	1872	0.25	0.93
OFCs and Gulf States 1971-1986	352	0.18	2.18
OFCs and Gulf States 1987-2003	396	1.79	4.13

Table 2.2: Average equity and debt to GDP ratios by sample. These values were subtracted from equity and debt to GDP ratios in order to aid the interpretation of the regression coefficients.

2.8 Consumption Regressions on GDP (Net of Investment and Government Consumption)

International Price Data

Dependent Variable: $\Delta c_{it} - \Delta c_{at}$	OECD21 1973-1986	1987-2004	Non OECD21 1971-1986	1987-2003
$\Delta ny_{it} - \Delta ny_{at}$	0.258**	0.309***	0.134***	0.220***
	(0.089)	*(0.062)*	*(0.048)*	*(0.080)*
$eo_{it}(\Delta ny_{it} - \Delta ny_{at})$	0.439	-0.298***	0.295	-0.328**
	(0.508)	*(0.102)*	*(0.198)*	*(0.137)*
$do_{it}(\Delta ny_{it} - \Delta ny_{at})$	0.069	0.183***	-0.168	0.026
	(0.126)	*(0.050)*	*(0.185)*	*(0.149)*
eo_{it}	0.016	0.008***	0.008	0.004
	(0.028)	*(0.003)*	*(0.056)*	*(0.021)*
do_{it}	-0.007	-0.006**	-0.030**	0.025***
	(0.005)	*(0.002)*	*(0.014)*	*(0.008)*
Δr_{it}	-0.134**	0.000	-0.104***	-0.047**
	(0.054)	*(0.001)*	*(0.021)*	*(0.022)*
N	285	378	525	833
R^2	0.11	0.16	0.11	0.11

Table 2.3: The estimated coefficients are based on OLS regressions with country fixed effects. Δny_{it} stands for the growth rate of output net of government consumption expenditure and fixed investment. The a subscript indicates aggregate, calculated over the (rest of) OECD 21 country sample. do_{it} and eo_{it} stand for equity and debt assets plus liabilities as percentages of GDP. To avoid endogeneity bias these variables have been lagged, so that the t subscript indicates the end-of-year $t-1$ value, appropriate for measuring risk sharing in year t. Δr_{it} stands for the growth rate of the real exchange rate. ***, ** and * indicate 1%, 5% and 10% significance, respectively. Robust standard errors are in parentheses. All panels are balanced. It appears that equity market integration facilitates consumption risk sharing by both OECD and non-OECD countries over the later panels. The robustness of this result for the non-OECD sample is explored in subsequent tables. The debt market integration coefficient for the OECD sample over the period 1987-2004 is positive, opposite to the predictions of classical risk sharing models. The explanation proposed for this finding is that consumers use access to debt markets to increase consumption during a period of output growth, thus increasing both financial integration and the comovement of consumption and output. This finding is present also for non-OECD countries when CPI deflated data are considered (Table 2.4).
For the OECD 1973-87 sample, the four financial openness related variables are jointly significant with a p-value of 0.053. The same test for the non-OECD countries over 1971-86 gives a p-value of 0.12. This suggests that over the earlier samples there may be some relationship between consumption risk sharing and financial openness which is obscured by the high collinearity among the variables, however a graphical analysis of the GDP coefficient as a function of financial openness revealed no support for this possibility.

National Price (CPI) Deflated Data

Dependent Variable: $\Delta c_{it} - \Delta c_{at}$	OECD21 1973-1986	1987-2004	Non OECD21 1971-1986	1987-2003
$\Delta ny_{it} - \Delta ny_{at}$	0.232***	0.290***	0.336**	0.413***
	(0.072)	*(0.059)*	*(0.122)*	*(0.120)*
$eo_{it}(\Delta ny_{it} - \Delta ny_{at})$	0.615	-0.316**	-0.187	-0.829**
	(0.401)	*(0.132)*	*(0.421)*	*(0.386)*
$do_{it}(\Delta ny_{it} - \Delta ny_{at})$	-0.305	0.210**	-0.455*	0.371***
	(0.203)	*(0.079)*	*(0.225)*	*(0.079)*
eo_{it}	-0.027	0.011***	-0.046	0.008
	(0.023)	*(0.003)*	*(0.069)*	*(0.024)*
do_{it}	-0.007	-0.008***	-0.058**	0.014
	(0.006)	*(0.002)*	*(0.022)*	*(0.011)*
Δr_{it}	-0.137**	0.001	-0.005	-0.003
	(0.060)	*(0.001)*	*(0.041)*	*(0.018)*
N	285	378	525	833
R^2	0.15	0.24	0.32	0.30

Table 2.4: The results for CPI-deflated data are similar to those using PWT data (Table 2.3), except for the coefficient of debt openness for Non-OECD countries over the later period. This coefficient is positive, in contrast to the predictions of classical risk sharing models. This appears to support the contention that consumers access debt markets to increase consumption during a boom, increasing the cyclicality of consumption and negating the effects of risk sharing. The same effect is seen among OECD countries, both here and in the results using international price data. Allowing more than one channel for the impact of financial integration on consumption appears to be necessary for an accurate assessment of this impact.
***, ** and * indicate 1%, 5% and 10% significance, respectively. All panels are balanced.

Control Variables and Financial Integration Breakdown, Non-OECD21 1987-2003

Dependent Variable:	$\Delta c_{it} - \Delta c_{at}$			
Controls		Breakdown		
$\Delta c_{i,t-1} - \Delta c_{a,t-1}$	0.002	$\Delta ny_{it} - \Delta ny_{at}$	0.370**	0.282**
	(0.038)		*(0.175)*	*(0.110)*
$\Delta ny_{it} - \Delta ny_{at}$	0.519***	$fdili_{it}(\Delta ny_{it} - \Delta ny_{at})$	-0.238*	-0.326**
	(0.119)		*(0.125)*	*(0.129)*
$eo_{it}(\Delta ny_{it} - \Delta ny_{at})$	-0.361***	$fdias_{it}(\Delta ny_{it} - \Delta ny_{at})$	-3.645*	
	(0.086)		*(1.984)*	
$do_{it}(\Delta ny_{it} - \Delta ny_{at})$	-0.072	$peqli_{it}(\Delta ny_{it} - \Delta ny_{at})$	0.270	
	(0.098)		*(2.742)*	
$eo_{it}\Delta r_{it}(\Delta ny_{it} - \Delta ny_{at})$	-1.336	$peqas_{it}(\Delta ny_{it} - \Delta ny_{at})$	-3.592	
	(1.665)		*(3.214)*	
$do_{it}\Delta r_{it}(\Delta ny_{it} - \Delta ny_{at})$	0.927***	$debtli_{it}(\Delta ny_{it} - \Delta ny_{at})$	-0.079	
	(0.283)		*(0.188)*	
$co_{it}(\Delta ny_{it} - \Delta ny_{at})$	-0.309***	$debtas_{it}(\Delta ny_{it} - \Delta ny_{at})$	0.556	
	(0.094)		*(0.532)*	
eo_{it}	-0.004	$fdili_{it}$	-0.009	0.011
	(0.094)		*(0.532)*	*(0.034)*
do_{it}	0.017**	$fdias_{it}$	0.006	
	(0.094)		*(0.532)*	
co_{it}	0.028	$peqli_{it}$	0.059	
	(0.094)		*(0.532)*	
$eo_{it}\Delta r_{it}$	-0.341**	$peqas_{it}$	-0.080	
	(0.094)		*(0.532)*	
$do_{it}\Delta r_{it}$	0.048	$debtli_{it}$	0.022*	
	(0.094)		*(0.532)*	
		$debtas_{it}$	0.050	
			(0.532)	
Δr_{it}	-0.079**		-0.044**	-0.045**
	(0.094)		*(0.532)*	*(0.021)*
Cons	-0.018		-0.022**	-0.004
	(0.094)		*(0.532)*	*(0.007)*
N	833		833	833
R^2	0.18		0.13	0.1

Table 2.5: The risk sharing finding appears robust to the inclusion of the lagged dependent variable, trade openness (co) and the real exchange rate, as well as interaction terms with the latter two variables. Removing one by one the insignificant control variables does not affect the significance of the equity openness interaction coefficient. A possible interpretation of the $do_{it}\Delta r_{it}(\Delta ny_{it} - \Delta ny_{at})$ coefficient is that debt market integration mitigates the effect of a rise in domestic prices on the dependence of consumption on output. The results from a breakdown of financial integration variables are broadly in line with expectations. FDI liabilities provide the main driver of consumption risk sharing. The coefficient of the FDI assets variable is difficult to interpret. This variable is significant only at the 10% level. The high FDI assets coefficient is dependent on the inclusion of Malaysia. Removing one by one the insignificant terms leads to a more parsimonious model, shown in the final column.

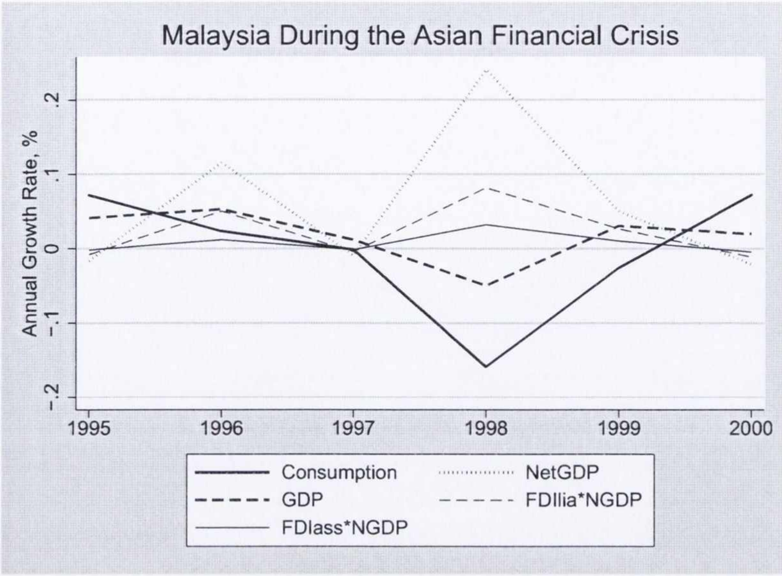

Figure 2.1: Malaysian Consumption, GDP, Net GDP, FDI assets*Net GDP and FDI liabilities*Net GDP. This graph explains the significance and anomalously large coefficient of the FDI assets interaction variable in Table 2.5. In 1998, Net GDP rose sharply due to the precipitous decline in investment. Gross GDP and consumption both fell. The FDI assets interaction variable is not significant in the regressions using Gross GDP (Table 2.7 below). Since investment is forward looking, it contains information about the persistence of shocks. Subtracting it from GDP may isolate a transitory component of output. This would argue for the use of gross GDP when risk sharing of permanent shocks is the variable of interest. The author is grateful to an anonymous referee for making this point. It is clear from the graph, however, that this effect of identifying a temporary component is swamped in the case of Malaysia during the Asian Financial Crisis by the magnitude of the fall in investment. In this case the subtraction of investment does not decrease the absolute magnitude of the change in output (thus isolating a component of it), but in fact reverses the fall. Using gross GDP may be counterintuitive, since money invested is not available for consumption, however this graph suggests that it might also be less affected by outliers. Regressions using Gross GDP are presented in Section 2.9.

The Equity Openness Coefficient for Non-OECD 21, 1987-2003 Excluding Individual Countries

Country	t-stat	EO coeff	EO average	Country	t-stat	EO coeff	EO average
Ethiopia	-2.61	-0.21	-0.15	Honduras	-2.37	-0.33	-0.05
Malaysia	-2.47	-0.33	0.44	South Africa	-2.37	-0.33	0.26
Senegal	-2.46	-0.34	-0.08	Trinidad & Tobago	-2.37	-0.34	0.6
Zambia	-2.46	-0.35	0.2	El Salvador	-2.37	-0.33	-0.11
Ghana	-2.45	-0.34	-0.03	Sri Lanka	-2.36	-0.33	-0.14
Ecuador	-2.45	-0.34	-0.02	Togo	-2.36	-0.33	0.1
Gabon	-2.43	-0.33	0.02	Kenya	-2.36	-0.32	-0.13
Nigeria	-2.42	-0.33	0.28	Algeria	-2.36	-0.33	-0.18
Swaziland	-2.42	-0.33	0.31	Botswana	-2.35	-0.35	0.13
Colombia	-2.42	-0.33	-0.09	Bangladesh	-2.35	-0.32	-0.22
Korea, Republic of	-2.42	-0.33	-0.12	Turkey	-2.35	-0.32	-0.18
Bolivia	-2.42	-0.33	0.04	Madagascar	-2.34	-0.32	-0.19
Chile	-2.41	-0.33	0.28	Papua New Guinea	-2.34	-0.33	0.26
Indonesia	-2.41	-0.33	-0.14	Pakistan	-2.34	-0.32	-0.17
Tunisia	-2.40	-0.33	0.36	Cote dIvoire	-2.34	-0.32	-0.06
Venezuela	-2.39	-0.33	-0.01	Nepal	-2.34	-0.33	-0.23
Iceland	-2.39	-0.33	-0.09	Dominican Republic	-2.33	-0.32	-0.03
Guatemala	-2.39	-0.33	-0.08	Hungary	-2.30	-0.32	0.03
Paraguay	-2.39	-0.33	-0.12	Jordan	-2.29	-0.33	-0.11
Jamaica	-2.39	-0.33	0.33	Uganda	-2.28	-0.32	-0.16
Tanzania	-2.38	-0.33	-0.16	Cameroon	-2.26	-0.31	-0.09
Mexico	-2.38	-0.33	-0.02	Argentina	-2.21	-0.3	-0.02
Poland	-2.38	-0.33	-0.15	Burkina Faso	-2.18	-0.32	-0.21
India	-2.38	-0.33	-0.19	Chad	-1.44	-0.37	0.08
Egypt	-2.38	-0.33	-0.03				

Table 2.6: The coefficient presented here is the equity openness coefficient from the regression presented in Table 2.3, Column 4, with each country in the sample excluded individually as a robustness test. The values for the full sample are coefficient -0.33, t-stat -2.40. Only Chad's exclusion affects the significance level, although the two risk sharing variables remain jointly significant with a p-value of .03 (.01 for gross GDP) on Chad's exclusion. The "average openness" column shows the average equity openness measure (assets plus liabilities) for that country over the period 1987-2003. The unit is percent of GDP and the average for all Non-OECD21 countries over this period has been subtracted.

2.9 Consumption Regressions on GDP (Gross of Investment and Government Consumption)

Consumption Regressed on GDP (Gross of Investment and Government Consumption)

Dependent Variable: $\Delta c_{it} - \Delta c_{at}$	OECD21 1971-1986	1987-2004	Non OECD21 1971-1986	1987-2003
$\Delta y_{it} - \Delta y_{at}$	0.706***	0.628***	0.475***	0.675***
	(0.039)	*(0.051)*	*(0.097)*	*(0.079)*
$eo_{it}(\Delta y_{it} - \Delta y_{at})$	-0.079	-0.302**	0.236	-0.415*
	(0.347)	*(0.107)*	*(0.526)*	*(0.213)*
$do_{it}(\Delta y_{it} - \Delta y_{at})$	-0.020	0.150**	-0.262	-0.240
	(0.120)	*(0.055)*	*(0.274)*	*(0.221)*
eo_{it}	0.027*	0.003**	-0.008	-0.017
	(0.015)	*(0.001)*	*(0.041)*	*(0.014)*
do_{it}	-0.008**	-0.002*	-0.018	0.015*
	(0.003)	*(0.001)*	*(0.011)*	*(0.009)*
Δr_{it}	-0.046	0.001	-0.093***	-0.024
	(0.036)	*(0.001)*	*(0.025)*	*(0.017)*
$Cons$	-0.001	-0.002***	0.000	-0.003
	(0.001)	*(0.000)*	*(0.002)*	*(0.002)*
N	304	378	560	833
R^2	0.51	0.54	0.26	0.25

Table 2.7: These regressions are presented in order to facilitate comparison with the literature. Risk sharing by the Non-OECD21 1987-2003 sample is rejected at the 5% level. Failure to consider the resources actually available to consumers in the form of net GDP could have contributed to the previous failure to find risk sharing by non-industrialized countries. Table 2.8 presents further possible explanations.

Gross GDP with Control Variables and Financial Integration Breakdown

Dependent Variable: $\Delta c_{it} - \Delta c_{at}$	Controls		Breakdown	
$\Delta c_{i,t-1} - \Delta c_{a,t-1}$	-0.010	$\Delta ny_{it} - \Delta ny_{at}$	0.905***	1.003***
	(0.039)		*(0.214)*	*(0.209)*
$\Delta ny_{it} - \Delta ny_{at}$	0.659***	$fdili_{it}(\Delta ny_{it} - \Delta ny_{at})$	-0.525*	-0.532**
	(0.166)		*(0.266)*	*(0.212)*
$eo_{it}(\Delta ny_{it} - \Delta ny_{at})$	-0.722***	$fdias_{it}(\Delta ny_{it} - \Delta ny_{at})$	-0.960	
	(0.234)		*(2.712)*	
$do_{it}(\Delta ny_{it} - \Delta ny_{at})$	-0.317	$peqli_{it}(\Delta ny_{it} - \Delta ny_{at})$	6.691*	
	(0.201)		*(3.932)*	
$eo_{it}\Delta r_{it}(\Delta ny_{it} - \Delta ny_{at})$	-2.817	$peqas_{it}(\Delta ny_{it} - \Delta ny_{at})$	1.951	
	(1.829)		*(3.938)*	
$do_{it}\Delta r_{it}(\Delta ny_{it} - \Delta ny_{at})$	1.054**	$debtli_{it}(\Delta ny_{it} - \Delta ny_{at})$	-0.308	-0.316
	(0.479)		*(0.305)*	*(0.285)*
$co_{it}(\Delta ny_{it} - \Delta ny_{at})$	0.010	$debtas_{it}(\Delta ny_{it} - \Delta ny_{at})$	0.370	
	(0.234)		*(0.534)*	
eo_{it}	-0.009	$fdili_{it}$	-0.028	-0.023
	(0.234)		*(0.534)*	*(0.024)*
do_{it}	0.009	$fdias_{it}$	0.194	
	(0.234)		*(0.534)*	
co_{it}	0.043**	$peqli_{it}$	-0.086	
	(0.234)		*(0.534)*	
$eo_{it}\Delta r_{it}$	-0.420**	$peqas_{it}$	-0.160**	
	(0.234)		*(0.534)*	
$do_{it}\Delta r_{it}$	0.044	$debtli_{it}$	0.015	0.014
	(0.234)		*(0.534)*	*(0.011)*
		$debtas_{it}$	-0.005	
			(0.534)	
Δr_{it}	-0.055	Δr_{it}	-0.026	-0.024
	(0.234)		*(0.534)*	*(0.018)*
Cons	-0.029**	*Cons*	-0.011	-0.008
	(0.234)		*(0.534)*	*(0.009)*
N	833		833	833
R^2	0.28		0.28	0.26

Table 2.8: The inclusion of control variables, particularly allowing the risk sharing measure to depend on growth in the real exchange rate, leads to a strong risk sharing effect of equity integration. FDI and debt liabilities are the most effective forms of financial integration in terms of risk sharing and smoothing. Running the regression with these variables as the only interaction terms (final column) leads to the finding of risk sharing at the 5% level (marginally for FDI and also jointly). Thus, distinguishing the different elements of financial integration is important when measuring consumption risk sharing.

