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# Does hedging tell the full story? Reconciling differences in US aggregate and industry-level exchange rate risk premia

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**Suomen Pankki**
**Bank of Finland**
**PO Box 160**
**FI-00101 HELSINKI**
**Finland**
**☎ +358 10 8311**

**http://www.bof.fi**

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* Lally School of Management, Rensselaer Polytechnic Institute. E-mail: francb@rpi.edu
** Rensselaer Polytechnic Institute and Bank of Finland. Corresponding author. E-mail: hasan@rpi.edu
*** College of Business, University of South Florida. E-mail: Dhunter@coba.usf.edu

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Bill B Francis – Iftekhar Hasan – Delroy M Hunter
Monetary Policy and Research Department

## Abstract

While the importance of currency movements to industry competitiveness is theoretically well established, there is little evidence that currency risk impacts US industries. Applying a conditional asset-pricing model to 36 US industries, we find that all industries have a significant currency premium that adds about 2.47 percentage points to the cost of equity and accounts for approximately 11.7% of the absolute value of total risk premia. Cross-industry variation in the currency premium is explained by foreign income, industry competitiveness, leverage, liquidity and other industry characteristics, while its time variation is explained by US aggregate foreign trade, monetary policy, growth opportunities and other macro variables. The results indicate that methodological weakness, not hedging, explains the insignificant industry currency risk premium found in previous work, thus resolving the conundrum that the currency risk premium is important at the aggregate stock market level, but not at industry level.

Keywords: exposure, currency risk premium, cost of equity, industry competition, international asset pricing

JEL classification numbers: C3, F3, F4, G3

# Kurssiriskien hallinnastako on kyse? Koko talouden ja toimialatason valuuttakurssien riskilisien yhteensovittaminen Yhdysvalloissa

## Suomen Pankin keskustelualoitteita 14/2008

Bill B Francis – Iftekhar Hasan – Delroy M Hunter
Rahapolitiikka- ja tutkimusosasto

## Tiivistelmä

Valuuttakurssimuutosten merkitys eri toimialojen kansainvälisen kilpailukyvyn kannalta on teoreettisesti kiistatonta. Yllättävää sen sijaan lienee, miten vähän on julkaistua empiiristä tutkimusta valuuttariskin vaikutuksista Yhdysvaltain eri toimialoilla. Tässä tutkimuksessa estimoidaan ehdollinen rahoitusvaateiden hinnoittelumalli Yhdysvaltain 36 toimialan tiedoista koostuvassa aineistossa. Tulosten mukaan valuuttakurssien riskilisä – kurssipreemio – estimoituu tilastollisesti merkitseväksi jokaisella toimialalla. Kurssipreemio kasvattaa estimointien mukaan toimialojen oman pääoman tuottovaatimusta keskimäärin 2,47 prosenttiyksikköä ja selittää likimain 11,7 % toimialojen kokonaisriskipreemion itseisarvosta. Maiden tulotason vaihtelu, toimialojen kilpailukyky, velkaantuneisuus, likviditeetti ja muut toimialakohtaiset ominaisuudet selittävät kurssipreemioiden maakohtaisia vaihteluita. Yhdysvaltain ulkomaankauppa, rahapolitiikka, kasvumahdollisuudet ja talouden tunnusluvut sen sijaan selittävät tulosten mukaan kurssipreemioiden vaihtelua ajan mittaan. Tutkimuksen tulokset tukevat myös käsitystä, että kurssiriskien hallinnan sijaan kurssipreemiota ei ole metodologisten puutteiden vuoksi kyetty estimoimaan tilastollisesti merkitseväksi aikaisemmissa tutkimuksissa. Näin ratkeaa myös monia aikaisempia tutkimuksia vaivannut ongelma, että osakemarkkinat yleisesti ottaen pitävät kurssipreemioita merkittävinä, vaikka kurssipreemioista on toimialatasolla vaikea löytää luotettavaa näyttöä.

Avainsanat: kurssiriskipositio, valuuttakurssin riskilisä, oman pääoman tuottovaatimus, toimialan kilpailu, rahoitusvaateiden kansainvälinen hinnoittelu

JEL-luokittelu: C3, F3, F4, G3

# Contents

# 1 Introduction

The dismantling of the fixed exchange rate system in the early 1970s led to a tremendous increase in the volatility of exchange rates (Bartov et al, 1996). Since then, purchasing power parity has been overwhelmingly rejected (see Frankel and Rose, 1995), implying that corporations and industries should be affected by currency risk (Frenkel, 1981, Froot and Klemperer, 1989, and Rogoff, 1996). Empirical research on whether corporations and/or industries are affected by currency risk has taken a two-pronged approach. The first approach, which is the focus of the majority of papers, tests the effect of exchange rate changes on ex post stock returns. These papers assume that ex post returns proxy for cash flows and regard evidence of an exchange rate effect as a cash-flow effect on firm value. This line of research generally concludes that exchange rate movements do not statistically or economically significantly affect the cash flows of either individual firms or industries.[1]

The second approach focuses on ex ante expected returns. It is motivated by the fact that currency risk could be a priced factor in ex ante expected returns and currency risk premium may be a large component of the cost of equity (Solnik, 1974, and Adler and Dumas, 1983), even if exchange rate changes have no effect on ex post returns. Surprisingly, even in light of the weak results from the first approach, there are very few studies that attempt to examine this alternative channel of exchange rate risk on firms and industries. Moreover, those that do find that currency risk is not significantly priced and that currency premium is not materially different from zero (see Jorion, 1991).

Both sets of results are puzzling. If, in fact, ex post returns proxy for cash flows, then the results from the first approach are inconsistent with evidence from practitioners that exchange rates significantly affect firm and industry profitability. For instance, Hung (1992) estimates that due to exchange rate movements US manufacturing firms lost about $23 billion, or 10% of gross profits, per year during the 1980s. Similarly, financial journalists regularly link firm performance to the value of the dollar.[2]

The results from the second approach is even more puzzling because, while they fail to show that exchange rate risk is priced at the industry level, Dumas and Solnik (1995), De Santis and Gerard (1998), and Carrieri et al (2006) find that currency risk is priced at the more aggregated stock market level and that

[1] Jorion (1990), Amihud (1994), Bartov and Bodnar (1994), and Doidge et al (2006) find only a small proportion of firms significantly exposed to exchange rate risk, while Bodnar and Gentry (1993), Allayannis (1997), Griffin and Stulz (2001), Allayannis and Ihrig (2001), and Bodnar et al (2002) find similar results at the industry level. Williamson (2001) finds slightly stronger results in the automobile industry.

[2] See, for example, 'Good News! The Dollar Is Down' in the BusinessWeek, May 26, 2003, p. 157.

currency risk premium accounts for about 20% of total risk premium in the US stock market (Carrieri et al, 2006).