2.10 The Idiosyncratic Variable Assumption

Risk Sharing Regressions using Non-Idiosyncratic Variables

Dependent Variable:	Δc_{it}		$\Delta c_{it} - \Delta c_{at}$
Δc_{at}	0.297		
	(0.183)		
Δy_{it}	0.636***	$\Delta y_{it} - \Delta y_{at}$	0.628***
	(0.052)		*(0.051)*
Δy_{at}	-0.099		
	(0.128)		
$eo_{it}\Delta y_{it}$	-0.277**	$eo_{it}(\Delta y_{it} - \Delta y_{at})$	-0.302**
	(0.108)		*(0.107)*
$do_{it}\Delta y_{it}$	0.149**	$do_{it}(\Delta y_{it} - \Delta y_{at})$	0.150**
	(0.054)		*(0.055)*
$eo_{it}\Delta y_{at}$	0.367***		
	(0.126)		
$do_{it}\Delta y_{at}$	-0.204**		
	(0.085)		
eo_{it}	0.004	eo_{it}	0.003**
	(0.003)		*(0.001)*
do_{it}	-0.002	do_{it}	-0.002*
	(0.002)		*(0.001)*
Δr_{it}	-0.002	Δr_{it}	0.001
	(0.002)		*(0.001)*
Const	-0.002	*Const*	-0.002***
	(0.002)		*(0.000)*
N	378		378
R^2	0.63		0.56

Table 2.9: Risk sharing regression results for OECD, 1987-2004 for the idiosyncratic variable model (reproduced from Table 2.3) and for the non-idiosyncratic (general) model.
General Formulation:
$\Delta c_{it} = \alpha_i + \zeta \Delta c_{at} + (\gamma_0 + \gamma_1 eo_{it} + \gamma_2 do_{it})\Delta y_{it} + (\beta_0 + \beta_1 eo_{it} + \beta_2 do_{it})\Delta y_{at} + \beta_3 eo_{it} + \beta_4 do_{it} + \Gamma Z_{it} + \varepsilon_{it}$
Idiosyncratic Formulation
$\Delta c_{it} - \Delta c_{at} = \alpha_i + (\gamma_0 + \gamma_1 eo_{it} + \gamma_2 do_{it})(\Delta y_{it} - \Delta y_{at}) + \gamma_3 eo_{it} + \gamma_4 do_{it} + \Gamma Z_{it} + \varepsilon_{it}$
The Null Hyphothesis:
$\zeta = 1, \gamma_0 = -\beta_0, \gamma_1 = -\beta_1, \gamma_2 = -\beta_2$
is rejected (p-value<.01), suggesting that the assumptions implicit in the idiosyncratic model are not justified. In practice, as can be seen from the table, the difference is not important (at least for the samples considered here). Risk sharing is present under both specifications.

2.11 Overseas Financial Centers and Gulf States

Risk Sharing Regression (1), OFCs and Gulf States

Dependent Variable: $\Delta c_{it} - \Delta c_{at}$	1970-1986	1987-2003
$\Delta ny_{it} - \Delta ny_{at}$	0.486**	0.081
	(0.184)	*(0.173)*
$eo_{it}(\Delta ny_{it} - \Delta ny_{at})$	0.838	-0.053
	(1.086)	*(0.111)*
$do_{it}(\Delta ny_{it} - \Delta ny_{at})$	-0.043***	-0.006
	(0.011)	*(0.007)*
eo_{it}	0.009	-0.010**
	(0.056)	*(0.004)*
do_{it}	-0.006***	-0.001
	(0.000)	*(0.001)*
Δr_{it}	-0.037**	0.022
	(0.014)	*(0.058)*
N	128	255
R^2	0.43	0.05

Table 2.10: Δny_{it} stands for the growth rate of output net of government consumption expenditure and fixed investment. The a subscript indicates aggregate, calculated over the (rest of) OECD 21 country sample. eo_{it} and do_{it} stand for equity and debt assets plus liabilities as percentages of GDP. r_{it} stands for the growth rate of the real exchange rate. ***, ** and * indicate 1%, 5% and 10% significance, respectively. Debt market integration may have facilitated smoothing of consumption in the earlier period. No evidence of risk sharing by these countries is found in the later period.

2.12 Further Analysis

2.12.1 Interaction Variable Figures

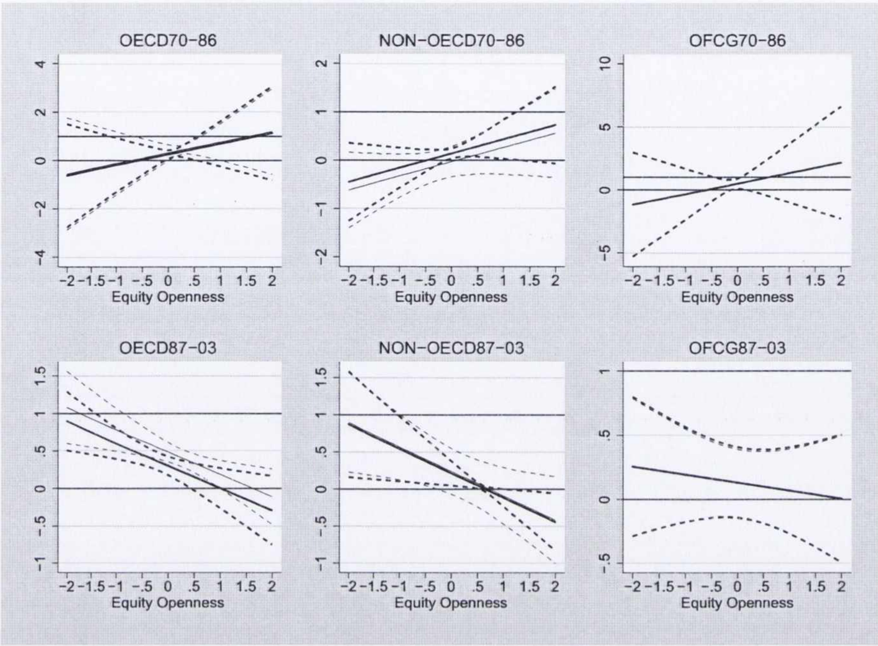

Figure 2.2: Net GDP Coefficient (vertical axis) for values of equity openness between 200% of GDP below average and 200% of GDP above average (horizontal axis), and for debt openness equal to the average (the dark line) and to 100% of GDP above the average (the blue/lightly shaded line), with 5% confidence intervals. The strong downward pattern in the graphs for OECD21 and Non-OECD21, 1987-2003/4, shows the risk sharing effect of equity openness, where the Net GDP coefficient can change from failure to reject financial autarkey (a unitary coefficient) to failure to reject perfect risk sharing (a zero coefficient) within a realistic range of equity openness. The graphs for other samples and periods show no strong pattern, with the 5% bounds encompassing the horizontal axis.

2.12.2 Net GDP Coefficients by Country in 2003

The below graph and tables show the coefficient of net output from the regression

$$\Delta c_{it} - \Delta c_{at} = \alpha_i + (\beta_0 + \beta_1 eo_{it} + \beta_2 do_{it})(\Delta y_{it} - \Delta y_{at}) + \beta_3 eo_{it} + \beta_4 do_{it} + \Gamma Z_{it} + \varepsilon_{it} \qquad (2.11)$$

after accounting for the effects of equity and debt openness in 2003 based on the results in Table 2.3.

Risk Sharing Coefficients with Standard Errors, OECD 2003

COUNTRY	β	se(β)	H0: β=0	H0: β=1
Sweden	0.03	0.13	F	R
Canada	0.09	0.10	F	R
Finland	0.11	0.11	F	R
Australia	0.12	0.10	F	R
Netherlands	0.13	0.14	F	R
New Zealand	0.21	0.08	R	R
Denmark	0.23	0.08	R	R
United States	0.23	0.07	R	R
France	0.24	0.08	R	R
Spain	0.27	0.07	R	R
Switzerland	0.29	0.13	R	R
Ireland	0.29	0.23	F	R
Norway	0.31	0.06	R	R
Japan	0.35	0.06	R	R
Belgium	0.37	0.09	R	R
Italy	0.37	0.06	R	R
Germany	0.39	0.06	R	R
Greece	0.46	0.07	R	R
Portugal	0.55	0.08	R	R
Austria	0.57	0.08	R	R
United Kingdom	0.62	0.08	R	R

Table 2.11: Column (1) reproduces the coefficients from Figure 2.3 (β refers to $\beta_0 + \beta_1 eo_{i,2003} + \beta_2 do_{i,2003}$, in other words consumption dependence on idiosyncratic GDP), with standard errors in Column 2. Column 3 shows the results of testing the null hypothesis H0: $\beta_0+\beta_1 eo_{i,2003}+\beta_2 do_{i,2003} = 0$ (perfect risk sharing). F stands for Fail to reject, R stands for Reject. Column 4 shows the results of testing the null hypothesis H0: $\beta_0 + \beta_1 eo_{i,2003} + \beta_2 do_{i,2003} = 1$ (no risk sharing). All countries fall into two categories - the risk sharing coefficient is either statistically insignificantly different from zero (at the 5% level) and significantly different from one, or strictly between zero and one. The high standard error of Ireland's coefficient is worth noting. This ranking may be of interest to researchers studying macroeconomic volatility or related questions, who might wish to control for the degree of risk sharing achieved by a country.

Risk Sharing Coefficients with Standard Errors, Non-OECD 2003

COUNTRY	β	se(β)	COUNTRY	β	se(β)
Trinidad and Tobago	-0.08	0.04	Poland	0.20	0.10
South Africa	-0.05	0.04	Ethiopia	0.20	0.07
Chad	-0.04	0.02	Egypt	0.20	0.09
Chile	-0.03	0.03	Colombia	0.20	0.09
Papua New Guinea	-0.03	0.08	Cote d'Ivoire	0.20	0.10
Malaysia	0.01	0.02	Senegal	0.21	0.08
Jamaica	0.03	0.04	Honduras	0.21	0.08
Bolivia	0.03	0.02	Tanzania	0.22	0.08
Tunisia	0.07	0.02	Jordan	0.22	0.09
Swaziland	0.07	0.10	Uganda	0.23	0.08
Hungary	0.08	0.03	Guatemala	0.23	0.13
Nigeria	0.09	0.03	Paraguay	0.24	0.09
Zambia	0.10	0.12	Cameroon	0.24	0.10
Argentina	0.13	0.24	India	0.24	0.14
Togo	0.13	0.08	Sri Lanka	0.25	0.10
Iceland	0.15	0.11	Pakistan	0.25	0.11
Ghana	0.15	0.09	Algeria	0.25	0.12
Venezuela	0.15	0.06	Gabon	0.26	0.10
Botswana	0.16	0.10	Kenya	0.26	0.11
Ecuador	0.16	0.06	Turkey	0.26	0.10
Mexico	0.17	0.11	Indonesia	0.26	0.10
Dominican Republic	0.17	0.10	Madagascar	0.27	0.10
El Salvador	0.18	0.08	Bangladesh	0.27	0.14
Korea, Republic of	0.19	0.11	Burkina Faso	0.27	0.12
Poland	0.20	0.10			

Table 2.12: β refers to $\beta_0 + \beta_1 eo_{i,2003} + \beta_2 do_{i,2003}$ - consumption dependence on idiosyncratic GDP. The coefficients are taken from Table 2.3, Column 4, and β is calculated using 2003 equity and debt openness values. Standard errors are shown in Column 2. The null hypothesis H0: $\beta_0 + \beta_1 eo_{i,2003} + \beta_2 do_{i,2003} = 1$ (financial autarkey) is rejected at the 5% level for all countries. The null hypothesis H0: $\beta_0 + \beta_1 eo_{i,2003} + \beta_2 do_{i,2003} = 0$ (perfect risk sharing) is not rejected at the 5% level for 20 of the 49 countries. It appears that financial openness explains a considerable amount of cross-sectional variation in risk sharing in 2003. The high standard error of Argentina's coefficient (coefficient 0.13, standard error 0.24) is worth noting. This ranking may be of interest to researchers studying macroeconomic volatility or related questions, who might wish to control for the degree of risk sharing achieved by a country.

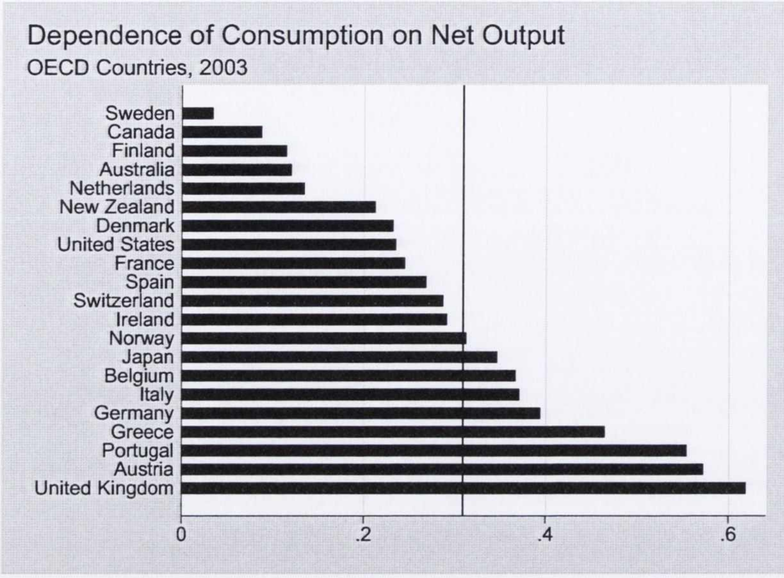

Figure 2.3: The graph shows the dependence of Idiosyncratic Consumption on Idiosyncratic GDP by country for the 21 country sample of OECD countries. Sweden achieves the highest level of risk sharing, with a coefficient almost equal to zero. All coefficients are significantly different from unity (financial autarkey). The dependence measure was calculated as $\beta_0 + \beta_1 eo_{i,2003} + \beta_2 do_{i,2003}$, with the coefficients taken from Table 2.3, Column (2). The red line shows the coefficient of idiosyncratic GDP for a country with average equity and debt openness.

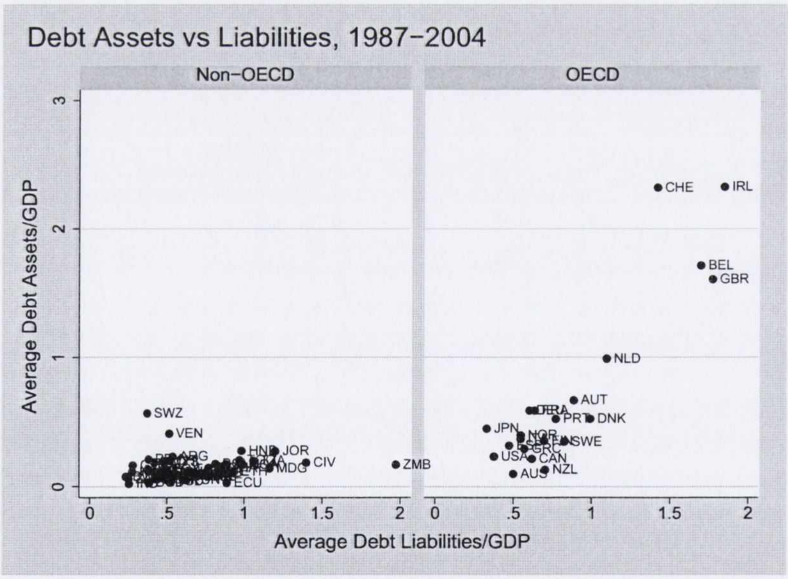

Figure 2.4: Debt Assets vs Liabilities by Sample

2.13 The "Adding Up" Constraint

If consumption were regressed on aggregate consumption instead of aggregate net output in Regression (2) (which allows a separate response of consumption to aggregate shocks), an adding up constraint would apply to the estimated coefficients. Since aggregate consumption and aggregate net output are highly correlated, the constraint may still be relevant. By construction of aggregate consumption, within the OECD subsample, if one country's consumption growth exceeds the average, another country's growth must fall short. Thus in a panel regression:

$$\Delta c_{it} = \alpha_i + \gamma \Delta y_{it} + \beta \Delta c_{at} + \eta \Delta y_{at} + \varepsilon_{it} \tag{2.12}$$

the coefficient of aggregate consumption must be one. If the coefficient varies by country:

$$\Delta c_{it} = \cdots + \beta_i \Delta c_{at} + \cdots \tag{2.13}$$

its average must be one. A special case of this is when the coefficient is a function of financial integration,

$$\Delta c_{it} = \cdots + (\beta_0 + \beta_1 eo_{it} + \beta_2 do_{it}) \Delta c_{at} + \cdots . \tag{2.14}$$

Again, in this case the average of the coefficient must be one. In the absence of an adding up constraint, the interaction variables in Equation (2.14) would explain deviations from β_0, which is common across countries. This remains true in the presence of the adding up constraint, but now the coefficients are constrained by $\beta_0 + \beta_1 \overline{eo}_{it} + \beta_2 \overline{do}_{it} = 1$, in other words they now explain deviations from one. As long as this interpretation is noted, the constraint poses no problem.

Chapter 3

The Determinants of Carry Trade Risk Premia

3.1 Introduction

Low interest rate currencies do not appreciate as much as the interest differential. This widely documented breach of the Uncovered Interest Parity condition leads to positive returns for investors who borrow money in a low interest rate currency and use their borrowings to purchase T-Bills or similar securities in a high interest rate currency, thus engaging in the so-called carry trade. A large literature debates the existence of risk factors which can explain these returns. The most recent contributions to this literature argue that currency crash risk provides a more plausible explanation for carry trade returns than correlation with traditional risk factors (Brunnermeier, Nagel and Pedersen, 2008). The present essay identifies risk factors that are significantly priced when controlling for currency risk, one of which is new to the literature. This new factor is equity risk of the target/funding currency ("portfolio equity risk"). One motivation for this factor is the observation that changes in risk aversion could affect portfolio allocations between risky equity and safer fixed income markets, leading to an association between stock market and T-Bill returns. Studying the correlation between stock and 10-year government bond returns, Baele, Inghelbrecht and Bekaert (2009) note that changes in economic fundamentals could affect risk aversion, and that both stock and bond returns respond to changes in risk aversion, possibly in opposite ways. The same argument could apply to T-Bills rather than bonds, which would lead to negative correlation between excess equity and T-Bill returns. This argument is developed further in Section 3.3.2, along with competing explanations for the significance of portfolio equity returns.

Apart from controlling for commonly cited risk factors (global equity returns and currency risk), the portfolio equity return explanation is also tested against the Consumption Capital Asset Pricing

Model with durable and non-durable goods (DCAPM) model examined by Lustig and Verdelhan (2007) (Jack Treynor (1961) and William Sharpe (1964)). The DCAPM assumes that all investors are intertemporal consumption maximisers with full knowledge of the correlation of consumption growth with asset returns, leading to a model where returns derive from an asset's correlation with consumption. This essay adopts a more general Arbitrage Pricing Theory (APT) framework, where returns are modeled as deriving from an asset's exposure to various macroeconomic risk factors (Ross, 1976). The APT framework is capable of incorporating consumption risk factors simultaneously with other factors commonly used in the literature, facilitating a direct comparison of the models.

This essay studies real returns to a U.S. investor investing in portfolios of foreign T-Bills. The Fama-Macbeth asset pricing procedure is used to test which factors from competing risk-based explanations can explain the returns (Fama and Macbeth, 1973). Exposure to global and portfolio stock market risk and to currency risk provides the most robust explanation for excess returns to the carry trade. In finding exchange rate volatility to be a risk factor that generates carry trade returns, this essay also contributes to an emerging literature which stresses the potential importance of rare disasters as an explanation for currency risk premia (Brunnermeier, Nagel and Pedersen, 2008 and Farhi and Gabaix, 2008). The results are qualitatively unaffected by a number of robustness checks, including varying the period of time under consideration, the countries included in the sample, the number of countries per portfolio, the number of portfolios, and the home country of the investor.

The essay proceeds as follows. Section 3.2 discusses related studies in the literature. Section 3.3 presents the risk factor model, including the motivation for the various factors tested. The data and test results are described in Section 3.4, while Section 3.5 summarises. Factor prices and betas are presented in the tables in the final sections, along with the results from a series of robustness tests.

3.2 Empirical Studies of Carry Trade Returns

The failure of the Uncovered Interest Parity (UIP) condition, which is necessary for the carry trade to be profitable, is of relevance to macroeconomists, since UIP is generally assumed in general equilibrium open economy models. Some models account for the observed failure of UIP by adding a shock to the UIP equation, a so-called Risk Premium shock (e.g. McCallum 1994). Such risk premium shocks affect domestic interest rates and hence real variables like consumption and output, as pointed out by Burnside et al (2006). Thus it is of interest to ask whether breaches of UIP are associated with risk factors, with investors who are exposed to such risk being compensated accordingly.

A large literature attempts to explain the failure of UIP. Proposed explanations include the importance of risk premia, the interaction of risk premia and monetary policy, and biases in expectations (Fama (1984), McCallum (1994), and Frankel and Rose (1994), respectively). Recent contributions include those of Alvarez, Atkeson, and Kehoe (2007), who investigate time-variation in risk premia resulting from endogenous market segmentation, and Bacchetta and Van Wincoop (2006), who suggest that the cost of actively managing foreign exchange portfolios may help to explain the failure of UIP.

In a paper which examines the choices facing a U.K. investor, Burnside et al (2006) confirmed the existence of high Sharpe ratios in returns to the carry trade, but concluded that these returns are not related to risk factors, and cannot be exploited due to a number of frictions. Among others, the authors tested U.K. consumption growth as a potential risk factor. In contrast, Lustig and Verdelhan (2007) find that aggregate consumption risk does explain returns to the carry trade on a large sample of countries over the period 1952-2002. According to the authors, the key innovation in their study is to form portfolios of currencies based on the interest rate. Burnside (2007a) raises a number of objections to the findings of Lustig and Verdelhan (2007), primarily that the constant in the second stage regression in the Fama-MacBeth equations run by Lustig and Verdelhan (2007) is too large to be credible, and that the authors ignored sampling uncertainty in the first stage of the procedure. Lustig and Verdelhan (2008) counter that the constant was not significantly different from zero, and so was not too large, and that the market price of consumption risk remains significantly different from zero after accounting for sample uncertainty in the first stage estimation. Lustig, Roussanov and Verdelhan (2009) confirm the finding of Lustig and Verdelhan (2007) that consumption risk can explain carry trade returns, and show that global equity risk is a significant explanatory factor of the cross-sectional variation in currency returns between high and low interest rate currencies.

Burnside et al (2008) use options data to calculate stochastic discount factors and payoffs in the peso currency crash state and the non-peso stable state, and find that realistic values for these discount factors can explain excess carry trade returns. The motivation for this approach is the failure to find significant covariance between carry trade returns and traditional risk factors. The present essay claims to have found such covariance. Equity risk of the countries in the carry trade portfolio is among the risk factors that account for carry trade returns, and is, to the best of the author's knowledge, new to the literature. Equity betas are not stable, showing considerable variation through time and across portfolios. The finding that carry trade and foreign equity returns are related complements the insights of Campbell, Serfaty-De Medeiros, and Viceira (2010), who, for example, show that the Australian and Canadian dollars comove positively with those countries' stock market returns, while the opposite is true for the Euro and Swiss Franc. As pointed out by the authors, if foreign equity returns denominated in their local currency covary negatively with the foreign currency, then a long position in foreign T-Bills provides a hedge against foreign equity risk. Investigating the relationship between carry trade and equity returns is therefore of interest to globally diversified equity investors. This essay concludes that engaging in the carry trade exposes investors to foreign and global equity market risk, and documents the cross sectional and time series variation in equity market exposure.

In addition to allowing for portfolio and global stock market risk, this essay also attempts to quantify the importance of exchange rate volatility in determining carry trade returns, thus combining insights from two separate strands of the carry trade literature. Recent papers that address the question of exchange rate volatility include those of Brunnermeier, Nagel and Pedersen (2008), who suggest that the presence or threat of liquidity crises may lead to the sudden unwinding of carry trade positions and negatively skewed exchange rates, and Koyama and Ichiue (2008), who link volatility to the unwinding of carry trade positions.

3.3 Explanations of Observed Returns

3.3.1 Return Calculations

Empirical asset pricing studies often seek to explain the returns to portfolios of assets, sorted on variables that predict returns (for the case of stocks, size and book-to-market ratio), thus eliminating the diversifiable, asset-specific component of returns that is not of interest. This produces more precise estimates of the risk/return trade-off in asset markets. Likewise, by sorting currencies into portfolios based on the nominal interest rate differential, it is possible to abstract from the country-specific component of exchange rate changes that is not related to the drivers of carry trade returns. This isolates the source of variation in excess returns that is of interest for the carry trade.

Following this approach, nominal returns are calculated as:

$$R^i_{t+1} = R^{for}_t (E^i_{t+1}/E^i_t). \tag{3.1}$$

where R^{for} stands for the foreign interest rate (T-Bill yield) and E is the nominal exchange rate, expressed as dollars per unit of foreign currency.

Real excess returns to a U.S. investor are then calculated as:

$$R^{i,e}_{t+1} = (R^i_{t+1} - R^{USD}_t)(P_t/P_{t+1}) \tag{3.2}$$

where P stands for the U.S. CPI index, and the e superscript indicates excess carry trade returns.

These calculations follow Lustig and Verdelhan (2007), among others. Countries are ranked by interest rate. They are then grouped into eight portfolios with an equal number of countries in portfolios 1-7 and the remaining countries in portfolio 8 (the highest interest rate portfolio). Bid-ask spreads are ignored. Most authors find bid-ask spreads to be too small to eliminate carry trade returns. Burnside et al (2008), for example, find that transaction costs reduce the average carry trade return from 1976-2008 from 4.77% to 4.43%.

3.3.2 Explanatory Risk Factors

Hypothesis 1: Carry Trade Returns Provide Compensation for Exposure to World and Portfolio Stock Market Risk and Exchange Rate Volatility.

Portfolio Stock Market Risk

The T-Bill yield of the target/funding currency is used as an estimate of the risk free rate and subtracted from that country's equity return. Portfolio equity returns are denominated in foreign currency. There are a number of reasons why carry trade and excess equity returns might be correlated. Equation 3.2 breaks down carry trade returns into their constituent parts. Real excess carry trade returns are a function of the foreign T-Bill yield, the exchange rate return, the U.S. T-Bill yield, and the U.S. consumer price deflator. Considering the exchange rate first, equity returns would be *negatively* correlated with the currency return if stocks are real assets and the shocks to foreign currency are primarily related to foreign inflation (Campbell, Serfaty-De Medeiros, and Viceira, 2010). This would lead to

$$Corr[dE_t, (R^i_{s,t} - R^i_t)(P_{t-1}/P_t)] < 0 \tag{3.3}$$

where E is the nominal exchange rate (in dollars per unit of foreign currency, e.g. dollars per euro), R_s refers to the return to a broad index of shares, R refers to the T-Bill yield, P refers to the domestic CPI and the i superscript indicates country. A negative correlation between equity returns and exchange rates could also occur via the portfolio rebalancing effect documented in Hau and Rey (2007), whereby higher equity returns in the target currency lead to greater exposure to that currency and hence a reallocation out of the currency, causing its depreciation. If many investors are marking to market, such aggregate effects are possible, as argued by Adrian and Shin (2010). A *positive* correlation could arise between the exchange rate and the inflation rate if the monetary policy authority follows a Taylor Rule (Clarida and Waldman, 2007). In this way higher inflation may imply an appreciating exchange rate and higher carry trade returns.

Considering the T-Bill component of carry trade returns, T-Bill and raw stock market returns might show *positive* correlation due to variation in real interest rates, since the prices of both assets are negatively related to the discount rate. Common movements in future expected returns likewise promote a positive correlation. Taking the three month T-Bill rate as an estimate of the risk free rate of a given target or funding country and subtracting it from equity returns should remove correlation due to these two sources. A *negative* correlation between excess equity and T-Bill returns could arise in a joint stock-bond asset pricing model with an equity-specific source of risk. In such a model, a shock to equity returns could lead to a reallocation of capital out of equity and into government debt, lowering stock prices and returns and increasing bond prices and returns. A change in risk aversion could have the same effect, with investors altering the relative weight of equity against fixed income (such as T-Bill) investments in their portfolio. Both of these possibilities argue for negative correlation between carry trade returns and (excess) stock market returns:

$$Corr[R_t^{i,e}, R_{s,t}^i - R_t^i] < 0, \tag{3.4}$$

in other words negative equity betas for every country i, or negative β_s^j for every portfolio j.

Thus, for a variety of reasons it could occur that carry trade returns depend on portfolio stock market returns

$$E[R^{j,e}] = \alpha + \beta_s^j \lambda_s + ... + \epsilon_j, \tag{3.5}$$

where $\lambda_s > 0$ is the associated risk premium and β_s^j is the factor loading. If $\beta_s^j < 0$ (following the changes in risk aversion channel of correlation), then an investor holding a long position in foreign equities can reduce portfolio risk by holding a long position in foreign currency, which could be achieved by buying foreign T-Bills. In this way a long carry trade position could hedge exposure to stock market risk, and vice versa for $\beta_s^j > 0$.

Correlation analysis affords some insight into which of the above factors may be behind the portfolio equity factor, as discussed in the results below. To preview, at monthly frequency, the significant correlation coefficients presented in Table 3.2 are consistent with the interpretation that portfolio equity returns proxy for general macroeconomic risk of the target/funding countries, with both the inflation risk and discount rate risk channels receiving some indicative support. At annual frequency, however, a mechanical breakdown of carry trade returns into its constituent components gives no significant correlation coefficients between portfolio equity returns and those components at the 5% level.

A global flight to quality effect, which might weaken the dependence of carry trade returns on any fundamental target/funding currency risk factor, can be accounted for by conditioning the factor (in this case stock market returns) on a measure of global risk aversion, such as VIX.

World Stock Market Risk

Campbell, Serfaty-De Medeiros, and Viceira (2010) show that for Australia, Japan, Canada and the U.K., local currency returns are positively correlated with a measure of global equity returns, while the correlation for Euroland and Switzerland is positive pre-1990, becoming negative thereafter. Two proxies for true global equity returns are used here, U.S. equity returns and the

MSCI world return index, with the results being insensitive to this choice of proxy. Including world equity returns ensures that a significant portfolio equity beta does indicate portfolio-specific risk exposure, as opposed to global risk exposure. This factor thus functions secondarily as a control variable.

Lower world equity returns could be associated with the depreciation of a country's exchange rate via the flight to quality effect. Such unwinding of investments during difficult times would reduce carry trade returns, giving rise to a correlation between carry trade returns and world equity returns. This flight to quality effect would cause time variation in the equity betas. In an attempt to capture this, VIX (the CBOE volatility index) is taken as a measure of global risk aversion and included as an interaction term with both equity factors.

Currency Crash Risk

Several studies find evidence of a link between exchange rate volatility and carry trade returns. Intuitively, exposure to exchange rate risk suggests that carry traders should care about exchange rate volatility, and that returns to the carry trade may compensate for this risk. In addition to affecting the volatility of carry trade returns, volatility may be associated with currency crashes. Koyama and Ichiue (2008) find evidence that high bilateral exchange rate volatility may be associated with the unwinding of carry trade positions, with periods of low volatility coinciding with failure of the Uncovered Interest Parity condition. Thus, regime changes in the exchange rate process may coincide with a switch from investing in carry trade positions to unwinding these investments. The authors find evidence for causality from volatility to unwinding and also the reverse.

Brunnermeier, Nagel and Pedersen (2008) present evidence that exchange rates between low and high interest rate currencies are negatively skewed, due to the sudden unwinding of carry trades which occurs during periods of decreased liquidity, again arguing for causality from the carry trade to exchange rates. The authors further suggest that the possibility of these crashes may discourage speculators from taking on large enough positions to enforce UIP, supporting a causal link from exchange rate volatility to carry trade returns. In related work, Farhi and Gabaix (2008) show how a country's exposure to disaster risk may lead to a depreciated currency with a high interest rate, reflecting a currency disaster risk premium. According to Galati et al (2007), bouts of higher exchange rate volatility have lead to "significant... declines in the attractiveness of some target currencies", notably the South African Rand. Accordingly, this essay also tests the importance of exchange rate volatility as an explanatory risk factor in carry trade returns.

Estimating Equation

The explanatory power of the above risk factors for carry trade returns can be tested in an

Arbitrage Pricing Theory setting, in which an asset's return is a linear function of k factors:

$$R^j = E[R^j] + \beta_1^j F_1 + ... + \beta_k^j F_k + \epsilon_j \tag{3.6}$$

and its expected return is given by

$$E[R^j] = R_f + \beta_1^j RP_1 + ... + \beta_k^j RP_k, \tag{3.7}$$

where R_f is the risk free rate, F is an underlying risk factor, and RP is a risk premium. This model assumes the factors to be mean-zero random variables. It is less restrictive than the CAPM, as it assumes that each investor will hold a unique portfolio with its own array of betas, as opposed to the identical "market portfolio".

Thus, the model being tested is:

$$E[R^{j,e}] = \alpha + \beta_v^j \lambda_v + \beta_{s,US}^j \lambda_{s,US} + \beta_{sv,US}^j \lambda_{sv,US} + \beta_{ve}^j \lambda_{ve} + \beta_s^j \lambda_s + \beta_{sv}^j \lambda_{sv} + \epsilon_j, \tag{3.8}$$

where the v subscript indicates VIX, s indicated portfolio equity returns, s, US indicates U.S. equity returns, the sv subscript refers to the multiplicative interaction term between stock market returns and VIX, and ve indicates the average standard deviation of the daily exchange rates in portfolio j in a given portfolio in a given year. The stock market return variables are real excess returns over the relevant (U.S. or local) T-Bill yield.

Hypothesis 2: Aggregate Consumption Risk Explains Carry Trade Returns.

Lustig and Verdelhan (2007) find evidence that engaging in the carry trade exposes investors to aggregate consumption risk and that this risk explains the resulting returns. The authors use the DCAPM (Capital Asset Pricing Model with non-durable and durable consumption) examined by Yogo (2006). The representative household's lifetime utility at t is:

$$\mathrm{U_t} = \left\{ (1-\beta)u(C_t, D_t)^{1-1/\sigma} + \beta \left[E_t(U_{t+1}^{1-\gamma}) \right]^{(1-1/\sigma)/(1-\gamma)} \right\}^{1/(1-1/\sigma)} \tag{3.9}$$

where C_t D_t represents the household's consumption of nondurable and durable goods, respectively, $0 < \beta < 1$ is the discount factor, $\sigma > 0$ is the intertemporal elasticity of substitution and $\gamma > 0$ measures risk aversion (a summary presentation of this model is given in Burnside, 2007a). The instantaneous utility function is

$$u(C, D) = \left[(1-\alpha)C^{1-1/\rho} + \alpha D^{1-1/\rho} \right]^{1/(1-1/\rho)} \tag{3.10}$$

From this expression the intertemporal marginal rate of substitution can be calculated (Equation 3 in Burnside (2007a)). Log linearizing the marginal rate of substitution and interpreting it as a stochastic discount factor gives Lustig and Verdelhan's null hypothesis that the expected value across all states of nature of the discounted excess returns is zero:

$$E(R_t^e m_t) = 0. \tag{3.11}$$

Because of the log-linearization the expected return is modeled as a linear combination of the risk factors, giving a testing equation identical to one which could be derived from an Arbitrage Pricing Theory perspective. The linear factor model implied (approximately) by the U.S. investor's unconditional Euler equation for the expected excess return on portfolio j is:

$$E[R^{j,e}] = b_c cov(\Delta c_t, R_t^{j,e}) + b_d cov(\Delta d_t, R_t^{j,e}), \tag{3.12}$$

where c stands for real per capita household consumption and d stands for real per capita durables consumption.

The $b_c cov(\Delta c_t, R_t^{j,e})$ term can be rewritten as $\beta_c^j \lambda_c$, where

$$\beta_c^j = cov(\Delta c_t, R_t^{j,e})/var(\Delta c_t) \tag{3.13}$$

are the factor loadings and

$$\lambda_c = b_c var(\Delta c_t) \tag{3.14}$$

the factor prices, and likewise for $b_d cov(\Delta d_t, R_t^{j,e})$, giving

$$E[R^{j,e}] = \beta_c^j \lambda_c + \beta_d^j \lambda_d. \tag{3.15}$$

In estimating the equation a constant can be included

$$E[R^{j,e}] = \alpha + \beta_c^j \lambda_c + \beta_d^j \lambda_d + \epsilon_j \tag{3.16}$$

because the risk free rate is imperfectly estimated as the real return on U.S. T-Bills (Burnside, 2007a). Thus the constant can be interpreted as the model's pricing error for the risk free rate. It is the factor prices that are of primary interest. A significant factor price shows that investors are rewarded for exposure to the risk associated with that risk factor.

3.4 Empirical Tests

3.4.1 Data

End of year (or as close as available to end of year) observations of three month T-Bill yields are taken from Global Financial Data (GFD), as are exchange rate data, the MSCI world return index and VIX, the Chicago Board Options Exchange Volatility Index. The only exceptions to this T-Bill maturity term are Costa Rica (six months) and The Former Yugoslav Republic of Macedonia (one month). The consumption price indices for the United States, Japan and the United Kingdom are also taken from GFD. Monthly data for the above variables and for inflation are also taken from GFD. The stock market data are the total return indices with a Datastream mnemonic that starts with TOTMK (e.g. for the U.S., TOTMKUS) or, for countries not covered by the TOTMK series, the International Finance Corporation (IFC) indices, also available from Datastream. The countries for which IFC data are used are: United Arab Emirates, Bangladesh, Bahrain, Botswana, Cote d'Ivoire, Ecuador, Egypt, Arab Rep., Estonia, Ghana, Croatia, Jamaica, Kazakhstan, Kenya, Kuwait, Lebanon, Lithuania, Latvia, Morocco, Mauritius, Oman, Panama, Qatar, Slovakia, Tunisia, Ukraine, Vietnam. Equity returns are denominated in their local currency.

The capital openness ratio is taken from Sebastian Edwards (2008).[1] Countries whose capital openness ratio is less than 20% are excluded, following Lustig and Verdelhan (2007). Countries that defaulted on bonds in year t are not included in a year t portfolio, and so not included in the returns in year $t+1$. A recovery rate of 70% is applied to countries whose T-Bills are included in a portfolio and who default, following Lustig and Verdelhan (2007). Bond default data are taken from Reinhart, Rogoff and Savastano (2003) and Reinhart and Rogoff (2008).

Exchange rate volatility was calculated as the standard deviation of the daily growth rate in the exchange rate over the relevant year, or month for monthly frequency. Consumption data were taken from Adrien Verdelhan's website.[2] For the purpose of selecting a sample of more developed countries, real per capita consumption in 2000 is taken from the Penn World Tables (Heston et al, 2006). Data were collected for 96 countries for at least one year, although a small number of these countries are never included in a portfolio, according to the above criteria. Argentine T-Bill data were not available due to the sporadic nature of T-Bill issues by the Argentine central bank over the period in question. The sample of countries used in this study is presented in Section 3.6. Summary statistics are presented in Table 3.1. The top panel shows statistics for variables that are common across portfolios, with the lower two panels showing statistics for portfolios 1 and 7. A carry trade strategy that goes long portfolio 7 and short portfolio 1 should maximise returns over the sample.