In this paper, we examine if both developing and industrialized countries' currency risks are priced and whether they give rise to an economically significant currency risk premium in the ex ante expected returns of US industries. Following the long-established tradition of empirical research examining exchange rate effects (see Jorion, 1991, Bodnar and Gentry, 1993, Allayannis, 1997, Griffin and Stulz, 2001, Williamson, 2001, and Allayannis and Ihrig, 2001) the industry is the unit of analysis. This is because despite the above evidence of aggregate-level exchange rate effects, these papers do not inform us if and how this carries over to the more disaggregated industry level. Understanding how and if the aggregate results can be generalized to the industry level is important for the following reasons. First, countries compete vigorously in international trade and currency movements affect their ability to compete (Griffin and Stulz, 2001). A large component of the literature on Michael Porter's model of competitive strategy is based on the premise that industry-level analysis is more important than country-level analysis.[3] Further, if exchange rate exposure differs systematically between industries, but less so across countries, then examining industry-level exposure is more relevant to policymakers because, as argued by Westphal (1990) and Murtha (1991), it is optimal to target specific industries in response to competitive challenges from foreign trading partners. This industry focus is also consistent with the view that currency exposure is largely determined at the industry level (Marston, 2001).

Second, examining industry-level currency risk enhances our understanding of international integration beyond that which is possible with an analysis at the aggregate market level. This is because sensitivity to exchange rate movements is correlated with the level of international integration and Carrieri et al (2004) show that industries, even within countries regarded as highly integrated internationally, vary widely in their level of integration and that integration (segmentation) at the country level does not preclude industry-level segmentation (integration).

Third, examining industry-level currency risk adds to the discussion that US investors can obtain international diversification benefits at home (Errunza et al, 1999). If, as is widely held, international integration at the market level has increased in recent years, then cross-industry diversification on the basis of the level of industry currency exposure may improve the portfolio performance of US investors. To this end, this study not only explicitly identifies the industries with the largest currency risk premiums, but it also identifies if this risk premium is positive or negative.

Our analysis is comprehensive and proceeds as follows. First, using an approach that addresses a weakness of most of the existing research, we examine

[3] See Miller (1993) and references therein for a discussion of this literature.

if currency risk is priced in the conditionally expected returns of industries and if the associated currency risk 'exposure' and risk premium are time varying.[4] Second, we estimate the magnitude of the currency risk premium and ascertain its economic importance in industry cost of equity. Third, we assess if industry characteristics, such as foreign income as a proportion of sales, industry competitiveness, leverage, and liquidity, explain the cross-sectional differences of industry currency risk premiums. Fourth, we examine the extent to which US foreign trade, aggregate growth opportunities, business cycle, tight monetary policy, and emerging market currency crises affect the time variation in industry currency risk premium.

Our approach allows us to distinguish between the two most likely explanations for the failure to find that industry returns contain a statistically and economically important exchange rate premium – weakness in the methodology used to address this issue and effective hedging of currency risk.[5] Previous empirical work that examines if industry expected returns contain a currency risk premium imposes constant parameters on the model (eg Jorion, 1991), although financial theory (Adler and Dumas, 1983) and economic intuition indicate that the effects of exchange rate risk change over time. Furthermore, it is now well established over a wide range of applications that constant-parameter models understate the importance of the estimated parameters relative to (conditional) models with time-varying parameters.[6] Thus, our methodological hypothesis contends that the lack of significant exchange rate premium arises from the use of fixed-parameter (unconditional) models that understate the importance of currency risk.

In contrast, the hedging hypothesis states that effective hedging eliminates currency risk premium in industry returns. If currency risk is priced at the stock market level and currency and stock markets are imperfectly integrated, then

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[4] In this paper, our estimate of currency risk 'exposure' is the conditional (time-varying) beta of equity returns with respect to conditionally expected exchange rate changes. Hence, our measure of 'exposure', which is akin to the 'quantity of risk' in De Santis and Gerard (1998), is different from the sensitivity of ex post equity returns to ex post currency changes used in the literature that focuses on the cash-flow effects of exchange rate changes. See sections 2 and 4 B below for further clarification.

[5] A third possibility is that companies pass through exchange rate changes to customers. However, Bodnar et al (2002) find inconclusive evidence of a relationship between pass-through and currency exposure. Moreover, an implication of significant pass-through is greater volatility of imported goods prices (as well as greater foreign price volatility of U.S. exports). However, goods prices are substantially less volatile than exchange rate changes.

[6] For example, McCurdy and Morgan (1992) find a significant risk premium in currency futures only after allowing time variation in the price of risk. Ferson and Schadt (1996) using conditional market-timing models find that mutual fund managers have timing skills, unlike the common finding from unconditional models. Jagannathan and Wang (1996) show that market beta is able to explain the cross-section of stock returns in the conditional CAPM and that the Fama-French size factor is unimportant. De Santis and Gerard (1998) (see also, Dumas and Solnik, 1995) show that currency risk is economically important for aggregate stock market returns, but only when they allow for time variation in both the quantity and the price of risk.

currency hedging can reduce industry cost of capital by eliminating the currency risk premium (Jorion, 1991). Though hedging may explain the insignificant currency premium in industry returns in previous papers, there has been no attempt to determine if in fact it does. This is despite the fact that currency risk is a systematic risk (Eun and Resnick, 1988) and there are well-established theories that predict that hedging reduces risk (see Hentschel and Kothari, 2001, for references). More specifically, several theoretical and empirical papers show that currency hedging reduces currency risk (eg Eun and Resnick, 1988, Black, 1990, and Glen and Jorion, 1993).

Bodnar et al (1998) and Allayannis and Weston (2001) provide evidence that firms hedge currency risk and suggest that this is the reason for the weak evidence of cash-flow exposure. However Guay and Kothari (2003) find that cash flows from hedging are small relative to firm size and operating or investing cash flows, while Hentschel and Kothari (2001) find no difference in risk between firms that hedge with derivatives and those that do not. It is therefore unclear if in fact the finding of lack of exposure documented in the extant literature can be attributed to the hedging of currency risk.

To distinguish between these hypotheses we use changes in the trade-weighted exchange rate indices of the currencies of the industrialized and developing economies, respectively, as our measure of currency risk. Trade with the industrialized countries constitutes the bulk of US foreign trade.[7] However, trade with the developing economies has become increasingly important, growing from 31% of total trade in 1980 to about 42% in 1999 and 48% in 2006 (Federal Reserve, 2007). While it has been easy for US firms to hedge the exchange rate risk of the currencies of the industrialized countries for a long time, it is only in the mid to late 1990s that hedging instruments (futures and options) for the currencies of developing economies became available, and even currently they are still not readily available for the currencies of some of the larger developing economies. Furthermore, US firms have fewer natural hedges (eg local currency liabilities and/or assets) in the emerging markets compared to the industrialized countries. Hence, if hedging were the reason for the insignificant currency risk premium, then despite the methodology, we should find that the currency risk premium associated with the currencies of the industrialized countries is not significantly different from zero, while the risk premium associated with the currencies of the developing economies is significantly different from zero.

[7] Perhaps this is why most previous studies that report weak cash-flow or cost-of-equity exchange rate effects use the currencies of the industrialized countries. For instance, Jorion (1990, 1991), Griffin and Stulz (2001), and Williamson (2001) use currencies of the major (top 15) economies. Although Allayannis and Ihrig (2001) use an index containing over 100 currencies, they study a different period, their industries are different, and they do not break out the index into its components as we do.

Conversely, if the methodological hypothesis explains the previous weak results, then we should find significant currency risk premium associated with both currency indices. To ensure that we have estimated the model over a period in which hedging instruments were highly unlikely to be available for emerging market currencies, we present results for two sub-periods, 1980 to 1989 and 1990 to 1999. If the exposures and premiums for both currency indices are significant and economically large in the first sub-period, then it is clearly not due to hedging why previous results find that currency risk is not priced.

We use a multivariate GARCH framework to estimate a five-factor asset pricing model in which the factors are the market return, the return on the SMB and HML portfolios, and the changes in an index of real exchange rates from the industrialized economies and from the developing economies, respectively. The first exchange rate factor is a trade-weighted index of the 16 major currencies that trade freely outside of their country of issue (MAJOR), while the second is a trade-weighted index of the currencies of the 'other important trading partners' of the US – 19 developing economies (OITP). The model is applied to 36 US industries – 31 manufacturing industries and five non-traded goods industries.

We find that all 36 industries have statistically significant and economically large time-varying currency risk premium. On average, the currency risk premium adds 2.47 percentage points (in absolute value, annualized) to the cost of equity. The mean absolute currency risk premium is never less than 1 percentage point for any industry and reaches a maximum of 7.78 percentage points. When averaged across all industries, currency risk premium accounts for 11.7% of total risk premium, with a minimum of 5.7% and a maximum of 32.9%. For 18 of the 36 industries, currency risk premium constitutes more than 10% of the total risk premium. Both sets of currencies contribute to the currency risk premium, implying that hedging cannot explain the insignificant currency risk premium in US industry returns found in previous empirical work. In addition, over the sub-periods of the 1980s and 1990s, there is no material difference in our results. This provides further evidence in support of the methodological, rather than the hedging, hypothesis.

To summarize, in contrast to Jorion (1991) and others, we find strong evidence that exchange rate risk is priced and constitutes an economically large part of US industry expected returns. In addition, we resolve the puzzle where De Santis and Gerard (1998) and others find that currency risk premium is a significant component of the total risk premium at the aggregate US stock market level yet researchers have failed to show the same at the industry level.

In additional analyses, we find that industry characteristics, such as foreign income as a proportion of sales, industry competitiveness, leverage, and liquidity explain up to 30% of the cross-industry variation in currency premiums. Similarly, US foreign trade, growth opportunities, recessions, tight monetary policy, and the Mexican and Asian currency crises jointly explain anywhere from

0 to 78% of the time variation in currency risk premium, depending on the industry. As discussed below, these results have important implications for the global competitiveness of US industries, for how time variation in cash-flow exposure is estimated, and they serve as an important model specification check not contemplated by previous work (De Santis and Gerard, 1998, and Carrieri et al, 2006).

The studies closest to ours are De Santis and Gerard (1998) and Carrieri et al (2006). De Santis and Gerard find that the exchange rate risk of a few developed market currencies is priced at the aggregate stock market level for developed countries. Carrieri et al, extending the latter work, show that emerging market currency risk is also priced at the aggregate level. Our work differs from these studies in the following ways. First, we estimate the effects of both industrialized and developing countries' currency risks on industry rather than on aggregate stock market returns. Our results simultaneously resolve the puzzle that their work raises (evidence of exposure at the aggregate but apparently not at the industry level) and distinguish between the most likely causes of this puzzle (hedging versus a bad model problem). Second, we explain the variation of the estimated currency risk premiums across industries and over time. These tests strengthen our understanding of how factors in the control of corporate managers and/or policymakers influence the level of the currency premium in industry returns. These tests also represent the first implementation of an alternative specification test to a modeling approach that is new to the currency premium literature (having first been used by De Santis and Gerard, 1998) because if the model is misspecified then we would not expect the variables of interest to have much explanatory power for the estimated currency premiums. Third, because we focus on industries rather than the aggregate stock market, our results provide new insights into aspects of the international competitiveness of US industries beyond that possible from an analysis at the aggregate level. For instance, open-economy macroeconomics suggests that the performance and competitiveness of open economies are sensitive to the terms of international trade. By estimating industry-level currency premiums we can gauge the level of openness of the economy by the dispersion of industry-level exchange rate effects because more open economies should have greater inter-industry dispersion (Bodnar and Gentry, 1993). Finally, given the literature that shows that exchange rate uncertainty affects industry investment (eg Campa and Goldberg, 1995), our results compliment work in this area by identifying a possible cost-of-equity channel of exchange rate effects on domestic investment.

There are five remaining sections to the paper. In section 2, we discuss the methodology and in section 3 we describe the data and preliminary analyses. The empirical results are in sections 4 and 5. A summary of the paper's main findings and conclusions are in section 6.

# 2 The conditional asset pricing model

In this section, we describe the five-factor asset pricing model that we estimate. The first three risk factors are the returns on the Fama-French (1993) factors: the value-weighted US market portfolio in excess of the risk-free rate (VWM), the returns on the 'size' factor (SMB), and the returns on the 'book-to-market' factor (HML). Given that SMB and HML have received widespread, though not uncontroversial, empirical support as priced factors in the asset pricing literature (see Fama and French, 1997) their inclusion in the model reduces the probability that exchange rate risk premium is significant because exchange rate risk is a proxy for some omitted macroeconomic risk.

There are two currency factors. The first is represented by percentage changes in the Treasury's trade-weighted index of the real bilateral exchange rates of developed countries' currencies with the US dollar (MAJOR). The second is represented by percentage changes in the index of real exchange rates of the currencies of the 'other important trading partners' from the developing countries (OITP).[8]

The asset pricing model specifies the expected excess returns on each industry portfolio as a product of the time-varying betas of the portfolio (relative to each of the five risk factors) and the conditionally expected returns of the factors. Specifically

$$\begin{aligned} E_{t-1}(r_{it}) = {} & \beta_{iVt-1}E_{t-1}(r_{Vt}) + \beta_{iSt-1}E_{t-1}(r_{St}) + \beta_{iHt-1}E_{t-1}(r_{Ht}) + \beta_{iOt-1}E_{t-1}(f_{Ot}) \\ & + \beta_{iMt-1}E_{t-1}(f_{Mt}) \end{aligned} \tag{2.1}$$

In this model, $E_{t-1}(r_{it})$ is the conditionally expected return at time t (conditioned on information up to t–1) on the ith industry in excess of the return on the risk-free asset. On the right side of the equation, $E_{t-1}(r_{kt})$ is the conditionally expected (excess) return of the kth equity factor, with $\beta_{ikt-1}$ being the corresponding time-varying beta of portfolio i relative to factor k, where k is equal to factor $r_V$ (market), $r_S$ (SMB), and $r_H$ (HML), respectively. Correspondingly, $E_{t-1}(f_{Ot})$ and $E_{t-1}(f_{Mt})$ are the conditionally expected change in the OITP and MAJOR currency indices and $\beta_{iO,t-1}$ and $\beta_{iM,t-1}$ are the respective currency betas

[8] An exchange rate index is inconsistent with the theory of the International CAPM (eg Adler and Dumas, 1983). However, it is a common practice to keep the estimation manageable (eg Jorion, 1991, Carrieri et al, 2006).

(exposures). Thus, the estimated model is a conditional version of the Fama-French three-factor model, augmented with the two currency factors.[9]

The conditionally expected returns on the equity factors are estimated as a function of lagged instruments (described below) that are well known in the asset pricing literature to have predictive power for equity returns (see Ferson and Harvey, 1991, De Santis and Gerard, 1998). To estimate the conditionally expected changes of the exchange rate factors we exploit the autocorrelation in the indices as well as use other variables that plausibly could forecast exchange rate changes (see below).