[1] These data extend to 2004. For regressions until 2007, the 2004 values were used.
[2] http://people.bu.edu/av/Research.html

3.4.2 Estimation

The models are estimated using the Fama-Macbeth Asset Pricing Procedure:

- Stage 1: for each portfolio, run time series regressions of currency portfolio returns on the factors to estimate factor betas for that portfolio (Fama and Macbeth, 1973). For portfolio j, estimate

$$R_{t+1}^{j,e} = \alpha^j + \beta_{F1}^j F1_t + \beta_{F2}^j F2_t + \ldots + \epsilon_{t+1}, \tag{3.17}$$

  where $F1$ represents the first risk factor, for example the growth rate of excess stock market returns. These equations can be estimated by OLS, or as a system using GLS, GMM or maximum likelihood. The OLS approach is chosen in this essay. Burnside (2007b) shows how GMM based procedures suffer from low power to reject proposed stochastic discount factors in the presence of weak risk factors.

- Stage 2: run a cross-section regression of average portfolio returns on the estimated betas in order to estimate factor prices.

$$E_T[R_t^{j,e}] = \gamma + \lambda_{F1}\hat{\beta}_{F1}^j + \lambda_{F2}\hat{\beta}_{F2}^j + \ldots + u^j \tag{3.18}$$

  Shanken (1992) proposes an adjustment to the covariance matrix of the estimated coefficients which accounts for the estimation error in the betas. The Shanken correction is presented with the results. Cross sectional fit is measured against a naive model which uses the cross sectional average of the (time series averaged) portfolio excess returns. Denoting the portfolio vector of average returns as $E_T[R_t^e]$ as $\bar{R}^e$ and the cross sectional average of this vector $E_j[\bar{R}_t^e]$ as $\bar{\bar{R}}^e$,

$$R^2 = 1 - \frac{(\bar{R}^e - \hat{R}_j)'(\bar{R}^e - \hat{R}_j)}{(\bar{R}^e - \bar{\bar{R}}^e)'(\bar{R}^e - \bar{\bar{R}}^e)}. \tag{3.19}$$

  This R-squared formula is given in Burnside (2007a) (Equation 12). This R-Squared will be zero for a model for which the sum of the cross-sectional squared errors equals that of the naive model.

3.4.3 Results

The results favour a risk based explanation of carry trade returns, with the proposed idiosyncratic equity return factor significantly priced. Second stage (factor price) regressions are only of interest when the null hypothesis that the vector of first-stage factor betas is the same across portfolios is rejected, based on a Seemingly Unrelated Regression χ^2 test (Zellner, 1962). This is the case for Hypothesis 1 (equity and exchange rate volatility factors) but not for Hypothesis 2 (consumption factors).

Stage 1: Factor Betas

The betas for Hypothesis 2 do not vary significantly across portfolios, giving no pattern to analyse. Table 3.3 in Section 3.7 shows the betas for Hypothesis 1. Although almost none are individually significantly different from zero, the betas do vary across portfolios at the 1% significance level, according to a Seemingly Unrelated Regression χ^2 test (Zellner, 1962). The average returns column shows that the strategy of investing in portfolio 7 currencies while shorting portfolio 1 countries would have maximized returns over the period 1980-2007. The portfolio 1 and portfolio 7 betas are significantly different, with a p-value less than 0.01.

The signs of the factor betas are consistent with expectations. Higher U.S. stock market volatility is associated with lower carry trade returns for high interest rate (Portfolio 8) currencies. This may be due to a flight to quality effect. Portfolio equity betas are negative for the highest interest rate currencies, which may be because the link from equity to carry trade returns works via inflation rates (Campbell, Serfaty-De Medeiros, and Viceira (2010)). This explanation receives some support from the correlation analysis of Table 3.2 in Section 3.6, where the negative correlation of equity returns and inflation could occur if the inflation shock is due to a supply shock, although it should be noted that this negative correlation is seen only at monthly frequency. Running the factor model with inflation in place of or in addition to portfolio equity (results not shown) leads to no significance, suggesting a more nuanced approach may be necessary. The alternative explanation, that the negative beta occurs via portfolio rebalancing between equity and debt in response to a change in perceived macroeconomic risk, also receives some indicative support from the negative correlation of T-Bill and equity returns shown in Table 3.2.

For other countries the portfolio equity beta is positive, possibly supporting the argument that movement in the discount rate, which affects both stock market and T-Bill returns, provides the link. The VIX interaction term is typically opposed in sign to the portfolio equity beta, weakening the link between carry trade returns and the portfolio equity market during periods of high volatility. U.S. equity betas increase in the interest rate but are positive for all countries (although the VIX interaction term could potentially alter this during times of high volatility), suggesting a strong global factor in equity returns.

Figure 3.2 shows carry trade equity betas broken down by portfolio. Carry trade betas are calculated as the difference between Portfolio 7 (high interest rate) and Portfolio 1 (low interest rate) betas. Examining the left panel, it is interesting to note that for Portfolio 1 (low interest rate) countries, exposure to U.S. equity risk appears almost constant through time, whereas for Portfolio 7 countries this exposure is volatile. Turning to the right panel, for Portfolio 7 countries, exposure to portfolio equity risk appears almost constant through time, whereas for Portfolio 1 countries this exposure is volatile, at times falling to zero. It appears that changes through time in the portfolio equity beta are due to changes in the beta of funding currencies, whereas changes in the beta of carry trade returns with U.S. equity returns come from the target currencies. The importance of the equity returns of countries in the funding portfolio to carry trade returns appears to be a novel stylised fact in the literature. This pattern is robust to the use of the MSCI World Return Index in place of U.S. equity returns as a proxy for global equity returns (see Table 3.10 in Section 3.9).

An investment in portfolio 1 (low interest rate currencies) provides exposure to the equity risk of the countries in this portfolio, however this exposure to portfolio equity risk dips close to or below zero twice. Both of these occasions coincide with negative or zero carry trade returns, eliminating the exposure. This is consistent with domestic factors (portfolio equity) of low interest rate countries falling in importance during carry trade unwinding, suggesting that sudden unwindings of carry trade investments tend to be correlated with global factors.

In Figure 3.3 the strong swings in magnitude of the betas can be clearly seen. Betas here refer to the partial derivatives of carry trade returns with respect to the relevant variable, VIX, U.S. equity returns, or portfolio equity returns. Starting from the first stage time series regression for portfolio j

$$R^{j,e} = \alpha + \beta_v^j VIX + \beta_{s,US}^j R_{s,US} + \beta_{sv,US}^j VIX(R_{s,US}) + \beta_{ve}^j Vol_{ER} + \beta_s^j R_s^j + \beta_{sv}^j VIX(R_s^j) + \epsilon_j, \quad (3.20)$$

(where the time index is suppressed) these partial derivatives are:

$$\frac{\partial R^{j,e}}{\partial VIX} = \beta_v^j + \beta_{sv,US}^j R_{s,US} + \beta_{sv}^j R_s^j \quad (3.21)$$

$$\frac{\partial R^{j,e}}{\partial R_{s,US}} = \beta_{s,US}^j + \beta_{sv,US}^j VIX \quad (3.22)$$

$$\frac{\partial R^{j,e}}{\partial R_s^j} = \beta_s^j + \beta_{sv}^j VIX, \quad (3.23)$$

where the s subscript indicates stock market returns, j refers to portfolio and sv refers to the interaction term between VIX and the relevant stock market returns. Controlling for VIX exposure, U.S. equity betas for the carry trade tend to hover around zero. A high measure of VIX means that the market expects the S&P index to either rise or fall substantially. During such times carry trade returns tend to rise, controlling for contemporaneous equity returns, although this beta is far from stable. The carry trade portfolio equity beta is almost always negative, meaning that strong equity returns in the funding countries spell weak carry trade returns. The reverse is also true, so that a carry trade investment can be used to hedge equity exposure in funding currencies, although time variation in the equity beta could reduce or eliminate this hedge on occasion.

Stage 2: Hypothesis 1 (Equity and Exchange Rate Risk Factors)

Table 3.4 in Section 3.8 presents the factor price estimates for Hypothesis 1. The risk factors explain a large proportion of the variation in returns across portfolios, and are jointly and individually significant. An interaction effect model naturally leads to collinearity among the explanatory variables, confounding somewhat the interpretation of the coefficients. This may help to explain the 19% premium on a carry trade portfolio whose excess return moves one-for-one with U.S. equity returns, which is higher than expected. The VIX interaction term serves to reduce this premium somewhat, as VIX/U.S. Equity interaction term betas are typically negative. Increasing the cross-sectional degrees of freedom by considering 16 portfolios gives a more realistic premium (Table 3.9).

The negative coefficient of VIX, although not significantly different from zero, is as expected. The interpretation is that a carry trade portfolio whose returns rise one for one as the implied volatility of U.S. stock markets rise, pays a negative risk premium (that is, requires an insurance premium) of 3.42% per annum. A carry trade portfolio whose excess returns move one-for-one with the excess stock market returns of the carry trade portfolio yields an average risk premium of around 19% per annum, but again this figure is without adjusting for interaction effects (which are time dependent). The second column of Table 3.4 presents the results from the same regression run over the period 1980-2007 (inclusive). This change in sample period has a negligible effect on the results, partly because data for many of the variables only become available much later than 1952, so that the overlap in samples is greater than it might seem. Portfolio equity returns and the interaction between this variable and VIX are jointly significant at the 1% level.

Including consumption factors jointly with equity factors leads to significance of the latter and insignificance of the former (Table 3.6). This table also shows that the equity factors remain significant at monthly frequency, using sixteen portfolios. As in the annual case, the monthly factor prices are larger than expected, which may be explained by collinearity.

Stage 2: Hypothesis 2 (DCAPM)

It is possible to replicate very closely the factor price estimates of Lustig and Verdelhan (LV) (2007, Table 5, second column), however the betas which replicate these estimates to within three decimal places (see Table 3.5) are not significantly different across portfolios, invalidating the second stage regression. These results are also sensitive to minor changes in sample. The country sample used in the present essay is reproduced in Section 3.6, and can be compared with that of Appendix A in LV. Using the present sample but limiting it to the time frame analyzed by LV gives factor price estimates that differ substantially from those of LV (Table 3.8). The insignificance of the consumption betas concurs with the finding of Burnside (2007a), but not that of Lustig and

Verdelhan (2008). The factor betas from a model with consumption/VIX interaction terms also do not differ across portfolios (Table 3.8).

Robustness

To check the robustness of the factor price and beta estimates, this model is run over the time frame (1952-2002) used in Lustig and Verdelhan. The factors betas and prices remain jointly significant when estimated on this sample period, although the factor prices are not individually accurately estimated. These results are shown in the first column of Table 3.7 in Section 3.9, while the second column shows the results for a model with consumption factors in place of portfolio equity returns (the novel factor), retaining the other explanatory variables (U.S. equity returns, VIX and exchange rate volatility). The two consumption factors are jointly insignificant in this specification.

Confirming that the portfolio equity risk factor adds explanatory power to the model, Table 3.9 presents the results for a sub-model in which this factor is excluded. The R^2 value is lower for the sub-model. The second column of Table 3.9 presents results for the same model using 16 portfolios, effectively doubling the degrees of freedom in the cross sectional (second stage, factor price) regressions. Although the individual significance levels of the risk factors falls somewhat, they remain jointly significant at the 1% level.

Table 3.10 shows the results when the model is run on a subsample of more developed countries, namely the fifty richest countries by GDP per capita in 2000. The results are qualitatively unchanged. The smaller factor price of portfolio equity risk reflects the omission of many of the riskiest countries in terms of volatility of equity returns. The portfolio equity returns factors are now also individually significant. As a further robustness check, Table 3.11 presents results for an investor domiciled in Japan and the U.K., instead of the U.S. The significance of the factor prices weakens somewhat, but they remain jointly significant at the 5% level for both countries, as do the two portfolio equity return factors.

3.5 Summary

This essay studies annual returns to an investment strategy that buys high interest rate currencies and sells low interest rate ones using a broad sample of countries over the period 1952-2007 inclusive. Exposure to global and to portfolio stock market risk, both conditioned by U.S. stock market implied volatility, and to exchange rate risk explains these carry trade returns. This is consistent with Lustig and Verdelhan's (2007) contention that a risk based explanation of carry trade returns is feasible, and contradicts the claim by other authors (for example, Burnside et al (2008)) that returns are not significantly correlated with risk factors. The new finding is that carry trade returns appear to compensate the investor for exposure to macroeconomic risk of the countries in her portfolio, in addition to exchange rate and global risk factors.

The correlation of carry trade returns with world equity returns appears to increase in the cross section with the interest rate, holding other factors constant (consistent with the findings of Lustig, Roussanov and Verdelhan, 2009). This may be due to covering of carry trade positions during a fall in global equity markets. Such a flight to quality could lead to depreciation of high interest rate currencies, and hence falling carry trade returns from those currencies. Carry trade investors should be aware that a long position in a portfolio of high interest rate currencies may provide exposure to world stock market risk, particularly during downturns in the world equity market. The presence of exchange rate volatility as a significant explanatory factor supports the conclusions of Brunnermeier, Nagel and Pedersen (2008), who claim that the possibility of currency crashes helps prevent arbitrageurs from eliminating carry trade returns. No support is found for the contention that consumption risk explains carry trade returns.

One apparently novel stylised fact is that if the stock markets of the funding currencies do well, carry trade returns suffer, and vice versa. This remains the case after controlling for world equity returns, the VIX volatility index, the MSCI world return index, and realized contemporaneous exchange rate volatility. Equity risk of countries in the funding portfolio is hedged by carry trade returns, although this relationship weakens in times of market stress.

3.6 Data

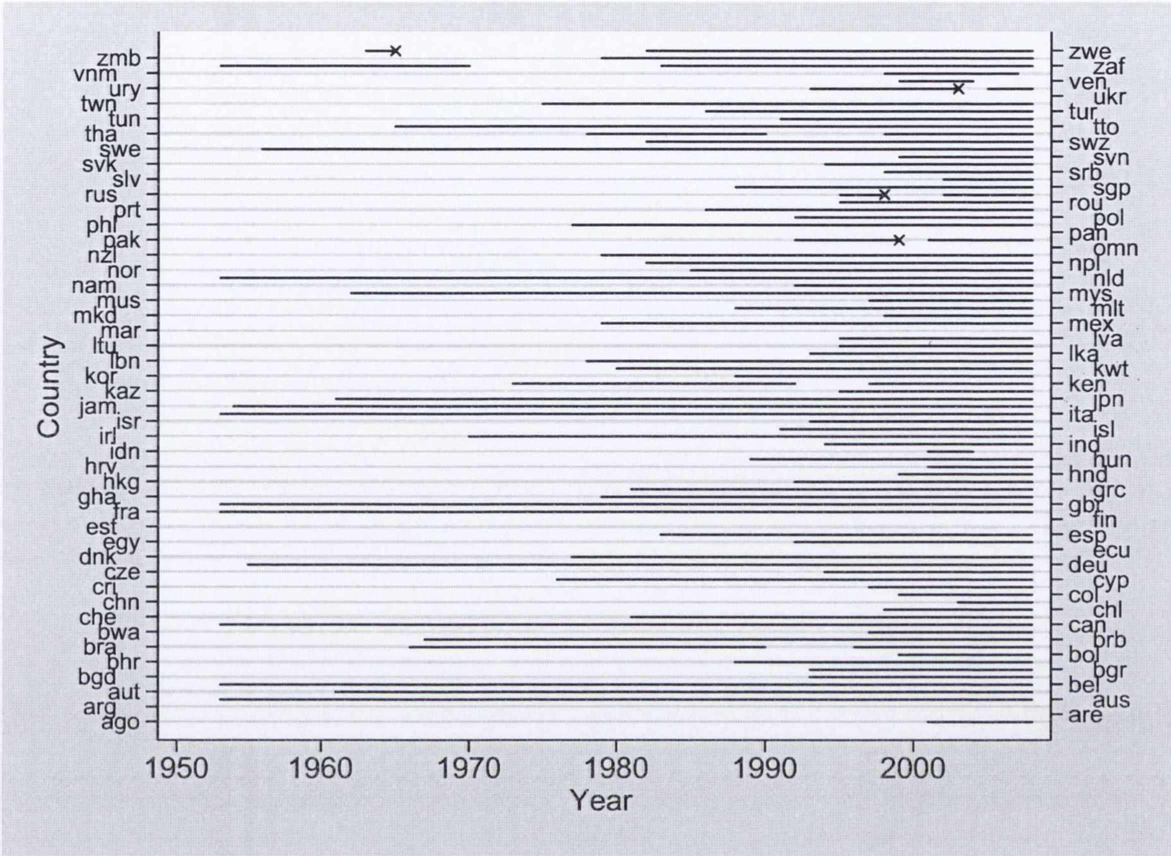

Figure 3.1: The above figure shows years for which each country is included in a portfolio. Countries are indicated by their three letter ISO codes (listed below). Countries were excluded if no data were available, if the capital openness ratio was less than 20%, or if the country defaulted on government bonds in the previous year (the decision to invest and portfolio allocation are made at the end of year t, with the return realised at the end of year $t+1$). Defaults are indicated with an X. Government bond default data are from Reinhart, Rogoff and Savastano (2003) and Reinhart and Rogoff (2008).

3.6.1 Countries and ISO Codes

Angola (AGO), United Arab Emirates (ARE), Argentina (ARG), Australia (AUS), Austria (AUT), Belgium (BEL), Bangladesh (BGD), Bulgaria (BGR), Bahrain (BHR), Bolivia (BOL), Brazil (BRA), Barbados (BRB), Botswana (BWA), Canada (CAN), Switzerland (CHE), Chile (CHL), China (CHN), Cote d'Ivoire (CIV), Colombia (COL), Costa Rica (CRI), Cyprus (CYP), Czech Republic (CZE), Germany (DEU), Denmark (DNK), Ecuador (ECU), Egypt, Arab Rep. (EGY), Spain (ESP), Estonia (EST), Finland (FIN), France (FRA), United Kingdom (GBR), Ghana (GHA), Greece (GRC), Hong Kong (HKG), Honduras (HND), Croatia (HRV), Hungary (HUN), Indonesia (IDN), India (IND), Ireland (IRL), Iceland (ISL), Israel (ISR), Italy (ITA), Jamaica (JAM), Japan (JPN), Kazakhstan (KAZ), Kenya (KEN), Korea, Rep. (KOR), Kuwait (KWT), Lebanon (LBN), Sri Lanka (LKA), Lithuania (LTU), Latvia (LVA), Morocco (MAR), Mexico (MEX), TFYR Macedonia (MKD), Malta (MLT), Mauritius (MUS), Malaysia (MYS), Namibia (NAM), Nigeria (NGA), Netherlands (NLD), Norway (NOR), Nepal (NPL), New Zealand (NZL), Oman (OMN), Pakistan (PAK), Panama (PAN), Peru (PER), Philippines (PHL), Poland (POL), Portugal (PRT), Qatar (QAT), Romania (ROU), Russia (RUS), Singapore (SGP), El Salvador (SLV), Republic of Serbia (SRB), Slovakia (SVK), Slovenia (SVN), Sweden (SWE), Swaziland (SWZ), Thailand (THA), Trinidad and Tobago (TTO), Tunisia (TUN), Turkey (TUR), Taiwan (TWN), Ukraine (UKR), Uruguay (URY), United States (USA), Venezuela (VEN), Vietnam (VNM), South Africa (ZAF), Zambia (ZMB), Zimbabwe (ZWE)

Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
VIX	22	20.55	7.36	11.46	39.45
Eq Ret_{US}	34	8.27	16.08	-36.83	30.52
VIX*Eq Ret_{US}	22	157.52	363.87	-828.43	702.66
Consumption (Non-dur)	50	1.56	1.47	-3.89	4.12
Consumption (Durable)	50	3.36	2.06	-1.87	7.06
		Portfolio 1			
ER Return	56	-0.02	5.54	-13.13	17.64
T Bill Rate	56	3.25	1.48	0.3	7.49
Carry Return	55	-1.94	6.27	-15	17.45
StD(ER)	56	0.31	0.23	0.01	0.82
Eq Ret_j	27	7.22	16.47	-22.29	37.41
VIX*Eq Ret_j	22	72.11	399.64	-879.3	593.2
		Portfolio 7			
ER Return	56	-1.69	7.78	-26.09	13.04
T Bill Rate	56	10	5.35	1.82	22.62
Carry Return	55	3.33	8.4	-19.46	27.4
StD(ER)	56	0.48	0.48	0	2.94
Eq Ret_j	36	1.46	19.44	-31.24	42.05
VIX*Eq Ret_j	22	11.13	417.25	-864.07	642.95

Table 3.1: Summary statistics for variables that are common across portfolios are presented in the top panel, followed by statistics for portfolio 1 (low interest rate) and portfolio 7 (high interest rate) countries. Carry returns are deflated using the US consumer price index. Equity returns are in excess of the local T-Bill return. Excess equity returns of portfolio 7 countries are more volatile than those of both portfolio 1 countries and the United States. High interest rate currencies tend to depreciate ("ER return"), though not sufficiently to eliminate returns to the carry trade. Factors are demeaned for estimation, but are shown here in raw form.