The equity and currency betas are time varying as a function of the time-varying covariance between each portfolio's excess returns and the returns on each factor divided by the time-varying variance of the factor returns, $\beta_{ikt-1} = \mathrm{cov}_{t-1}[r_{it}, r_{kt}] / \mathrm{var}_{t-1}[r_{kt}]$. The current model efficiently utilizes information that investors use to update their expectations. This represents a major difference between the current approach to modeling time variation in 'exposure' and that of previous papers, such as Allayannis (1997), Allayannis and Ihrig (2001), Williamson (2001), and Bodnar et al (2002). Unlike the seemingly unrelated regression technique employed in these papers that only exploits the correlation between the residuals from each test portfolio to improve the efficiency of estimating the standard errors of the portfolio betas, our approach uses much more information to capture the time-varying covariances between portfolio and factor returns, the variances of the risk factors, and the expectations of the factors. This aids in the precision of the estimates of both the betas and their standard errors and ultimately the ex ante expected risk premiums.

We jointly estimate the expected returns on the factors and the betas in a system of equations, similar to several previous papers, eg McCurdy and Morgan (1991).[10] The estimated system of one industry portfolio ($r_i$) and five factors ($r_V$, $r_S$, $r_H$, $f_O$, $f_M$) is as follows

$$\begin{aligned} r_{it} = {} & \beta_{iVt-1}(r_{Vt} - \varepsilon_{Vt}) + \beta_{iSt-1}(r_{St} - \varepsilon_{St}) + \beta_{iHt-1}(r_{Ht} - \varepsilon_{Ht}) \\ & + \beta_{iOt-1}(f_{Ot} - \varepsilon_{Ot}) + \beta_{iMt-1}(f_{Mt} - \varepsilon_{Mt}) + \varepsilon_{it} \end{aligned} \tag{2.2}$$

$$r_{Vt} = E_{t-1}(r_{Vt}) + \varepsilon_{Vt} = a_0 + a_1 z_{1t-1} + \ldots + a_4 z_{4t-1} + \varepsilon_{Vt} \tag{2.3}$$

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[9] We use expected, rather than ex post, exchange rate changes because it is consistent with theory (Adler and Dumas, 1983) and the empirical models of Dumas and Solnik (1995) and De Santis and Gerard (1998). Ferson and Harvey (1991) show that time variation in factor returns, and not betas, primarily drives the variation in expected returns and Fama and French (1997) show that models with conditional factor returns provide more precise estimates of industry cost of equity.

[10] The model closely resembles that of De Santis and Gerard (1998) and Carrieri et al (2006). In their model $\beta_{ik}$ is replaced by the 'quantity of risk', $\mathrm{cov}_{t-1}[r_{it}, r_{kt}]$ and the conditional variance component of $\beta_{ik}$ is instead used to standardize the expected factor return, $E_{t-1}(r_{kt})/\mathrm{var}_{t-1}(r_{kt})$, to obtain the 'price of risk'. Our specification is more appropriate for the further analyses of the estimated risk premiums that we conduct below.

$$r_{St} = E_{t-1}(r_{St}) + \varepsilon_{St} = b_0 + b_1 z_{1t-1} + ... + b_4 z_{4t-1} + \varepsilon_{St} \quad (2.4)$$

$$r_{Ht} = E_{t-1}(r_{Ht}) + \varepsilon_{Ht} = c_0 + c_1 z_{1t-1} + ... + c_4 z_{4t-1} + \varepsilon_{Ht} \quad (2.5)$$

$$f_{Ot} = E_{t-1}(f_{Ot}) + \varepsilon_{Ot} = d_0 + d_1 x_{1t-1} + ... + d_4 x_{4t-1} + \varepsilon_{Ot} \quad (2.6)$$

$$f_{Mt} = E_{t-1}(f_{Mt}) + \varepsilon_{Mt} = g_0 + g_1 x_{1t-1} + ... + g_4 x_{4t-1} + \varepsilon_{Mt} \quad (2.7)$$

$$E_{t-1}(e_t) = (\varepsilon_i, \varepsilon_V, \varepsilon_S, \varepsilon_H, \varepsilon_O, \varepsilon_M)' \sim N(0, H_t) \quad (2.8)$$

$$H_t = C'C + A_1' e_{t-1} e_{t-1}' A_1 + B_1' H_{t-1} B_1 \quad (2.9)$$

In equation (2.2), the realized excess returns on each industry are regressed on the conditionally expected returns of the factors, where $E_{t-1}(r_{kt}) = (r_{kt} - \varepsilon_{kt})$ is the expected return on the k equity factors and $E_{t-1}(f_{jt}) = (f_{jt} - \varepsilon_{jt})$ is the expected change in (return on) the j exchange rate factors. In equations (2.3) to (2.5), a vector of lagged instruments ($z_1$, $z_2$, $z_3$, $z_4$) is used to generate the expected returns on each equity factor and in equations (2.6) and (2.7) a vector ($x_1$, $x_2$, $x_3$, $x_4$) is used to estimate the expected change in the exchange rate factors. These instruments are described in the Data section.

Estimating the betas require time-varying estimates of the second moments of the portfolios and risk factors. As asset pricing theories do not specify how the conditional second moments should be modeled we follow other researchers and use a GARCH framework (eg, Bollerslev et al, 1988, and De Santis and Gerard, 1998). We, therefore, parameterize the variance-covariance matrix using a GARCH (1,1) specification of the diagonal BEKK model (Engle and Kroner, 1995). More specifically, let $e_t$ (in equation 2.8) represent an n vector (n represents the sum of portfolio and factors) containing the errors from the above system of equations and assume that they are conditionally normally distributed with a mean of zero and variance-covariance H; ie $E_{t-1}(e_t) \sim N(0, H_t)$. Following Bollerslev et al (1988) and De Santis and Gerard (1998), among others, in equation (2.9) we specify $A_1$, $B_1$ as diagonal matrices. Therefore, we model the n×n variance-covariance matrix of the system $H_t$ as a function of a constant, lagged error terms, and lagged variance-covariance terms. For instance, the conditional covariance between the portfolio returns (the first element in the 6×6 variance-covariance matrix) and the returns on the first exchange rate factor (the fifth element in the 6×6 variance-covariance matrix) is modeled as $h_{15t} = c_{15} + a_{15}(e_{1t-1} e_{5t-1}) + b_{15} h_{15t-1}$. The estimate of this is the numerator in the currency beta with respect to the developing countries' currencies. C is an n×n upper-triangle matrix of constants; hence, positive definiteness of $H_t$ (eg positive variances) is guaranteed.

Because normality is not always observed in financial markets data the estimation uses a quasi-maximum likelihood (QML) approach whereby the log-likelihood function from the conditional normal specification is maximized, but the variance-covariance matrix of the coefficients is made robust to the distribution of the error terms. This allows for regular statistical inferences even if the residuals are non-normal. An advantage of the QML estimation is that Wald tests are robust to non-normality.

One drawback to our approach is that because we do not estimate the risk premium of all the industry portfolios simultaneously, there is still some efficiency loss. However, it is impossible to estimate one large system containing all 36 industries and five risk factors, as this would require estimating a 41x41 variance-covariance matrix. Even the reduced system containing a single portfolio has a 6x6 variance-covariance matrix, which is already stretching the limit of current multivariate GARCH technology. Previous studies overcome this shortcoming by focusing on only a small number of portfolios (eg De Santis and Gerard, 1998). This approach is not appropriate in this paper because, given the existing weak evidence it is imperative to determine if exchange rate risk affects a wide cross-section of US industries. Alternatively, others have used a two-step procedure (eg Bekaert and Harvey, 1995) where, for instance, the world price of risk is estimated in the first and used in the second in order to focus on estimating the effect of local risks. Given that we are interested in the simultaneous estimation of the effect of several factors, this approach is not appropriate here. Furthermore, this would result in an errors-in-variables problem. Hence, like Carrieri et al (2006), and others, we settle for the advantages provided by the above approach and estimate the model one industry at a time. This is not dissimilar to, say, the approach of Fama and French (1997) who use OLS on an industry-by-industry basis. Because our main objective is to examine if exchange rate risk is important for a given industry, this does not pose any major problems.

# 3 Data

## 3.1 Description of industry portfolios

We use monthly excess returns for 36 industries, comprised of 31 traded-goods (manufacturing) industries and five non-traded goods industries – entertainment (fun), construction, meals (hotels, motels, and restaurants), retail goods, and banking. These definitions are from Bodnar and Gentry (1993).[11] As is common in the literature (see Starks and Wei, 2005), we select industries that are most likely to be affected by currency risk via foreign outputs or exports of domestic outputs, foreign inputs, foreign competition, foreign clientele, or relationships to other industries that are affected by exchange rate movements. While it is well known that manufacturing industries are likely to be exposed to currency risk primarily because of foreign trade, less is known about the level of exposure of non-traded industries. We discuss this in the results below.

The data cover the period January 1980 to December 1999. Panel A of Table 3.1 reports summary statistics of the returns for each industry in excess of the risk-free rate. The mean excess returns range from -0.116% per month for the coal industry to 1.319% per month for the smoke (tobacco products) industry. Of the 36 industries, 22 have mean excess returns that are significantly different from zero at the 5% level. A small number of industry returns have significant first-order autocorrelation and most are not normally distributed.

Table 3.1 **Summary statistics of return of industries and risk factors**

Panel A reports summary statistics for 31 manufacturing industries and five non-traded goods industries. These are from the Fama-French (1997) value-weighted industry portfolios. Returns (% per month) are in excess of the risk-free rate, which has a mean of 0.559% per month. $\rho_1$ is the first-order autocorrelation. J-B is the Jarque-Bera statistic for the test of the null hypothesis that the returns are normally distributed. Non-traded goods industries, using the definitions in Bodnar and Gentry (1993), have a (n) to the right of their name. In Panel B, the risk factors are the Fama-French (1993) factors – market excess return on the CRSP value-weighted market (VWM), returns on 'small minus big' firms (SMB), and returns on 'high minus low' book-to-market value firms (HML). The currency factors are represented by percentage changes in the real US. Treasury trade-weighted exchange rate index comprised of the currencies of 16 developed countries that are the main trading partners of the US (MAJOR) and the real index of the currencies of the 'other important trading partners' from the emerging economies (OITP). The indices are in foreign currency per US dollar. Panel C reports OLS betas (exposures) from regressing the market-adjusted returns of each industry on the changes in the OITP and MAJOR indices jointly. Following Griffin and Stulz (2001), the market return is subtracted from each industry's return. Panel D reports coefficients (and robust p-values) from regressions used to test if the factor returns are predictable. The instrumental variables are the default premium (DEFAULT) – the spread between the yields on Moody's Baa- and Aaa-rated corporate bonds; the term premium (TERM) – the difference in the yields of the Treasury constant-maturity 10-year and the 1-year notes; the Fed funds rate (FED); and the lagged dependent variable (factor). For the currencies, the instruments are EXPRATIO – the percentage of US exports to GDP, IMPRATIO – the percentage of US imports to GDP, FED, and the lagged dependent variable (factor). All instruments are lagged one period relative to the factor returns. Data are monthly from January 1980 to December 1999 (240 observations). **Bold** numbers are significant at least at the 5% significance level.

[11] These data and those for the equity-related factors and the risk-free rate are obtained from Ken French's website. We thank him for making these data available. For a complete description of the data, see Fama and French (1997).

Panel A: Summary statistics of portfolio excess returns

| | Industry | Mean | Std | $\rho_1$ | J-B | | Industry | Mean | Std | $\rho_1$ | J-B |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agri | agriculture | 0.690 | 6.161 | -0.005 | **652.8** | FabPr | fabricated products | 0.336 | 6.230 | **0.160** | **66.77** |
| Food | food products | **0.915** | 4.739 | 0.011 | **16.59** | Mach | machinery | 0.434 | 5.951 | 0.122 | **140.6** |
| Soda | candy&soda | **1.018** | 5.128 | -0.046 | **29.14** | ElcEq | electrical equipment | **1.053** | 6.606 | 0.071 | **392.2** |
| Beer | beer&liquor | **1.108** | 6.503 | 0.119 | **26.48** | Autos | automobiles&trucks | **0.802** | 5.931 | 0.124 | **71.13** |
| Smoke | tobacco prod. | **1.319** | 7.910 | 0.059 | **23.78** | Aero | aircraft | **0.871** | 6.356 | 0.091 | **106.9** |
| Toys | recreation | **0.989** | 6.729 | 0.047 | **7.833** | Ships | shipbuilding, railroad equipment | 0.621 | 6.819 | 0.074 | **46.15** |
| Fun (n) | entertainment | **1.285** | 5.647 | 0.014 | **91.65** | Guns | defence | 0.670 | 6.811 | 0.083 | **138.6** |
| Books | printing&publishing | **1.029** | 5.469 | **0.138** | **53.88** | Gold | precious metals | 0.299 | 11.11 | 0.024 | **34.27** |
| Hshld | consumer goods | **1.095** | 4.783 | 0.007 | **52.47** | Mines | non-metallic, industrial metal mining | 0.135 | 7.038 | 0.004 | **67.60** |
| Clths | apparel | 0.488 | 6.178 | **0.242** | **126.5** | Coal | coal | -0.116 | 6.510 | 0.029 | **49.81** |
| MedEq | medical equip. | **1.004** | 6.604 | 0.017 | **7.016** | Comps | computers | **0.852** | 6.337 | 0.098 | **3.13** |
| Drugs | Pharmaceut. products | **1.115** | 5.175 | -0.001 | **10.35** | Chips | electronic equipment | **1.154** | 6.827 | 0.056 | **9.61** |
| Chems | chemicals | **0.772** | 5.416 | 0.015 | **149.4** | LabEq | measuring&control equipment | **1.067** | 8.001 | 0.042 | **2.34** |
| Rubbr | rubber, plastic products | 0.728 | 5.879 | 0.065 | **195.3** | Paper | business supplies | **0.759** | 5.827 | -0.012 | **99.02** |
| Txtls | textiles | 0.580 | 6.056 | **0.264** | **222.8** | Boxes | shipping containers | **0.666** | 5.094 | -0.023 | **284.8** |
| BldMt | construction materials | 0.709 | 5.622 | 0.106 | **147.9** | Rtail (n) | retail | **1.203** | 5.729 | **0.194** | **84.81** |
| Cnst (n) | construction | 0.246 | 7.153 | **0.236** | **44.28** | Meals (n) | restaurants, hotels, motels | **0.761** | 5.520 | **0.164** | **42.41** |
| Steel | steel works etc | 0.430 | 6.458 | -0.025 | **126.6** | Banks (n) | banking | **0.969** | 5.958 | **0.156** | **51.11** |