Correlation Coefficients for Portfolio Equity Returns vs the Components of Carry Trade Returns, Monthly Frequency

	Inflation	Port. Eq. Ret.	ER Return	T-Bill Return
Inflation	1.00			
Excess Portfolio Equity Return	-0.05	1.00		
	<0.01			
ER Return	-0.10	-0.04	1.00	
	<0.01	*0.01*		
T-Bill Return	-0.01	-0.04	-0.01	1.00
	0.56	*0.02*	*0.64*	

Table 3.2: P-values are shown beneath the correlation coefficients. The number of observations is around 4000 (16 portfolios by 12 months by 22 years). The coefficients are based on the assumption that correlation coefficients are common across portfolios, which is not the case, however they may be of interest as summary statistics. The negative correlation of inflation with the exchange rate is consistent with the law of one price for goods, while the negative correlation of inflation and excess equity returns could occur, for example, in response to a negative supply shock. This would suggest that portfolio equity returns proxy for the idiosyncratic macroeconomic risk to which carry trade investors are exposed. The significant negative correlation between T-Bill returns and excess equity returns, which could occur if portfolio reallocations arise from changes in idiosyncratic macroeconomic risk, further suggests such risk lies behind the portfolio equity factor.

3.7 Hypothesis 1 Factor Betas

Hypothesis 1 Betas, 1953-2007

Portfolio	Avg Return	VIX	Eq Ret_{US}	VIX*Eq Ret_{US}	StD(ER)	Eq Ret_i	VIX*Eq Ret_i
1	-1.94	0.01	0.41	0.00	-32.41	0.33	-0.03
2	-0.48	0.09	0.95	-0.04	3.66	-0.35	0.01
3	0.18	0.02	0.48	-0.02	-5.31	0.2	-0.01
4	-0.37	0.54	0.31	-0.02	-8.35	0.17	0.00
5	0.65	0.18	0.32	-0.01	-9.9	-0.27	0.01
6	1.2	0.72	0.85	-0.04	5.7	0.32	-0.01
7	3.33	0.23	0.45	-0.02	19.16	-0.04	0.00
8	2.53	0.34	1.33	-0.05	-7.72	-0.27	0.01

Table 3.3: Average carry trade returns and factor betas by portfolio for Hypothesis 1. The betas are not individually significant (p-values are not shown), but the null hypothesis that they are equal across portfolios is rejected at the 1% level, based on a Seemingly Unrelated Regression χ^2 test (Zellner, 1962). Portfolio 1 represents the lowest interest rate currencies, Portfolio 8 the highest. Portfolio equity betas appear to decrease in the interest rate, with negative betas possibly related to inflation shocks, while positive betas may reflect changes in the discount rate.

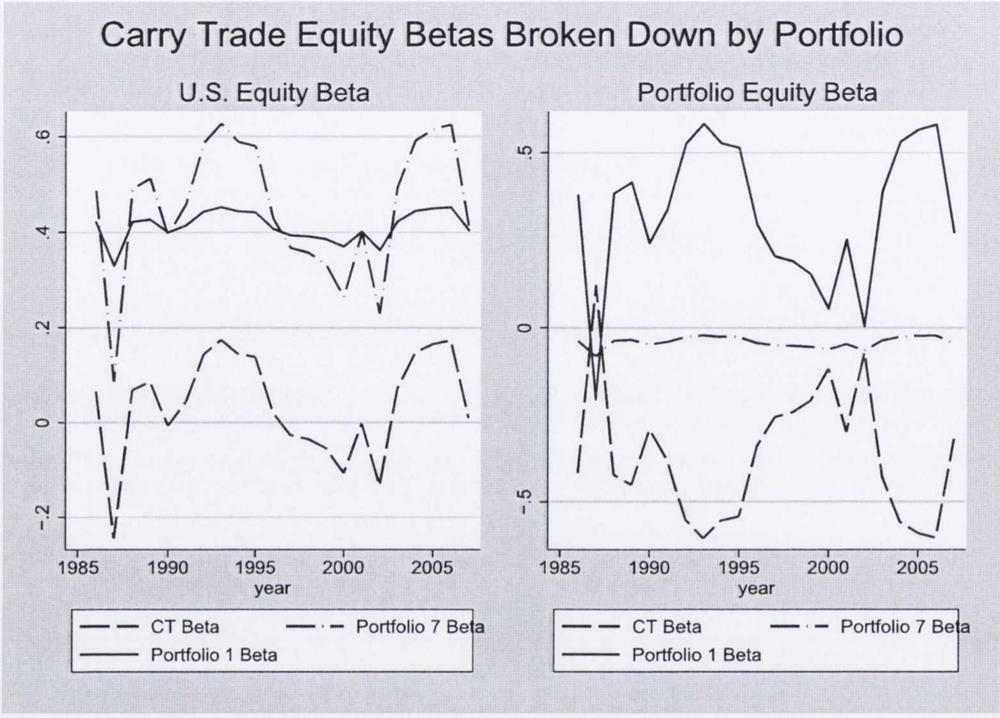

Figure 3.2: This and the following graph show data beginning in 1986, the earliest date for which VIX is available, however the regressions underlying the graphs are based on data since 1953. The carry trade strategy chosen here goes long portfolio 7 and short portfolio 1, which should maximize returns for the sample studied. The portfolio 7 (high interest currencies') world equity beta is highly volatile, whereas the portfolio 7 portfolio equity beta is relatively flat. The carry trade world equity beta is sometimes positive (particularly during a falling world equity market) and at other times negative. The carry trade portfolio beta is usually negative, occasionally rising almost to zero. This implies that carry trade returns suffer when funding currency equity markets rally.

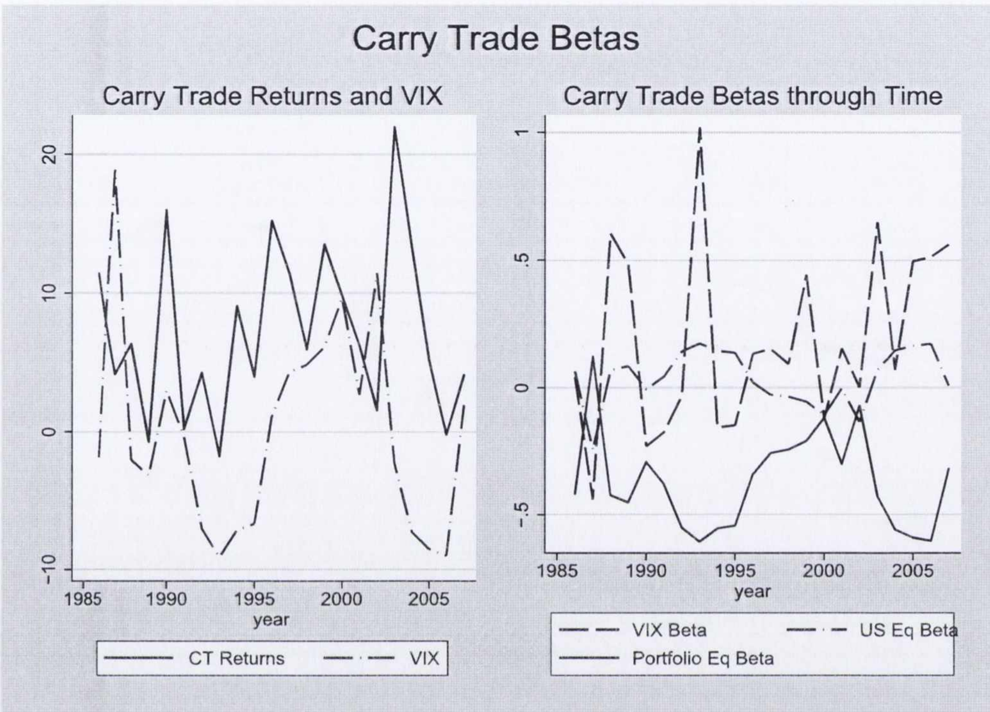

Figure 3.3: This figure shows carry trade returns and VIX on the left panel, with the conditional betas for VIX, world stock markets and portfolio stock markets on the right panel. When the VIX beta peaks carry trade returns tend to be negative or close to zero. This can be seen in 1987, 1993 and 2006. This means that the carry trade may deliver greater exposure to world stock market returns during downturns. Thus, increasing comovement between carry trade returns and world stock market returns may constitute a warning signal for carry trade investors. In a related manner, when portfolio equity betas hit troughs, the carry trade tends to perform badly. Time variation in the betas is economically significant in magnitude and should be carefully observed by carry trade investors.

3.8 Factor Prices for Hypotheses 1 and 2

Hypothesis 1 Factor Price Estimates

	1952-2007	1980-2007
VIX	-3.42*(2.69)*	-6.37*(3.93)*
Eq Ret_{US}	19.37****(5.48)*	24.91****(8.21)*
VIX*Eq Ret_{US}	507.13****(135.74)*	640.40****(200.96)*
StD(ER)	0.16****(0.02)*	0.20****(0.04)*
Eq Ret_i	19.22***(7.35)*	26.36***(10.28)*
VIX*Eq Ret_i	442.09****(158.80)*	595.19***(224.24)*
Constant	3.72***(1.54)*	4.79*(2.67)*
Betas Vary	<0.01	<0.01
R-Squared	97%	99.7%
Shanken Factor	3.56	5.29
Test FPs	<0.01	<0.01
Observations	440	224

Table 3.4: Factor price standard errors are shown in parentheses. "Betas Vary" reports the p-value from testing the null hypothesis that the set of first-stage factor betas is the same across portfolios, based on a Seemingly Unrelated Regression χ^2 test (Zellner, 1962). "Test FPs" reports the p-value from an F-test for the joint significance of the explanatory variables (factor prices). Shanken (1992) correction factors, which correct for the fact that the second stage regression is based on estimated instead of known betas, are somewhat lower than that reported by Burnside (2008) for the Consumption-CAPM model (6.79) (the standard errors are shown before applying this correction. Jagannathan and Wang (1998) show that the direction of bias of the standard errors is unclear). Increasing the degrees of freedom by examining 16 portfolios instead of 8 reduces the factor considerably (see Table 3.9, right panel). The formula for the R-squared statistic is given in Equation 3.19. These regressions strongly support the risk factor explanation of carry trade returns. Equity returns of the countries in portfolio i constitute a significantly priced risk factor. This appears to be a novel finding in the literature. In a univariate model (absent collinearity), the risk factor could be interpreted as the per annum return to an investment which covaries one-for-one with a given risk factor. In this case, collinearity obscures the interpretation somewhat. Increasing the cross sectional degrees of freedom by examining 16 portfolios (results below) helps alleviate this problem.

Hypothesis 2 (DCAPM) Factor Price Estimates

	1952-2002
Consumption (Non-dur)	4.60*** *(1.00)*
Consumption (Durable)	1.97** *(0.92)*
Constant	-3.06*** *(0.85)*
Betas Vary	0.97
R-Squared	74%
Shanken Factor	6.06
Test FPs	<0.01
Observations	400

Table 3.5: These factor prices replicate closely those of Lustig and Verdelhan (2007), however the underlying betas are not significantly different across portfolios (see row "Betas Vary"). This makes the factor price estimates invalid. The discrepancy in estimated betas may be due to sample error. Table 3.8 shows the effect of small changes in sample.

Hypotheses 1 and 2 Jointly Estimated, and Hypothesis 1 at Monthly Frequency

	1952-2007	1986-2007, Monthly
VIX	-2.68* *(1.52)*	3.43* *(1.86)*
Eq Ret_{MSCI}	2.50 *(2.43)*	3.34*** *(1.21)*
VIX*Eq Ret_{MSCI}	27.59 *(52.56)*	106.11*** *(34.40)*
StD(ER)	0.19 *(0.15)*	-0.13 *(0.09)*
Eq Ret_i	9.17** *(3.67)*	3.09** *(1.37)*
VIX*Eq Ret_i	146.25** *(66.72)*	96.24** *(41.28)*
Consumption (Non-dur)	0.05 *(0.17)*	
Consumption (Durable)	-0.37 *(0.43)*	
Constant	2.25* *(1.21)*	-0.01 *(0.16)*
Betas Vary	<0.01	<0.01
R-Squared	14.9%	48.2%
Shanken Factor	1.41	2.68
Test FPs	0.02	<0.01
Observations	827	4222

Table 3.6: Factor price estimates for Hypotheses 1 and 2 jointly, and for Hypothesis 1 at monthly frequency, both based on sixteen portfolios, with standard errors shown in parentheses. "Betas Vary" reports the p-value from testing the null hypothesis that the set of first-stage factor betas is the same across portfolios, based on a Seemingly Unrelated Regression χ^2 test (Zellner, 1962). "Test FPs" reports the p-value from an F-test for the joint significance of the explanatory variables (factor prices). These factor price estimates support the existence of an idiosyncratic risk factor in carry trade returns. The consumption factors are insignificant, with collinearity between consumption and world equity factors also rendering the latter insignificant, despite the use of MSCI in place of U.S. equity returns as a proxy for world equity returns. The estimated R-Squared drops significantly on inclusion of the consumption risk factors. This fall occurs because the R-Squared used here considers only a second stage fit, where the low degrees of freedom make the measure sensitive to the inclusion of additional factors (the formula for the R-squared statistic is given in Equation 3.19). The results are borne out at monthly frequency. The right panel shows monthly factor premia. Multiplying by twelve gives annualised premia which, as in the annual case, are somewhat higher than expected, but of the correct sign, with the high magnitude possibly caused by collinearity. The change in sign of the VIX coefficient is contrary to the usual interpretation that assets with a high VIX beta offer insurance, but is consistent with the alternative view that periods of high volatility may impair the functioning of arbitrage, allowing significant excess returns to remain.

3.9 Robustness

Portfolio Equity (Hypothesis 1) and Consumption Factors (Hypothesis 2) compared on a Common Sample

	1952-2002		1952-2002
VIX	3.32*(3.07)*	VIX	-2.58*(3.80)*
Eq Ret_{US}	8.33*(7.08)*	Eq Ret_{US}	20.87*(12.81)*
VIX*Eq Ret_{US}	210.27*(176.74)*	VIX*Eq Ret_{US}	567.49*(376.95)*
StD(ER)	0.07*(0.06)*	StD(ER)	0.15****(0.03)*
Eq Ret_i	-4.35*(8.13)*	Consumption (Non-dur)	-0.46*(0.86)*
VIX*Eq Ret_i	4.11*(185.93)*	Consumption (Durable)	-0.34*(1.03)*
Constant	-0.42*(1.95)*	Constant	3.89*(4.18)*
Betas Vary	<0.01	Betas Vary	<0.01
R-Squared	89%	R-Squared	88%
Shanken Factor	2.28	Shanken Factor	4.13
Test FPs	<0.01	Test FPs	<0.01
Test Target Eq FPs	<0.01	Test Consmptn FPs	0.77
Observations	400	Observations	400

Table 3.7: This table compares the Consumption CAPM model against the portfolio equity factors on a common sample, controlling for exchange rate volatility and world equity returns. The two portfolio equity factors are jointly significant, while the two consumption factors are not (second from bottom row). Collinearity combined with the low degrees of freedom reduces individual significance levels to the extent that the individual point estimates are not accurately estimated. Other row labels are explained in Table 3.4.

Hypothesis 2 (DCAPM) Factor Price Estimates, Alternative Cross Sectional Sample Selection Criteria

	1952-2002		1952-2002
Consumption (Non-dur)	1.40** *(0.61)*	VIX	0.08 *(1.65)*
Consumption (Durable)	2.61** *(1.01)*	Consumption (Non-dur)	0.61* *(0.34)*
Constant	-2.12 *(1.28)*	Consumption (Durable)	0.74* *(0.40)*
		VIX*Consumption (Non-dur)	14.45 *(9.94)*
		VIX*Consumption (Durable)	11.22 *(14.24)*
		Constant	1.16 *(0.92)*
Betas Vary	0.97	Betas Vary	0.44
R-Squared	27%	R-Squared	79%
Shanken Factor	2.7	Shanken Factor	2.1
Test FPs	0.03	Test FPs	<0.01
Observations	400	Observations	400

Table 3.8: DCAPM factor prices for the cross sectional sample used throughout this essay, but limited to the time frame examined by Lustig and Verdelhan (2007). There is no significant variation in betas across portfolios. A model with VIX-based interaction effects, allowing for time variation in the betas, likewise fails to produce significantly different factor betas. There appears to be little evidence to support a DCAPM explanation of carry trade premia.

World Equity Factor Prices, and Portfolio and World Equity Factor Prices with 16 Portfolios

	1952-2007		1952-2007, 16 Portfolios
VIX	1.92*(1.61)*	VIX	-2.85*(1.76)*
Eq Ret_{US}	9.93****(3.22)*	Eq Ret_{US}	6.84**(3.97)*
VIX*Eq Ret_{US}	241.13****(77.71)*	VIX*Eq Ret_{US}	118.97*(79.01)*
StD(ER)	0.12****(0.02)*	StD(ER)	-0.04*(0.04)*
Constant	0.90*(1.34)*	Eq Ret_i	13.93***(5.73)*
		VIX*Eq Ret_i	359.74****(123.41)*
		Constant	0.07*(0.89)*
Betas Vary	0.03	Betas Vary	<0.01
R-Squared	90%	R-Squared	57%
Shanken Factor	1.86	Shanken Factor	1.67
Test FPs	<0.01	Test FPs	<0.01
Observations	440	Observations	826

Table 3.9: The first column shows factor price estimates for a sub-model of Hypothesis 1, where portfolio equity returns are excluded. The 7% drop in R^2 compared to the full model suggests that portfolio equity returns contribute a reasonable degree of explanatory power. The second column shows the full model where return calculations have been based on a greater number of portfolios (16) with a smaller number of countries in each. The increase in cross-sectional degrees of freedom leads to a smaller Shanken correction factor. The explanatory factors remain highly significant in a joint test ("Test FPs"). Other quantities are explained in Table 3.4.