Panel B: Summary statistics of returns on the risk factors

| | Mean | Std dev | $\rho_1$ (first order auto) | J-B statistics |
|---|---|---|---|---|
| VWM (Market) | **0.854** | 4.401 | 0.051 | **193.31** |
| SMB (Size) | -0.029 | 2.666 | **0.132** | **4.367** |
| HML (Book-to-Market) | 0.188 | 2.799 | **0.225** | **2.725** |
| | | | | |
| OITP Currency index | 0.110 | 1.229 | **0.203** | **280.642** |
| Major Currency index | 0.036 | 1.830 | **0.318** | 1.618 |

Panel C: OLS estimates of exchange rate exposure

| Industry | OITP Coeff | MAJOR Coeff | Adj $R^2$ | Industry | OITP Coeff | MAJOR Coeff | Adj $R^2$ |
|---|---|---|---|---|---|---|---|
| Agri | -0.571 | -0.120 | 1.689 | Fabr | -0.316 | 0.062 | -0.046 |
| Food | **0.329** | -0.048 | 0.298 | Mach | **-0.453** | -0.088 | 3.003 |
| Fun (n) | -0.191 | 0.087 | -0.532 | ElcEq | **-0.470** | 0.037 | 1.339 |
| Soda | 0.304 | -0.066 | 0.033 | Autos | 0.176 | 0.135 | 0.008 |
| Beer | 0.149 | 0.204 | -0.207 | Aero | -0.107 | 0.184 | -0.137 |
| Smoke | -0.210 | 0.033 | -0.641 | Ships | 0.103 | **0.520** | 2.709 |
| Toys | 0.000 | **0.401** | 1.644 | Guns | 0.146 | 0.044 | -0.661 |
| Books | 0.070 | **0.273** | 2.196 | Gold | -0.062 | **-1.022** | 2.560 |
| Hshld | 0.152 | 0.125 | 0.920 | Mines | -0.321 | **-0.328** | 1.484 |
| Clths | -0.277 | **0.342** | 1.773 | Coal | 0.018 | 0.081 | -0.742 |
| MedEq | **0.256** | -0.048 | -0.118 | Comps | -0.155 | -0.161 | -0.007 |
| Drugs | **0.426** | -0.147 | 1.514 | Chips | **-0.585** | 0.054 | 2.251 |
| Chems | 0.093 | -0.105 | -0.363 | LabEq | **-0.900** | 0.123 | 3.219 |
| Rubbr | **-0.324** | 0.024 | 0.471 | Paper | -0.089 | -0.042 | -0.650 |
| Txtls | **-0.401** | **0.254** | 1.114 | Boxes | 0.016 | -0.107 | -0.537 |
| BldMt | -0.152 | -0.062 | -0.019 | Rtail (n) | 0.019 | **0.350** | 3.063 |
| Cnst (n) | -0.218 | 0.073 | -0.435 | Meals (n) | -0.040 | 0.209 | 0.633 |
| Steel | -0.200 | -0.108 | -0.176 | Banks (n) | 0.065 | **0.352** | 2.664 |

Panel D: Predictability of risk factors

| Dependent variable | Constant | $DEFAULT_{t-1}$ | $TERM_{t-1}$ | $FED_{t-1}$ | Dep $variable_{t-1}$ | $\mathbf{H_0}$: All coeff = 0 | Adj $R^2$ |
|---|---|---|---|---|---|---|---|
| VWM (Market) | 3.288 | 3.708 | -0.992 | -0.734 | -0.024 | 15.266 | 4.60 |
| | (0.007) | (0.001) | (0.022) | (0.000) | (0.749) | (0.004) | |
| SMB (Size) | -0.442 | 2.071 | -0.118 | -0.2340 | 0.075 | 21.812 | 5.52 |
| | (0.569) | (0.000) | (0.664) | (0.035) | (0.338) | (0.000) | |
| HML (Book-to-Market) | -2.314 | -2.005 | 0.960 | 0.489 | 0.154 | 20.547 | 9.77 |
| | (0.004) | (0.001) | (0.001) | (0.000) | (0.046) | (0.000) | |
| | Constant | $IMPRATIO_{t-1}$ | $EXPRATIO_{t-1}$ | $FED_{t-1}$ | Dep $variable_{t-1}$ | $H_0$: All coeff = 0 | Adj $R_2$ |
| BROAD Currency index | -0.182 | 0.005 | -0.023 | 0.030 | 0.329 | 45.315 | 11.85 |
| | (0.422) | (0.762) | (0.085) | (0.329) | (0.000) | (0.000) | |
| OITP Currency index | -0.242 | -0.021 | -0.006 | 0.047 | 0.192 | 15.383 | 6.55 |
| | (0.245) | (0.178) | (0.634) | (0.051) | (0.118) | (0.004) | |
| MAJOR Currency index | -0.167 | 0.019 | -0.032 | 0.026 | 0.320 | 44.379 | 10.12 |
| | (0.553) | (0.347) | (0.059) | (0.497) | (0.000) | (0.000) | |

## 3.2 Description of factors

Panel B reports summary statistics for the risk factors. Both currency indices are expressed as foreign currency per US dollar so that log first difference of the index represents the percentage appreciation/depreciation of the dollar. An advantage of using the real exchange rate is that a change in the real index reflects both a change in the inflation differential between the US and its trading partners as well as a change in the nominal value of the currency. Thus, even if a currency has a fixed exchange rate relative to the dollar or experiences only discrete changes in nominal value, it could still experience significant real exchange rate changes.

Column 1, rows 4 and 5, of Panel B reports the mean monthly appreciation of the dollar. This is an average of 0.04% per month against the currencies in the MAJOR index, about a third of that against those in the OITP index (0.11%), though neither is statistically significant. These differences suggest that the currency premium could differ substantially across the currency indices. The exchange rate factors are not significantly correlated with each other or with the equity factors. This suggests that if the currency factors are priced risk this will not be because they proxy for these other factors. Additionally, because we include the main equity factors that have recently gained prominence in empirical asset pricing, it is unlikely that exchange rate risk will be priced because it is a proxy for an omitted risk factor.

Panel C reports OLS results of industry returns in excess of the market returns regressed on changes in the currency indices. This replicates previous work focusing on the effect of exchange rate changes on ex post returns (see Griffin and Stulz, 2001). Not unexpectedly, the results are consistent with those in previous work, as only nine industries are exposed to the respective indices. Several other specifications led to the same qualitative result. The importance of this is that if we find that currency risk premium is significantly different from zero it cannot be construed as arising from, say, differences in how our industries are formed or the time period of our study, relative to earlier studies.