Hypothesis 1, 16 Portfolios, Rich Country Subsample and with MSCI World Equity Index

	1952-2007, 50 countries		1952-2007, MSCI
VIX	3.54*** *(0.72)*	VIX	-1.28 *(1.47)*
Eq Ret_{US}	-0.35 *(2.07)*	Eq Ret_{MSCI}	8.45* *(4.55)*
VIX*Eq Ret_{US}	5.29 *(44.24)*	VIX*Eq Ret_{MSCI}	171.62* *(92.52)*
StD(ER)	-0.02 *(0.03)*	StD(ER)	-0.01 *(0.03)*
Eq Ret_i	4.84 *(3.36)*	Eq Ret_i	10.19** *(5.06)*
VIX*Eq Ret_i	87.36* *(49.57)*	VIX*Eq Ret_i	241.04** *(108.83)*
Constant	1.65 *(1.24)*	Constant	-0.45 *(1.30)*
Betas Vary	<0.01	Betas Vary	<0.01
R-Squared	72%	R-Squared	45%
Shanken Factor	1.41	Shanken Factor	1.36
Test FPs	<0.01	Test FPs	<0.01
Observations	755	Observations	826

Table 3.10: Factor price estimates for Hypothesis 1 when calculated on a sub-sample of the 50 richest countries by GDP per capita in 2000 are shown in the left panel. The world and portfolio equity factor prices are substantially lower. This suggests that the high values on the broad sample are due to the high volatility and average level of returns of some of the less developed countries and collinearity between the explanatory factors. Row labels are explained in Table 3.4. The lower degrees of freedom due to the sample restriction means that individual coefficients are less accurately estimated, however joint significance remains high. Estimating the model with the world equity or with the portfolio equity factors removed in order to economise on degrees of freedom reinforces the significance of both sets of factors (results available on request). The right panel shows results with the MSCI World Return Index used to estimate global equity returns in place of U.S. equity returns. The coefficients remain similar and retain a high degree of statistical significance jointly, although the substantial drop in explanatory power is notable.

Hypothesis 1 Factor Price Estimates by Home Country of Investor, 1952-2007

	Japan	United Kingdom
VIX	3.00*(4.49)*	-2.10*(2.42)*
Eq Ret_{US}	18.23****(6.18)*	18.96****(4.69)*
VIX*Eq Ret_{US}	504.15****(145.41)*	491.19****(153.10)*
StD(ER)	0.01*(0.07)*	-0.04*(0.13)*
Eq Ret_i	6.87*(6.29)*	11.27*(13.62)*
VIX*Eq Ret_i	181.69***(80.83)*	347.92*(233.44)*
Constant	3.36**(1.79)*	-1.31*(3.41)*
Betas Vary	<0.01	<0.01
R-Squared	76%	81%
Shanken Factor	3.77	3.13
Test FPs	0.08	<0.01
Test Target Eq FPs	<0.01	<0.01
Observations	376	440

Table 3.11: This table shows factor prices for a Japanese and United Kingdom based investor. Returns are calculated in yen or pounds discounted with the appropriate consumer price index series. The Japanese or British T-Bill return is subtracted from the raw carry trade return. United States equity returns are converted to the appropriate currency (yen or pounds), while portfolio equity returns remain in domestic currency. The results appear broadly robust to the choice of investor's home country. The point estimates of the factor prices change considerably, however this is not surprising in an interaction effect model with high collinearity. More importantly, the explanatory factors remain jointly significant. The row "Test Portf Eq FPs" reports the p-value from a joint F-test of the portfolio equity returns factor and its interaction with VIX, the S&P volatility index. The change in sign of the VIX factor price suggests that U.S. equity volatility may be less important for Japanese and U.K. investors than for U.S. investors. Row labels are explained in Table 3.4.

Chapter 4

Global Funding Liquidity, Equity Returns and Crash Risk: Implications for Monetary Policy

4.1 Introduction

This essay asks whether equity market returns incorporate a risk premium for low interest rates, opposing the usual prediction that high interest rates constitute a risk factor. Low interest rates could constitute a risk factor if they lead to excess leverage, thus increasing crash risk. To limit the risk of endogeneity bias from equity prices to lending rates, common volatility in exchange rate markets is used as an indicator of the component of equity risk deriving from liquidity risk. Assuming that investors in equity and currency markets have access to the same global credit markets, the funding conditions faced by both investors are common across asset classes as well as assets. An increase in the shared component of volatility across assets could indicate the increased importance of liquidity conditions over fundamentals, signaling increased crash risk. In summary, this essay seeks to show that excessively low interest rates could increase leverage and crash risk, which in turn could increase excess equity returns, as investors demand compensation for this risk.

While there is a literature on incorporating liquidity risk in asset pricing models, to the best of the author's knowledge this will be the first essay to empirically test whether excessively loose global funding liquidity, rather than tight funding liquidity or low market liquidity, is a priced risk factor. This is akin to asking if investors know when interest rates are at a level which encourages excess leverage. If excess funding liquidity is a risk factor, then changes in common volatility may provide a means by which monetary policy or other financial oversight authorities can infer when low interest rates are causing or contributing to an asset price bubble.

The essay begins by establishing an empirical relationship between increased sensitivity of exchange rates to global shocks (increased common volatility) and changes in funding liquidity. This allows the liquidity-driven component of sensitivity to global shocks to be used as an indicator of the presence of global funding liquidity risk. Equity returns are then regressed on this factor. Commonality in variance is used because, unlike variance or covariance (commonality in returns), there is no clear mechanism whereby commonality in variance across assets in one market would influence global credit market conditions. Its use as an exogenous indicator of liquidity risk may therefore be less problematic than the use of commonality in returns. To further ensure the exogeneity of estimated liquidity risk to equity prices, predicted liquidity risk is used in the second stage. The procedure can be summed up as estimating a variable indicating excess liquidity and testing whether equity markets incorporate a risk premium when the excess liquidity indicator is high.

This essay relates most directly to Brunnermeier and Pedersen's (2009) contribution on Market and Funding Liquidity, where the authors derive an asset pricing equation which incorporates a cost of capital premium, part of which is asset specific and part of which is common across assets. Brunnermeier and Pedersen's model provides a theoretical justification for the contention that common variance across assets could depend on liquidity conditions. This essay also relates to the literature on volatility risk premia, but differs in that the volatility in question is not an asset's own volatility, but rather common volatility from the currency markets. Adrian and Shin (2010) note that changes in repo positions forecast the volatility risk premium, explaining that an expansion in balance sheets due to increased collateralized lending and borrowing releases new funding which chases yields, "selling the tails" and sending the risk premium higher. This provides some intuitive and empirical support for the contention that funding liquidity conditions can drive returns.

Finally, this essay also relates to the expansive literature on market liquidity premia, since market and funding liquidity are linked. Many studies have shown an asset-specific market liquidity premium. Ang et al (2006) have studied aggregate market liquidity, showing that this too is priced in equities. The present essay contributes to this literature in three ways: it offers an economic argument for the significance of aggregate liquidity which differs from the usual market liquidity premium hypothesis, it empirically links returns back to aggregate funding liquidity, and it estimates a timely indicator of funding liquidity conditions.

4.2 Previous Studies of Liquidity Premia

A number of recent studies have highlighted the link between the balance sheets of financial intermediaries and perceived market risk appetite. Adrian et al (2009) claim that "As balance sheets expand and leverage rises, the constraints faced by financial intermediaries loosen, thereby increasing their risk appetite". This expansion or contraction in balance sheets is found to forecast exchange rate returns, potentially providing some empirical basis for the use of exchange rate volatility as an indicator of the liquidity risk priced in equities. Likewise, Adrian and Shin (2010) show that changes in dealer repurchase agreements, which is the primary margin of adjustment for the aggregate balance sheets of intermediaries "forecast changes in financial market risk as measured by the innovations in the Chicago Board Options Exchange Volatility Index (VIX)". This is consistent with high funding liquidity causing increased financial risk, although in the present essay it is claimed that this occurs through greater leverage providing greater exposure of equity prices to liquidity conditions, rather than through increased risk appetite per se. The predictions from the two mechanisms potentially oppose each other. If increased funding availability decreases the price of risk, it will also decrease option-implied volatility (VIX), whereas if it provides greater exposure to liquidity risk, it will increase the common component of volatility and also the cross sectional average.

Brunnermeier and Pedersen (2009) present a model of market and funding liquidity spirals. Such spirals are also discussed by Garleanu and Pedersen (2007), where, according to the authors, a fall in market liquidity may lead to tighter risk management due to the longer time required to sell a security. Tighter risk management in turn leads to lower market liquidity, since it takes longer to find a buyer with unused risk-bearing capacity. This liquidity spiral leads to a fall in prices. It seems plausible that the spiral would be steeper if investors are more highly leveraged, funding their positions partly via credit, unlike in Brunnermeier and Pedersen (2009) where speculators fund their positions from existing wealth. If investors are more highly leveraged, pressure to service debt and renew lines of credit provide additional sources of uncertainty, further tightening risk management. Following this logic, this essay tests whether tight ex ante credit conditions choke movement down the liquidity spiral, while loose credit conditions enable this movement.

Studying the US equity market, Ang et al (2006) find that stocks with high exposure to systematic volatility risk earn low returns, and that market-wide liquidity risk does not explain this effect. The present essay claims that liquidity should have a differential effect on equity returns over different horizons, whereby high liquidity enables a liquidity crisis, and a reduction in liquidity is the precipitative cause. This is the rationale for examining liquidity-induced uncertainty (volatility), which may be an indicator of potential liquidity crises which have yet to manifest in actual liquidity.

This essay will also contribute to the literature on common risk factors in exchange rates. Lustig and Verdelhan (2009) show how a single common factor, equal to the difference between the return to high and low interest rate currencies, can explain a significant portion of the returns to the carry trade. It is possible that this factor is related to global liquidity, a question which this essay will help to answer. Guo, Neely and Higbee (2008) have shown that realized foreign exchange volatility is priced in equity returns, possibly because an increase in exchange rate volatility makes the hedging of exchange rate level risk more difficult. Some portion of the foreign exchange volatility risk premium identified by these authors may be attributable to liquidity risk, with volatility proxying for crash risk. This essay suggests that this is the case.

4.3 Empirical Model

Brunnermeier and Pedersen present a model of funding and market liquidity in which ϕ, the shadow cost of capital to a speculator, partly determines asset prices (indexed by j at time $0, 1$):

$$p_0^j = E_0[p_1^j] + Cov_0[\phi_1, p_1^j]/E_0[\phi_1]. \tag{4.1}$$

A high ϕ means that the level of funding available is low relative to the level needed by the market. Normally, some part of a speculator's position will be leveraged, and the speculator must return to the credit market at intervals to roll over her loans. If funding liquidity is relatively low in some period, the speculator may have to reduce her open portfolio positions. Thus, changes in the cost of capital can influence prices by forcing speculators to reduce (or allowing them to increase) the absolute value of their long or short positions. This is one way in which a liquidity spiral of the type studied by Brunnermeier and Pedersen can begin. In that paper larger margin requirements play the role of an increasing cost of capital, however it seems likely that if larger margin requirements force a sell-off of assets this would have to be accompanied by higher interbank lending rates, since the marginal investor would fund part of the additional margin through the credit market and part by reducing her position in the asset. Increasing margin requirements and increasing interbank lending rates both affect asset prices by reducing available funding.

In a model where liquidity plays a role in prices, the effect on prices of a unit change in the cost of capital will vary depending on the initial level of funding provision, which in turn depends on interest rates. Letting h and l indicate high and low interest rate regimes, P the principal and i the interest rate, the change in interest repayments is greater under the low regime:

$$(i^h + 1)P^h - i^h P^h < (i^l + 1)P^l - i^l P^l. \tag{4.2}$$

This condition is satisfied as long as $P^h < P^l$, in other words more is borrowed under the low interest rate regime. Ceteris paribus, the speculator will be forced to sell a greater proportion of her position under the low interest rate regime than under the high. If we suppose the net order flow from the speculator is a function of the change in interest repayments, which would occur if the speculator invests until her budget constraint binds (as is the case in Brunnermeier and Pedersen for speculators who take a non-zero position in some asset) then we expect order flow and asset prices to depend more on interest rate changes under a low interest rate regime. In this way, the interest rate level determines the extent to which funding liquidity drives asset price uncertainty. To establish this relationship empirically requires an estimate of liquidity-driven volatility, where volatility is used as an indicator of uncertainty.

Following from Equation 4.1, an asset's volatility can be decomposed into a fundamental-driven, idiosyncratic component and a common, liquidity-driven component:

$$Var(p^j) = a^j Var^j + b^j Var(\phi). \tag{4.3}$$

The cross-sectional average volatility

$$\overline{Var}(p^j) = 1/k\Sigma_j a^j Var^j + \bar{b^j} Var(\phi) \tag{4.4}$$

provides an estimate of the liquidity driven volatility factor which is unbiased under the assumption that idiosyncratic volatility is mean zero with zero covariance in the cross section, in which case the first term on the right hand side is zero for a sufficiently large sample size of assets, k. In the empirical analysis, volatility z-scores (whose construction is explained below) are used. These have zero mean but possibly non-zero cross-sectional correlation. The correlation, and thus the term $1/k\Sigma^j a^j Var^j$, may be non-zero if there is some factor other than liquidity conditions that determines the degree of common variation in exchange rates. Zero correlation of non-liquidity related volatility is not required, since estimated common volatility is used in the second stage. As long as non-liquidity related volatility is orthogonal to interest rates, this estimated volatility is an unbiased estimate of liquidity-induced volatility. This orthogonality is guaranteed by definition of the common volatility as the component of volatility that derives from the interest rate level.

As discussed above, the interest rate level (i_t) may determine the component of average asset price uncertainty that derives from uncertainty in liquidity ($\bar{b}_t^j Var(\phi_t)$). By definition of the common volatility component as the component of volatility deriving from liquidity risk, average fundamental volatility ($1/k\Sigma^j a^j Var^j$) is orthogonal to interest rates. Regressing average asset volatility on interest rates

$$\overline{Var}(p_t^j) \equiv 1/k\Sigma_t^j a_t^j Var_t^j + \bar{b}_t^j Var(\phi_t) = c + f(i_t) \tag{4.5}$$

thus produces an estimate of the liquidity driven component of asset price volatility, $\widehat{\overline{Var}(p_t^j)} = \widehat{\bar{b}_t^j Var(\phi_t)}$. To further strengthen the claim for the exogeneity of common exchange rate volatility to equity returns, predicted common volatility is used in the equity regressions instead of realized volatility. Predicted common volatility is interpreted as an indicator of crash risk arising from the level of liquidity and leverage. The final step in the procedure is to regress equity returns on predicted common volatility, to test whether liquidity risk is a priced risk factor. The twelve month lagged moving average of the three-month T-Bill rate is used to represent the interest rate level. This time horizon is consistent with the argument that excess liquidity could build up over a sustained period of excessively low rates.

4.4 Model Estimation and Data

4.4.1 Model Estimation

The model is estimated in two stages.

Stage 1: Estimate the uncertainty due to liquidity conditions in exchange rate markets by regressing average exchange rate volatility on the lagged (by one month) twelve-month moving average of the three-month T-Bill return:

$$\overline{Var}(p_t^j) = \alpha + \beta i_{t-1} + \epsilon_t. \tag{4.6}$$

To allow a causal interpretation of the effect of the interest rate level on liquidity volatility, this regression is implemented within a Structural VAR, identified by the restriction that time-t exchange rate volatility cannot affect the lagged twelve month moving average of the T-Bill return.

Stage 2: Determine if liquidity volatility is priced in equity markets by regressing equity returns on predicted common exchange rate volatility

$$r_t = \gamma + \delta\widehat{\overline{Var}}(p_t^j) + \zeta F_t + u_t, \tag{4.7}$$

where F is a vector of other factors commonly used to explain equity returns. The factors used are the market return, the size and value factors of Fama and French (1993), the momentum factor of Jegadeesh and Titman (1993), changes in the VIX volatility index, Pastor and Stambaugh's (2001) market liquidity factor, the TED spread and realized exchange rate volatility.

Calculation of Global Currency Volatility

Country i's volatility in month t is $\omega_t^i = (\sigma_t^i - \bar{\sigma}_t^i)/\sigma_{\sigma_t^i}$ where σ_t^i is the standard deviation in month t of the daily exchange rate and $\sigma_{\sigma_t^i}$ is the standard deviation over all periods of the monthly standard deviations. This gives a scale-free measure of exchange rate volatility for a given month. For example, $\omega_t^i = 0$ if month t's volatility is equal to the long run average, and $\omega_t^i = 1$ if it exceeds by one standard deviation the long run average. Global volatility is then calculated as $\omega_t = \Sigma_i b_i \omega_t^i$, where b_i is country (or block of countries in the case of the euro) i's static weight, calculated as its share of total GDP of the six areas in 2000. The weights are given in Table 4.1. The global currency volatility measure is based on the six major floating currencies against the dollar: yen, euro, pound, Swiss franc, Australian and Canadian dollars. Prior to the introduction of the euro, the Deutschmark is used in its place, with the weights adjusted accordingly.

4.4.2 Data

Size, value and momentum factors, as well as the market return and the 25 size by value portfolios are all taken from Kenneth French's data library.[1] For countries other than the US, market return, book to market equity and earnings/price data are also taken from Kenneth French's data library. International returns are based on dollar prices. The countries for which these data are provided are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Italy, Japan, Malaysia, Netherlands, New Zealand, Norway, Singapore, Spain, Sweden, Switzerland, United Kingdom.

Exchange rate data, VIX (the Chicago Board Options Exchange implied volatility index), T-Bill returns and the TED spread are taken from Global Financial Data. The TED spread is the difference between 3-month LIBOR (an average of interest rates offered in the London interbank market for 3-month dollar-denominated loans) and the 3-month treasury bill rate. A rising TED spread may be an indication that liquidity is being withdrawn. LIBOR data are available from 1986, and this year is chosen as a starting point for the analysis.

GDP data for the purpose of weighting currencies in the average volatility calculation are taken from the Penn World Tables (Heston, Summers and Aten, 2009).

4.5 Empirical Results

The empirical results are consistent with the hypothesis advanced above, that low interest rates can increase equity risk by increasing investors' degree of leverage. Table 4.1 shows that the major exchange rates display a strong common volatility factor. Regressions of individual exchange rate volatilities on the estimated common factor have significant explanatory power in every case. Figure 4.1 shows the considerable variation in interest rates over the period 1986-2008, and also suggests that the choice of interest rate will not be a critical factor at monthly frequency. Figure 4.2 plots realized common exchange rate volatility against the three-month T-Bill rate. It is possible that contemporaneous exchange rate volatility is endogenous to the T-Bill rate, with both variables potentially responding to financial market distress, for example. This is consistent with the significant negative correlation shown in Table 4.8. Of greater interest in this essay is any possible long run effect of the interest rate level on common exchange rate volatility, which is interpreted as an

[1] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

estimate of the common asset price volatility arising from risks to funding liquidity. In order to analyze this possible relationship, a structural vector auto-regression is estimated. It is interesting to note that both realized and predicted common exchange rate volatility are significantly positively correlated with the TED spread, which is sometimes used as an indicator of illiquidity. Rather than indicating actual illiquidity, the average volatility variable is intended to estimate uncertainty in funding liquidity, so that a perfect correlation with actual illiquidity would not be expected. Similarly, the correlation with Pastor and Stambaugh's liquidity factor (not shown) is significant and negative for both realized and estimated liquidity volatility, although the p-value in the case of estimated volatility is higher at 0.06.

The SVAR regressions show a significant causal effect from shocks in the lagged twelve-month moving average interest rate to common exchange rate volatility. This is consistent with the hypothesis that holding interest rates low for too long can increase the risk of a funding liquidity crash, via increasing leverage, and vice versa: high interest rates reduce leverage, reduce the crash risk arising from possible changes in funding liquidity, and reduce common asset price volatility. Figure 4.3 shows that a shock to the moving average of the interest rate has a significant effect on exchange rate volatility after about a year. The forecast error variance decomposition is show in Figure 4.4. The component of the exchange rate volatility forecast error attributable to shocks in the moving average t-bill rate is not significant at standard significance levels. This may be a consequence of high persistence rendering the moving average representation on which the error decomposition is based less accurate. Explicitly detrending the series using Elliott, Rothenberg and Stock's (1996) generalized least squares Dickey Fuller procedure, instead of relying on the lag structure used in the SVAR, produces immediately significant forecast error component (shown in the right panel of Figure 4.4). The SVAR lag structure is preferred since it is more readily interpretable and because forecasting is not the primary aim of this research.

Table 4.3 presents equity betas for predicted exchange rate volatility based on the estimated SVAR. The dependent variables are the returns to twenty-five size-by-value Fama French portfolios (Fama and French, 1993). The estimated betas explain part of the variation in returns in both the time series and the cross-section. Eight of twenty-five coefficients are significant in the time series, and, moreover, the twenty-five coefficients are jointly significantly different from each other and from zero at the 1% level. When predicted exchange rate volatility is added to the three factor Fama-French model, the cross-sectional correlation coefficient between the volatility betas and average returns is -0.5 (p-value .01), suggesting that portfolios that do well when predicted volatility is high (have a high beta) pay lower returns, or in other words, require an insurance premium. Likewise, for negative beta portfolios, which fall when liquidity crash risk is high, investors appear to demand compensation for exposure to this risk.

The recessions of the early 1990's and late 2000's coincided with significant financial market turmoil. To test if this fact influences the results, the model is re-estimated over the sub-period 1993-2006 (inclusive). The relationship between common exchange rate volatility and interest rate levels is still clearly seen over this period, although it is notable that the delay between an interest rate shock and the resulting common volatility is somewhat longer (Figure 4.5). This may be influenced by the response to the recession of the early 2000's. The results appear to suggest that the initial drop in interest rates in response to this recession did not adversely affect liquidity risk, but the sustained low interest rates over several years eventually had an effect. The second stage results also remain significant, although the level of significance falls. The p-value for the test of joint significance of the predicted exchange rate volatility betas over the 1993-2006 period rises to 0.06 (Table 4.4).

An alternative line of robustness checks investigates other measures of volatility. The first is range-based volatility, where the daily range of an exchange rate is calculated as the absolute difference between the daily high and low values. Standardized monthly averages of this value are then calculated, in line with the calculations detailed in Section 4.4. The second alternative measure controls for shifts in the exchange rate by subtracting the absolute value of the difference between the open and close prices from the range. This variable is examined in first differences, due to high persistence in the levels. Structural VAR's based on both of these variables satisfy the stability conditions, despite the high persistence (Figure 4.6). Estimated betas based on the range measure are presented in Table 4.5. These betas are jointly significant at the 1% level.

Finally, Table 4.6 shows the estimated market betas for a number of countries, controlling for the international Fama French factors. Predicted volatility betas are not significant in the four portfolio cross section formed on the book-to-market equity and earnings/price ratio available from Kenneth French's website, but they are significant for a number of countries when tested on the market returns. Many of the countries for which the volatility beta is significant are countries which often witness funding liquidity-related changes in capital flows, most notably Japan, due to its involvement in the carry trade.

4.6 Further Work

One criticism of this research could be that the focus on equity markets in the second stage makes it difficult to rule out the possibility that the liquidity indicator was found to be significant by chance. Broadening the test to include other asset markets could help to strengthen the evidence.

Property markets in the United States and around the world may have undergone liquidity fueled bubbles around the mid-2000s, and could therefore provide a natural testing ground, however the development of mortgage backed securities contemporaneously with this bubble may have caused a structural change in real estate markets which would be difficult to control for. Considering a longer sample may help to overcome this problem, but would likely involve controlling for other structural changes, such as the introduction of electronic trading, the rise of hedge funds, and changes in the degree of international financial integration.

Bond markets may not provide a suitable test of the liquidity indicator, since the prediction that returns compensate for crash risk may not apply to these markets, which often post positive returns during periods of market turmoil. Despite the difficulties of taking the test to other markets, focusing on equity markets alone is a shortcoming of this work which should be addressed in a more expansive study.

Similar to the focus on equity markets in the second stage, the dependence on foreign currency markets in the first stage of the test could be criticised for being too narrow. It is possible that the common volatility component derived from an array of asset classes instead of simply exchange rates could provide a less noisy indicator of liquidity risk.

A second means of broadening the testing framework would be to estimate a within-country liquidity effect. The credit market considered in this essay is a global market, however it is possible that during periods when the credit market was more fragmented, domestic credit conditions may have contributed to domestic asset price crash risk. Although exchange rate volatility would not provide an indicator of liquidity crash risk in the domestic case, volatility data for an alternative, domestic proxy market, may be available. The endogeneity problem in the domestic case could be more acute than for global markets, but it may still be possible to identify a market which is influenced by credit conditions, without itself influencing those conditions.

A third direction for further work is to augment the liquidity measure. This essay has focused on the monetary policy decision variable as the main determinant of funding availability, since the target overnight interbank lending rate affects many kinds of credit in the economy, and studying the impact of changes in the monetary policy decision variable ensures this work is relevant for policy analysis. Examining the link between debt and monetary aggregates and funding liquidity might help to improve the measurement of liquidity. One difficulty is that credit and monetary aggregates reflect innovations in securitization, rendering their empirical content as a liquidity indicator uncertain. Kevin Warsh, a member of the Federal Reserve Open Market Committee, has stated "I doubt ... that traditional monetary aggregates can adequately capture the form and structure of liquidity ... incorporating notions of credit availability, fund flows, asset prices, and leverage."[2]

Despite the difficulties posed by structural changes in the credit markets, several studies have attempted to analyse the price implications of monetary aggregates. Using simple regression analysis and correlations, Baks and Kramer (1999) find that global money growth (a weighted average

[2]Address to the Institute of International Bankers Annual Washington Conference, Washington, D.C., March 2007. Available from http://www.federalreserve.gov/newsevents/speech/warsh20070305a.htm

of narrow and broad money measures for G7 countries) is negatively related to interest rates and positively related to stock returns. Both of these stylized facts support the findings of the present research, in particular, the negative relation between interest rates and money growth is consistent with the use of interest rates as an indicator of liquidity. Sousa and Zaghini (2004) find that an unexpected increase in money abroad causes a permanent increase in euro area money, and leads to price pressure on consumer goods. The possibility of such liquidity spillovers is a necessary condition for exchange rate volatility to react to liquidity provision, and for the tests of the liquidity risk effect on foreign equity markets presented in Section 4.11. A challenge for future research will be to adapt these measures of monetary liquidity to allow for credit availability and leverage, forming an inclusive indicator of funding liquidity.

Some recent results in the liquidity literature reinforce the relevance of funding availability to market liquidity, which is widely acknowledged as a priced risk factor, and thus complement the results presented here. Hameed, Kang and Viswanathan (2010) show that "negative market returns decrease stock liquidity, especially during times of tightness in the funding market". In a similar vein, Comerton-Forde et al (2010) show that market liquidity responds to market-maker balance sheet variables, suggesting that the funding constraints of the liquidity supplier matter. These contributions provide evidence for the second stage of the liquidity effect studied in this essay, where predicted funding liquidity is thought of as a risk factor. Similar studies addressing the first stage, where loose monetary policy encourages levered investment, which could perhaps follow Comerton-Forde et al in using firm-level data, would bolster the argument.

By examining the lagged effects of monetary policy over an extended period, this essay abstracts from the spiral dynamic that forms the main focus of empirical research, instead focusing on a pre-condition for such a spiral. The approaches are complementary, but differ in timing and in scope, with the present study explicitly attempting to derive policy implications. The dependence of volatility on funding conditions relies on the spiral and crash mechanism, so that empirical evidence of this mechanism provides additional motivation for the present approach. A framework which allows direct causal inference from interest rate levels to asset prices, perhaps involving a scaling up of this essay's two-variable structural VAR, would help to strengthen the case for a funding liquidity risk premium.

4.7 Summary

Responding to the late 2000's financial crisis, many commentators have suggested that excessively low interest rates may have contributed to the build-up of leverage in the financial system, and that the high levels of leverage increased crash risk. If such liquidity crash risk is undiversifiable, then investors may have demanded a risk premium for exposure to it. This essay tests whether this occurred. A decomposition of asset return variance into the liquidity (common) and the idiosyncratic component produces an estimate of liquidity volatility. Since this source of volatility is common across assets and asset classes, it is possible to estimate funding liquidity volatility on one asset class and test its significance on another. Exchange rates are chosen as the asset class on which volatility is estimated, with the second stage testing performed on equities. The results support a long run (one year and above) causation from the interest rate level to funding liquidity uncertainty. This uncertainty is found to be priced in equity markets.

In addition to documenting the systemic risk engendered by low interest rate regimes, this essay provides an indicator of whether asset prices are supported by excess leverage. Based on a structural VAR of exchange rate volatility and lagged interest rates, this indicator is available in real time and is easily calculated. When estimated liquidity volatility is high, monetary policy or financial oversight authorities should consider taking steps to reduce the overheating in credit markets, and thus reduce the risk of a liquidity crash.

4.8 Data

COUNTRY	GDP WEIGHT		R-Squared
	Pre-Euro	*Post-Euro*	
Euro	-	0.54	87
Japan	0.38	0.23	44
Germany	0.26	-	67
United Kingdom	0.18	0.11	45
Canada	0.1	0.06	24
Australia	0.06	0.04	29
Switzerland	0.03	0.02	60

Table 4.1: The table shows weights for the exchange rates used to calculate global exchange rate volatility, and the R-squared from a regression of estimated global exchange rate volatility on the volatility of a given country or area (monthly regressions using the average daily volatility for a given month, based on the bilateral dollar exchange rate). All R-squared values are significant, including for those rates with a small weight in the calculation. This supports the existence of a common factor in exchange rate volatility.

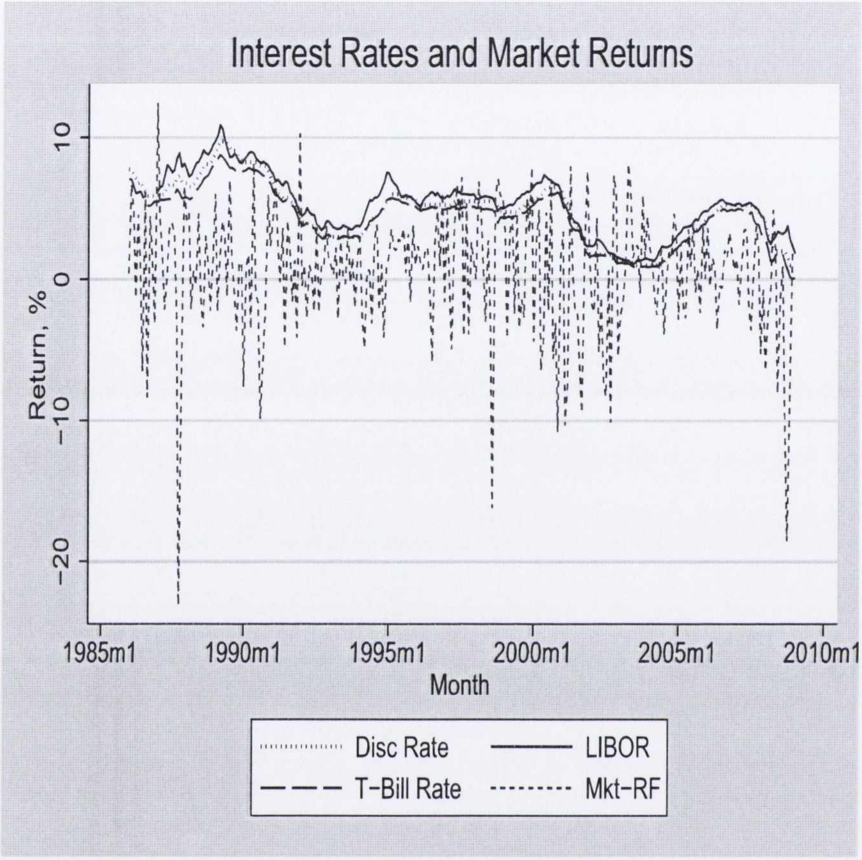

Figure 4.1: "Disc Rate" refers to the target discount rate for the Federal Reserve Bank of New York City (the Federal Funds Rate). LIBOR refers to the United States three-month LIBOR rate. The T-Bill rate is, likewise, for three month T-Bills. The three interest rates are seen to comove closely at monthly frequency. Falling interest rates tend to coincide with notable negative excess returns to the S&P 500, consistent with interest rates falling in response to weak economic conditions. This suggests there may be a negative contemporaneous correlation between interest rates and market turmoil. Lagged, longer term effects are tested via Structural VARs reported below.

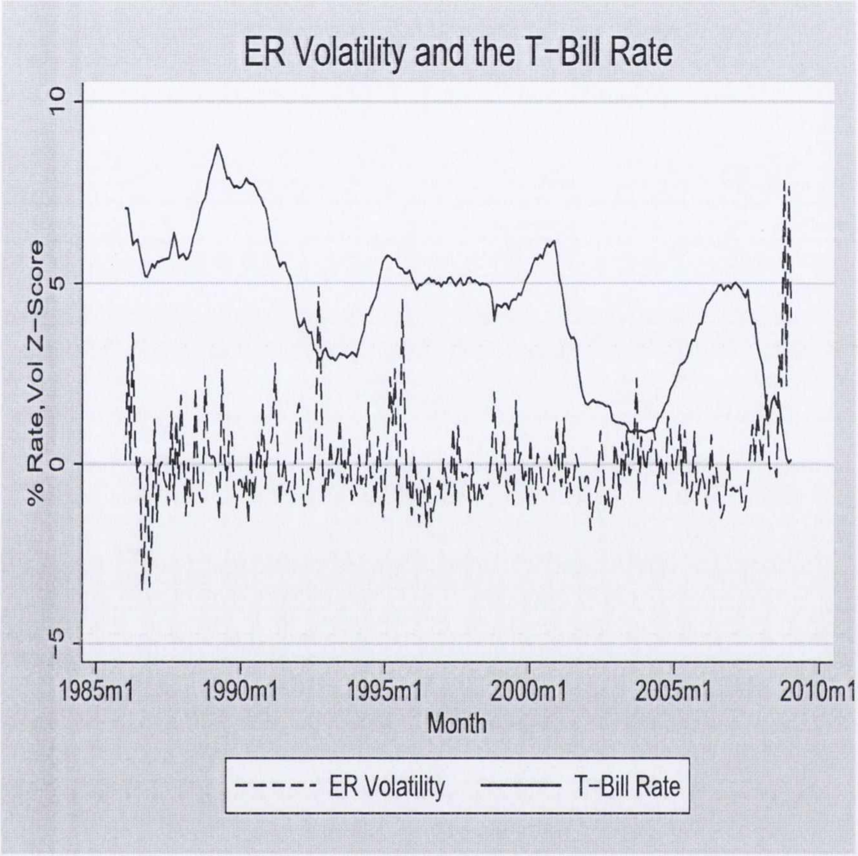

Figure 4.2: Average exchange rate volatility and the U.S. T-Bill return. The volatility unit is the (rescaled) weighted cross-sectional average z-score, as described in Section 4.4.2. The spike in late 1992 is caused by the Exchange Rate Mechanism crisis, which saw high volatility in many major exchange rates. Exchange rate volatility clearly displays high variance and a large number of positive spikes.

	ER Vol	$\widehat{ERVol}$	TED	HML	SMB	ΔVIX	MOM	TB MA	TB_t	Market
ER Vol	1									
$\widehat{ERVol}$	0.44*	1								
TED	0.32*	0.27*	1							
HML	-0.04	-0.08	0	1						
SMB	0.02	0.06	-0.1*	-0.3*	1					
ΔVIX	0.20*	-0.03	0.46*	0.1	-0.2*	1				
MOM	0.04	0	0.04	-0.11	0.09	0.1	1			
TB MA	-0.09	-0.2*	-0.03	-0.05	-0.11	0	0.04	1		
TB_t	-0.1*	-0.3*	-0.02	-0.04	-0.1*	0	0.03	0.90*	1	
Market	-0.1*	0.02	-0.2*	-0.4*	0.20*	-0.6*	-0.11	0.04	0.07	1

Table 4.2: Correlation coefficients for explanatory variables. A star indicates significance at the 5% level. TED is the difference between the interest rates on interbank loans and T-Bills, an indicator of illiquidity. The positive and significant correlation of TED with both realized and predicted exchange rate volatility may support the interpretation of this variable as signifying liquidity risk. HML and SMB refer to the Fama French value and size factors, respectively. Predicted exchange rate volatility is not unconditionally correlated with the market return, in contrast to these traditional risk factors. "TB MA" refers to the twelve month lagged moving average of the T-Bill rate. Exchange rate volatility is negatively correlated with both the T-Bill and market excess return, although the T-Bill and market excess return are not themselves correlated. This may be consistent with the use of volatility as an indicator of liquidity related risk, if such risk is priced.

4.9 Structural VAR and Equity Pricing Results

4.9.1 Structural VAR

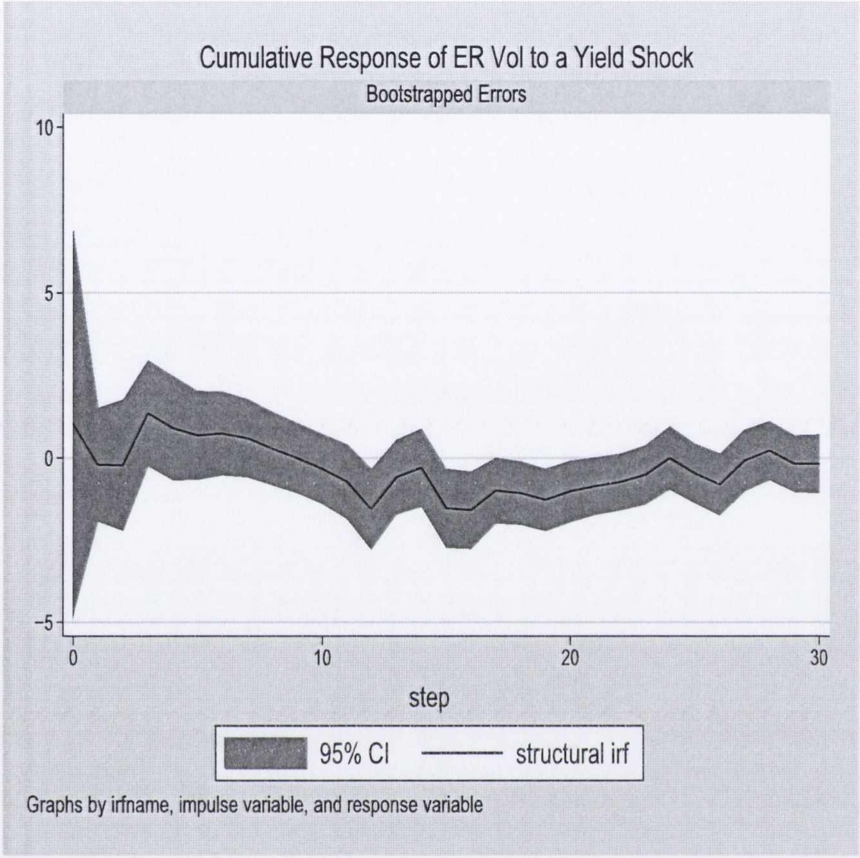

Figure 4.3: Structural Impulse Response Function, 1986-2008, monthly frequency. The identifying restriction is that the time-t exchange rate volatility cannot influence the lagged twelve-month moving average of the T-Bill rate. A shock to the lagged moving average of the interest rate has a significant negative effect on exchange rate volatility after approximately a year, which persists for several months. The predicted exchange rate volatility based on this relation is used in the second stage, reported below. The highest order lag included in the SVAR is 16. The lag selection process used started with 24 lags and individually eliminated insignificant lags according to the Wald Lag exclusion criteria. The confidence interval is based on bootstrapped standard errors.