## 3.3 Information instruments

It is now well established that short- and long-horizon equity returns are predictable. This predictability has been attributed to time variation in expected returns (Ferson and Harvey, 1991). In light of this, we use instruments that are frequently used in the asset pricing literature to estimate the expected returns on the equity factors. These are: the term premium (TERM) – the difference in the yields of the Treasury constant-maturity 10-year and the 1-year notes; the default premium (DEFAULT) – the spread between the yields on Moody's Baa- and Aaa-rated corporate bonds; and the Fed funds rate (FED) – this is indicative of monetary policy. All instruments are lagged one period relative to the factor returns. Data for the term and default premiums and the Fed funds rate are from the Federal Reserve System. In addition, given the significant first-order autocorrelation observed for most of the factors (Panel B of Table 3.1) we also include the first lag of the respective factor in each factor equation.

We use US imports and exports, respectively, as a percentage of GDP and the Fed funds rate to predict changes in the exchange rate factors. Given the quarterly frequency of GDP, within any quarter only the numerator of the trade-related instruments varies. These variables are lagged one period. Additionally, given the autocorrelation in the changes in the exchange rates we also use the lagged change in the currency factors. Data for US aggregate imports and exports are obtained from the International Financial Statistics (IFS) database of the International Monetary Fund.

To provide a preliminary sense of the suitability of these instruments, Panel D reports results of the factors regressed on the instruments. The $R^2$s range from 4.60% for the market returns to 10.12% for the changes in the MAJOR index. This level of predictability is similar to that generally found in the asset pricing literature (see Ferson and Harvey, 1991). However, the predictability of the factors in equations (2.3 to 2.7) of the GARCH models is what really matters. Below, we present robust Wald tests of the hypothesis that the returns on or changes in the risk factors are not predictable.

# 4 Empirical results for currency risk premium

We present the main empirical results in this section. In the first sub-section, we briefly examine the industry betas relative to the equity-related factors. In the second sub-section, we focus on the exchange rate betas, while in the third sub-section we discuss the currency risk premiums. In the fourth sub-section, we address the issue of whether or not hedging can explain the previously weak results. In the final sub-section, we discuss various diagnostic and robustness tests.

## 4.1 Asset pricing estimates of equity betas

Panel A of Table 4.1 reports the mean estimates and significance levels of the time-varying equity betas. The mean market betas (shown under the heading VWM) are all positive and significantly different from zero at the 1% level. They range from 0.666 for the gold industry to 1.380 for the measuring and control equipment (LabEq) industry, with an average of 1.04. Among the least sensitive to the market are the agriculture, beer and liquors (beer), food products (food), soda and candy (soda), and precious metals (gold) industries, whereas the industries with the highest market betas include the recreation (toys), construction, electrical equipment, electronics equipment (chips), and measuring and control equipment (LabEq) industries. On the basis of the t-test in Panel B, we reject the null hypothesis (at less than the 1% level) that the average market beta across the 36 industries is equal to zero.

The mean of the time-varying SMB betas ranges from -0.344 for the drugs industry to 0.999 for the electrical equipment industry and has an average of 0.36. Of the 36 industries, 30 have a positive mean SMB beta and all mean betas are significantly different from zero at less than the 1% level. The positive mean SMB beta means that, on average, given an increase in the expected return on the SMB risk factor there is an increase in the industry's cost of equity. Fama and French (1993) conjecture that the SMB factor is a proxy for financial distress and, as such, represents default risk. If this is in fact the case, then it is not surprising that some industries have positive and others negative SMB beta given that some industries are much more prone to financial distress than others. The t-test in Panel B indicates that the average SMB beta across the 36 industries is significantly different from zero.

Table 4.1 **Time-varying industry betas relative to the equity factors**

This table reports the sample mean of the time-varying equity-related factor betas estimated from the system of equations (2.2 to 2.9). The portfolios are 31 manufacturing industries and five service industries. Non-traded goods industries, using the definitions in Bodnar and Gentry (1993), have (n) to the right of their name. The equity risk factors are the Fama-French (1993) factors – market excess return (VWM), returns on 'small minus big' firms (SMB), and returns on 'high minus low' book-to-market value firms (HML). Significance at the 10%, 5%, and 1% levels are represented by *, **, and ***, respectively.

Panel A: Mean of estimated time-varying betas

| Industry | VWM | SMB | HML | Industry | VWM | SMB | HML |
|---|---|---|---|---|---|---|---|
| Agri | 0.864*** | 0.696*** | -0.693*** | FabPr | 0.930*** | 0.857*** | -0.692*** |
| Food | 0.794*** | -0.309*** | -0.373*** | Mach | 1.158*** | 0.655*** | -0.951*** |
| Soda | 0.867*** | -0.387 | -0.679*** | ElcEq | 1.269*** | 0.999*** | -1.476*** |
| Beer | 0.776*** | -0.163*** | -0.572*** | Autos | 1.034*** | 0.240*** | -0.394*** |
| Smoke | 0.920*** | -0.237*** | -0.354*** | Aero | 1.077*** | 0.154*** | -0.809*** |
| Toys | 1.258*** | 0.662*** | -1.382*** | Ships | 0.956*** | 0.401*** | -0.626*** |
| Books | 1.026*** | 0.184*** | -0.620*** | Guns | 1.060*** | 0.287*** | -0.929*** |
| Fun (n) | 1.121*** | 0.449*** | -0.810*** | Gold | 0.666*** | 0.801*** | -0.399*** |
| Hshld | 1.005*** | -0.214*** | -0.769*** | Mines | 0.994*** | 0.675*** | -0.683*** |
| Clths | 1.109*** | 0.602*** | -0.942*** | Coal | 0.955*** | 0.509*** | -0.607*** |
| MedEq | 1.029*** | 0.037*** | -1.092*** | Chips | 1.273*** | 0.631*** | -1.453*** |
| Drugs | 0.968*** | -0.344*** | -0.899*** | LabEq | 1.380*** | 0.980*** | -1.601*** |
| Chems | 1.070*** | 0.089*** | -0.695*** | Paper | 1.085*** | 0.196*** | -0.670*** |
| Rubbr | 1.140*** | 0.751*** | -0.974*** | Boxes | 0.911*** | 0.086*** | -0.613*** |
| Txtls | 0.968*** | 0.960*** | -0.699*** | Rtail (n) | 1.104*** | 0.342*** | -0.884*** |
| BldMt | 1.124*** | 0.250*** | -0.758*** | Meals (n) | 1.035*** | 0.315*** | -0.830*** |
| Cnst (n) | 1.251*** | 0.801*** | -0.905*** | Banks (n) | 1.177*** | 0.042*** | -0.362*** |
| Steel | 1.038*** | 0.559*** | -0.640*** | Comps | 1.038*** | 0.389*** | -1.225*** |

Panel B: Summary statistics of betas

| | VWM | SMB | HML |
|---|---|---|---|
| Average of mean betas | 1.040 | 0.360 | -0.807 |
| Standard deviation of means betas | 0.150 | 0.396 | 0.314 |
| | | | |
| T-test: $\mathbf{H}_0$: Average of all industries = 0 | 41.609 | 5.450 | -15.426 |

The mean of the time-varying HML beta for each of the 36 industry portfolios is negative and significantly different from zero. An inspection of the graph of the individual betas (not reported) indicates that for many industries the HML betas were positive for some periods. The mean beta of the measuring and control equipment industry has the largest magnitude, 1.60, while the tobacco products (smoke) industry has the smallest, 0.354. The average beta across the 36 industries is -0.807, which is significantly different from zero. Industries with a negative mean HML beta may be regarded, on average, as hedging portfolios in the sense that during periods when the expected return on the HML risk factor is high investors tend to demand lower risk premiums. Overall, the results in this sub-section point to the fact that the industry portfolios are significantly exposed to the equity-related sources of risk.