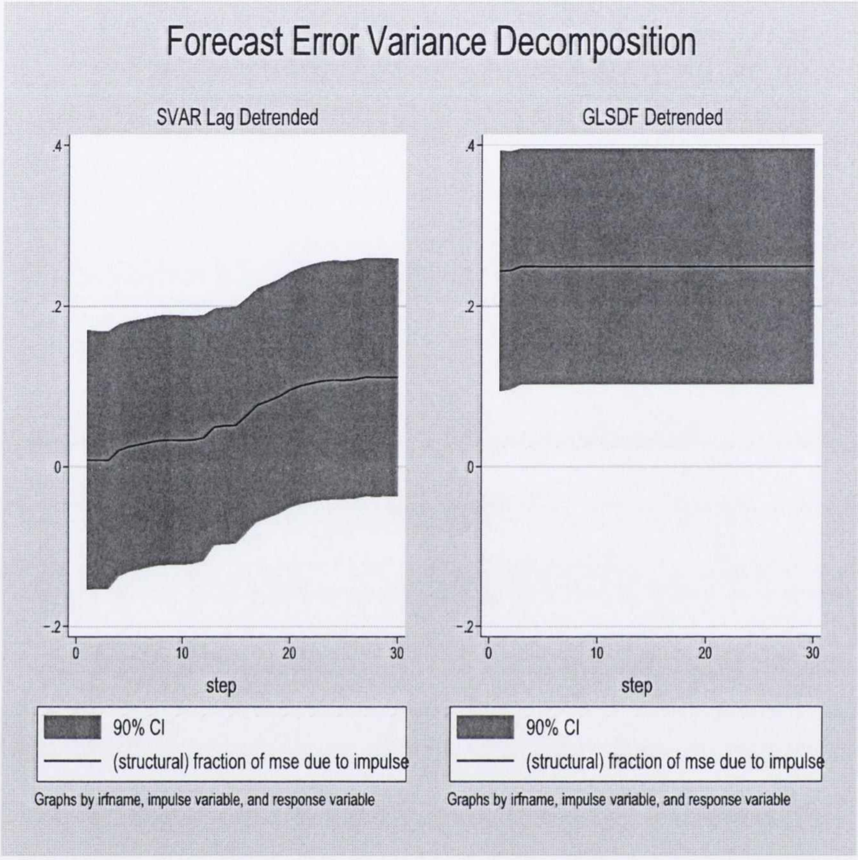

Figure 4.4: The graphs show the structural forecast error variance decomposition for the SVAR of the interest rate and exchange rate volatility, with 90% confidence intervals. The impulse variable is the lagged twelve-month moving average of the T-Bill rate and the response variable is the average exchange rate volatility. The high variance of the estimated variance decomposition may be due to persistence in the variables rendering the moving average representation on which the decomposition is based less accurate. The right hand graph shows the decomposition when both variables are subjected to explicit detrending (using a Generalized Least Squares Dickey Fuller procedure) before estimating the SVAR. In this case the proportion of the variance of exchange rate volatility which derives from an interest rate shock is clearly significant, with a point estimate of about 24%.

4.9.2 Equity Pricing

	Value				
	Low	2	3	4	High
Small	-4.32	-4.08*	-2.74*	-3.59**	-3.79**
2	1.43	-0.95	2.1	-1.32	1.11
3	0.24	1.39	1.4	0.74	6.95***
4	-1.44	0.14	0.47	-1.79	-0.85
Big	-2.47**	0.6	-1.55	-3.46**	4.30*

Table 4.3: Predicted exchange rate volatility betas for 25 Fama French Factors, 1986-2008. Market returns, the HML, SMB and momentum factors, as well as changes in VIX and realized exchange rate volatility, are all controlled for. The significance levels of the predicted exchange rate volatility factor are not as great as for those of the traditional factors, however they are jointly significant according to a Seemingly Unrelated Regression χ^2 test (Zellner, 1962). When conditioned on these other factors, it is difficult to discern a pattern in the betas, although there may be a pattern of increasing coefficients towards Large and High Value companies. The betas for a four factor model (including Market Return, HML and SMB) are almost identical to those shown here. Inclusion of two estimates of actual (il)liquidity, the TED spread and Pastor and Stambaugh's (2001) aggregate market liquidity factor, does not significantly affect the results. This is consistent with the interpretation of predicted volatility as reflecting actual, unobserved liquidity volatility.

4.10 Robustness

4.10.1 Estimation over the Period 1993-2006

Structural VAR

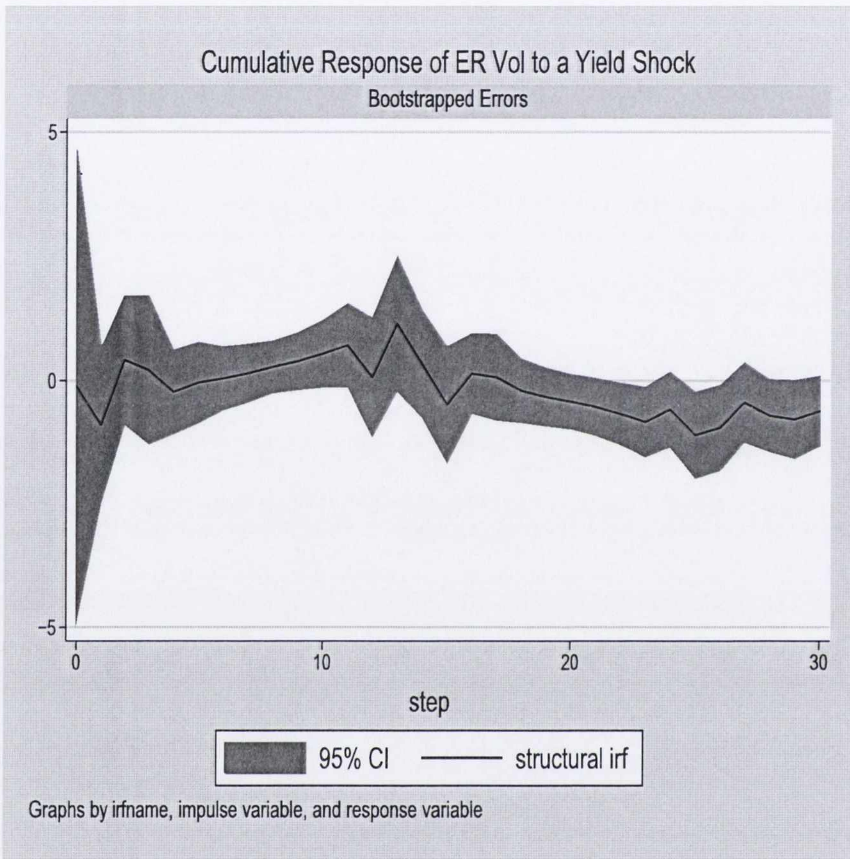

Figure 4.5: The structural VAR is re-estimated over a sample excluding the two recessions which were associated with financial market turmoil, those of the early 1990s and of the late 2000s. The graph shows the response of exchange rate volatility to an interest rate innovation. The response is slower than for the full sample, but remains negative and significant. The delay may be due to the rate drop around 2001 being initially justified, in the sense that it did not cause excess liquidity, but the continued regime of low interest rates eventually increased liquidity volatility.

Equity Pricing

	Value				
	Low	2	3	4	High
Small	0.46	-5.77	-3.13	-6.52**	-2.72
2	2.3	-0.65	0.36	-5.74**	-2.17
3	2.98	0.92	-2.22	-0.44	0.18
4	-0.94	-4.84	-1.63	-1.78	-1.5
Big	-4.22**	-1.44	-3.12	-4.81	5.05

Table 4.4: Betas for predicted exchange rate volatility for the sample excluding the recessions of the early 1990s and of the late 2000s. The dependent variables are the returns to the 25 Fama French Factors. Betas retain joint significance, with a p-value of .06. Market returns, and the size and value factors are included as alternative explanatory variables. The significance levels are weaker than for traditional factors, but can be considered as providing weak evidence in favour of liquidity as a risk factor.

4.10.2 Estimation using Alternative Volatility Estimators

Structural VAR

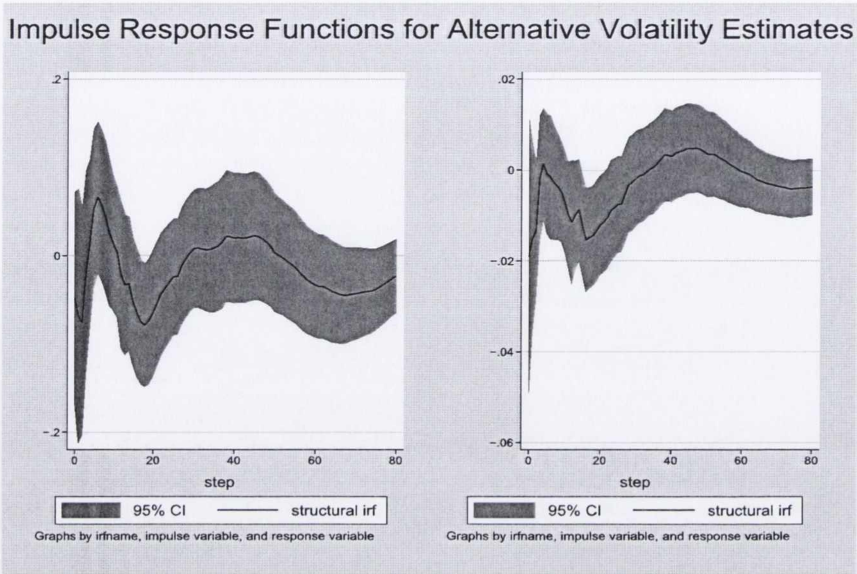

Figure 4.6: The left panel shows the structural IRF for range-based volatility, estimated over 1986-2008, where range refers to the absolute difference between the daily high and low exchange rates, controlling for level changes in the exchange rate. To control for level changes, the absolute value of the difference between the daily close and open rates is subtracted from the range. The left panel shows the effect of a shock to the lagged moving average T-Bill rate on average intra-daily volatility, while the right panel shows the affect on first-differenced volatility. In both cases there is a significant negative reaction of volatility to a rise in interest rates, consistent with the results for the main volatility estimate. Persistence in both cases is clearly considerable, however the eigenvalue stability conditions are satisfied.

Equity Pricing

	Value				
	Low	2	3	4	High
Small	-1.6	-1.29	-1.86	-0.55	-2.64*
2	1.87	0.64	1.55	0.09	2
3	-0.29	1	3.54**	1.2	7.40***
4	-0.03	0.45	0.76	-1.07	-2.45
Big	-1.54	1.69	-0.39	-1.14	5.38**

Table 4.5: Betas for predicted exchange rate volatility for the range-based volatility estimate, where range refers to the absolute difference between the daily high and low exchange rates, controlling for level changes in the exchange rate. The dependent variables are the returns to the twenty-five Fama French Factors. These betas are jointly significant at the 1% level, suggesting that the result is not sensitive to the method used to calculate volatility. Betas increase towards the High Value/Large market capitalization corner, as was the case for the main volatility estimate. Market returns and the size and value factors are included as alternative explanatory variables.

4.11 International Results

COUNTRY	$\widehat{ERVOL}$	BEME	EP
Australia	0.09	-0.17	-0.29***
Austria	0.05	0.04	-0.07
Belgium	0	0.09	0.13
Canada	0.09	-0.04	-0.29***
Switzerland	0.06	0.28***	-0.14*
Germany	0	-0.01	-0.29***
Denmark	-0.05	-0.05	-0.11
Spain	0.08	-0.21**	-0.17*
Finland	0.19*	-0.43***	-0.09
France	0.05	-0.01	0.1
United Kingdom	0.08	0.21**	0.06
Hong Kong	0.17*	0.63***	-0.15
Ireland	0.01	-0.06	0
Italy	0.07	0.28***	-0.19**
Japan	0.17**	0.31***	-0.76***
Malaysia	0.46*	0.61***	-0.17
Netherlands	0	0.12**	0.15**
Norway	0.1	0.12**	0.03
New Zealand	0.13	-0.04	0.23***
Singapore	0.21**	0.36***	-0.29***
Sweden	0.17*	0.07	-0.30***

Table 4.6: Factor betas for market returns for various countries, 1986-2008 (data taken from Kenneth French's website). The (scaled) predicted exchange rate volatility variable ($\widehat{ERVOL}$) is significant for six of twenty-one countries at at least the 10% level. The countries which show a significant beta may correspond to those countries which are often implicated on either side of the carry trade, such as Japan, Malaysia and Hong Kong. The volatility of carry trade flows could enable the global funding liquidity risk factor to be detected in these countries' equity markets.

Chapter 5

Conclusions

Integration into international financial markets has important implications for macroeconomic risk. This thesis has analysed these implications from the perspective of consumers and investors. For consumers, financial market integration helps to decrease domestic consumption risk. For investors, their willingness to take on macroeconomic risk of the countries in their portfolio earns a reward which helps to understand the returns to international fixed income investment. With these benefits of financial integration comes increasing exposure to aggregate risk, which has implications both in financial markets and in the real economy.

Chapter 2 addressed the consumption correlation puzzle, the finding that increasing financial integration does not appear to lead to greater sharing of consumption risk by developing and emerging countries. The resolution of this puzzle required a number of adjustments to the empirical testing framework. In previous tests, financial integration is expected to unilaterally decrease consumers' dependence on domestic output. In fact, debt market access may be used by consumers to increase consumption pro-cyclically. These contrasting effects mean that the implications of financial integration for risk sharing cannot be studied using a single measure of integration. Allowing for separate effects of debt and equity market integration leads to the finding of significant consumption risk sharing by both OECD and non-OECD countries over the period 1987-2003/4. The risk sharing effect of financial integration was robust to the possibility of both international and internal (consumer vs producer) price differentials facilitating a smoothing of consumption in the face of output shocks. The findings were also robust to the data source, the method used to deflate current price series, outliers and a number of control variables.

One ancillary finding of Chapter 2 was that aggregate consumption and output (based on a subset of OECD countries) show no relation to domestic variables for non-OECD countries. This suggests a better estimate of aggregate risk may be of interest. It may also be the case that there is no truly aggregate risk, suggesting the possibility of a market for trading what is typically considered as aggregate risk, which is assumed to be uninsurable in the literature. Examining the nature of the macroeconomic risk that is common across non-OECD countries, if such risk exists, could shed further light on risk sharing by these countries.

Broadening the analysis to examine risk sharing from the investor's perspective, Chapter 3 studied returns to the carry trade, which is the strategy of buying government debt in high interest rate currencies and selling it in low interest rate ones, thus securing the interest differential at the cost of exchange rate risk. Exchange rate risk alone cannot explain the historical returns to this strategy, suggesting that other risk factors may be present. Chapter 3 showed that carry trade returns can be understood as providing compensation for exposure to three sources of risk, a global factor, exchange rate crash risk, and a country-specific factor, proxied by equity returns of the countries in the portfolio. No support was found for the contention that correlation of returns with the investor's domestic consumption explains carry trade returns, which is one alternative hypothesis drawn from the literature. It appears that the carry trade is one of the ways in which the macroeconomic risk of a country is shared with foreign investors. A number of mechanisms for this sharing were considered, including the possibility that T-Bill returns respond to changes in idiosyncratic risk aversion or the discount rate, and the possibility that shocks to inflation working via the exchange rate provide the link to carry returns. Some indicative support for each of these possibilities was presented.

The correlation of carry trade returns with their underlying risk factors (the betas) is not expected to be constant, posing an estimation problem. The approach to modeling time dependence taken in Chapter 3 allowed the betas to vary as a function of global risk appetite, but this is just one of many methods that might be considered. One advantage of this approach is its intuitive appeal, since it is often observed that carry trade unwinds tend to coincide with periods of high global risk aversion. One disadvantage is that the interaction variable specification implied naturally causes collinearity in the explanatory variables, making interpretation of the coefficients difficult. The assumption that the betas change while the factor premia are constant is also subject to debate. Alternative methods of modeling time dependence in the coefficients would contribute to our understanding of carry trade risk factors.

Financial integration brings increasing exposure to aggregate risks, one of which is liquidity risk. Chapter 4 decomposed asset return variance into liquidity (common) and idiosyncratic components, producing an estimate of liquidity volatility. Since this source of volatility is common across assets and asset classes, it was possible to estimate funding liquidity volatility on one asset class and test its significance on another. Exchange rates were chosen as the asset class on which volatility was estimated, with the second stage testing performed on equities. The results supported a long run (one year and above) causation from the interest rate level to funding liquidity uncertainty, with this uncertainty priced in equity markets in the United States and possibly in other countries.

The link from liquidity risk to the monetary policy stance suggests that the central bank should be aware of the medium and long term implications of the interest rate level for asset prices. The fact that funding liquidity appears to be a global variable means that central banks must co-ordinate their policies if they wish to address the asset price implications of their actions. Monetary policy authorities often claim that their ability to deflate an asset price bubble, even assuming one can be identified, is far from clear, however credit and leverage in the economy do respond to the interest rate. William McChesney Martin, the ninth Chairman of the United States Federal Reserve, stated that the job of the Federal Reserve was "to take away the punch bowl just as the party gets going", that is, to raise interest rates when the economy is growing quickly. A corollary of this dictum might be that the central bank should reduce liquidity when asset markets start to overheat.

Given that liquidity and more general financial risk can have substantial effects on the real economy, aggregate liquidity risk is of importance to the consumer considering her level of risk diversification. Aggregate financial risk is a recent development, a consequence of global financial integration which is poorly understood. Further studies into the existence and economic importance of risks like global liquidity risk would be valuable additions to the macro-finance literature. That the economic significance of aggregate financial risk is not trivial appears clear in the light of the financial crisis of the late 2000's, however empirical quantification of this risk would be useful, as would an explanation of the cross-country variation in the economic fallout from global financial events. The depth of the financial crisis suggests the possibility that crash risk may increase more than proportionately with the size of financial markets, so that integrating two autarkic financial markets leads to an increase in overall risk. A fuller understanding of the macroeconomic effects of financial integration awaits more research on this aggregate financial dimension.

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Abstract

Macroeconomic Risk and International Financial Markets

by

Aidan Corcoran

This thesis investigates the use of financial markets by consumers and investors to hedge or gain exposure to macroeconomic risk. The thesis makes three main contributions, corresponding to each of three essays.

The first essay finds economically significant levels of consumption risk sharing by industrialized and emerging/developing countries over the period 1987-2003/4. Failure to account for the distinct effects of different types of financial integration (particularly the possible procyclicality of debt liabilities) and for the role of the real exchange rate in determining the extent of risk sharing may explain the lack of evidence for risk sharing by emerging and developing countries in previous studies. The need to allow for different responses of consumption to aggregate and domestic shocks, which could occur if the two types of shocks display different degrees of persistence, receives empirical support, but does not materially affect the measure of risk sharing. This essay also establishes that the use of different deflators proposed in the literature does not materially affect the findings, except in the case of debt market integration by Non-OECD countries.

The second essay studies returns to an international investor in government debt markets, to investigate whether such returns reflect macroeconomic risk of the countries in the investor's portfolio. Equity market risk of the countries in the portfolio, a new factor in the literature, is significantly priced after controlling for commonly cited factors. Correlation analysis suggests that equity exposure may be partly due to inflation affecting both equities and the exchange rate, and partly due to changes in risk aversion within an economy affecting both equities and T-Bill returns. It thus appears that the carry trade can be considered as one channel through which macroeconomic risk is shared.

The final essay considers a form of aggregate, undiversifiable risk, namely liquidity risk. Excessively loose monetary policy may encourage a high level of debt and liquidity in the economy, which may present a crash risk if asset prices are supported by such liquidity. Equity returns in the United States and in a number of other developed nations appear to provide compensation for liquidity risk, with high risk states being associated with higher returns. This finding has implications for monetary policy, which is one determinant of the level of liquidity, and also illustrates the diminishing marginal returns to financial integration, whereby increasing cross-country correlation of financial and macroeconomic risk reduces potential risk diversification.

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