## 4.2 Estimates of time-varying exchange rate betas

In our test, the currency beta reflects the sensitivity of industry expected returns to the conditionally expected (ex ante) changes in the exchange rate factor. It is a component of the currency risk premium – the effect of exchange rate risk on the cost of equity, which is a part of the denominator of the value equation. For an industry with a positive mean currency beta, a positive product of the currency beta and the factor expectation implies a higher expected currency risk premium. Hence, for a given level of expected cash flows firm value is expected to decline. That is, such a firm is expected to lose value as the dollar is expected to appreciate.

Table 4.2 reports the mean of the time-varying currency betas, their standard deviations, and their minimum and maximum values over the sample period. We also present the mean of their absolute values and use these as the focus of the discussion of our results. It should be noted, however, that the same qualitative results hold if we use the mean values instead.

The evidence indicates that industry expected returns have significant sensitivity to both measures of currency risk. The pervasive impact of exchange rate movements on US industries is consistent with the results of the recent Philadelphia Fed survey, which finds that over 45% of US firms reported that they are affected by currency movements, and indicates why during the late 1990s the leading manufacturing associations urged then Treasury Secretary, Paul O'Neill, to clarify the Treasury's policy on the issue of the strong dollar and requested a meeting to discuss its effect on their businesses (Rosenberg, 2003, p. 53).

A closer inspection of the results indicates that, not only are the mean currency betas statistically significant but, on the basis of their magnitude, they also appear economically important, though their economic importance can only be fully appreciated in combination with the conditionally expected returns on the factors, which we turn to in the next sub-section. Of the 36 mean absolute OITP betas, only that of the fun (entertainment) industry is less than 0.20, while the others range from 0.21 to 1.15, with a mean of 0.49. For the MAJOR index, the mean absolute betas range in value from 0.022 to 1.11 with a total of 17 having values greater than 0.20 and only three less than 0.10. The overall average magnitude is about 0.25. As reflected by the minimum and maximum values, most of the industries experience both positive and negative currency betas during the sample period. It is noteworthy that there is significant variation in magnitude and sign across industries. This dispersion in exchange rate sensitivity is consistent with the US economy being an open economy.

Table 4.2 **Time-varying currency betas for each industry**

This table reports the sample mean of the time-varying currency factor betas estimated from the system of equations (2.2 to 2.9). 'Mean Abs' is the mean of the absolute betas. The industry portfolios are 31 manufacturing industries and five non-traded goods industries. Non-traded goods industries, using the definitions in Bodnar and Gentry (1993), have (n) to the right of their name. The currency factors are percentage changes in the Treasury's OITP and MAJOR trade-weighted indices, in foreign currency per dollar. Significance at the 10%, 5%, and 1% levels are represented by *, **, and ***, respectively.

| | OITP | | | | | MAJOR | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Industry | Mean Abs | Mean | STD | Min | Max | Mean Abs | Mean | STD | Min | Max |
| Agri | 0.375*** | -0.343*** | 0.259 | -1.222 | 0.917 | 0.354*** | -0.354*** | 0.038 | -0.438 | -0.238 |
| Food | 0.570*** | 0.437*** | 0.552 | -2.030 | 2.411 | 0.218*** | -0.212*** | 0.108 | -0.506 | 0.200 |
| Soda | 0.392*** | -0.149*** | 0.517 | -1.942 | 1.481 | 0.160*** | -0.096*** | 0.167 | -0.500 | 0.240 |
| Beer | 0.335*** | 0.244*** | 0.368 | -1.260 | 2.006 | 0.158*** | -0.132*** | 0.123 | -0.333 | 0.166 |
| Smoke | 0.574*** | 0.337*** | 0.676 | -2.251 | 2.661 | 0.116*** | 0.105*** | 0.093 | -0.152 | 0.363 |
| Toys | 0.597*** | -0.204*** | 0.785 | -4.084 | 2.114 | 0.239*** | -0.164*** | 0.239 | -0.559 | 0.677 |
| Fun (n) | 0.169*** | 0.073*** | 0.229 | -1.240 | 0.914 | 0.119*** | 0.119*** | 0.060 | 0.003 | 0.278 |
| Books | 0.319*** | 0.151*** | 0.402 | -2.207 | 1.285 | 0.202*** | 0.202*** | 0.118 | -0.026 | 0.459 |
| Hshld | 0.339*** | 0.126*** | 0.445 | -2.128 | 1.381 | 0.103*** | -0.023*** | 0.122 | -0.236 | 0.316 |
| Clths | 0.541*** | -0.077 | 0.766 | -5.160 | 2.605 | 0.113*** | 0.053*** | 0.128 | -0.299 | 0.375 |
| MedEq | 0.331*** | 0.267*** | 0.306 | -0.969 | 0.987 | 0.173*** | -0.172*** | 0.065 | -0.332 | 0.034 |
| Drugs | 0.406*** | 0.336*** | 0.350 | -0.838 | 1.805 | 0.333*** | -0.331*** | 0.172 | -0.702 | 0.126 |
| Chems | 0.456*** | 0.076* | 0.641 | -3.856 | 2.542 | 0.371*** | -0.371*** | 0.065 | -0.492 | -0.076 |
| Rubbr | 0.621*** | -0.563*** | 0.523 | -2.669 | 2.599 | 0.253*** | -0.212*** | 0.206 | -0.633 | 0.342 |
| Txtls | 0.600*** | -0.135*** | 0.824 | -5.285 | 3.241 | 0.096*** | -0.043*** | 0.128 | -0.491 | 0.298 |
| BldMt | 0.391*** | -0.246*** | 0.468 | -1.929 | 2.492 | 0.184*** | -0.087*** | 0.194 | -0.463 | 0.420 |
| Cnst (n) | 0.511*** | -0.286*** | 0.576 | -3.270 | 1.412 | 0.144*** | -0.033*** | 0.170 | -0.418 | 0.330 |
| Steel | 0.557*** | -0.473*** | 0.466 | -2.803 | 1.082 | 0.301*** | -0.300*** | 0.123 | -0.472 | 0.029 |
| FabPr | 0.473*** | -0.409*** | 0.405 | -1.822 | 1.410 | 0.022*** | -0.014*** | 0.025 | -0.095 | 0.158 |
| Mach | 0.589*** | -0.566*** | 0.355 | -1.999 | 0.565 | 0.462*** | -0.462*** | 0.081 | -0.592 | -0.195 |
| ElcEq | 0.892*** | -0.717*** | 0.883 | -3.982 | 3.872 | 0.282*** | -0.101*** | 0.331 | -0.908 | 0.949 |
| Autos | 0.477*** | 0.303*** | 0.539 | -2.644 | 2.058 | 0.067*** | -0.037*** | 0.070 | -0.186 | 0.167 |
| Aero | 0.369*** | 0.273*** | 0.357 | -1.660 | 1.470 | 0.133*** | -0.030*** | 0.160 | -0.608 | 0.341 |
| Ships | 0.622*** | 0.170*** | 0.819 | -4.308 | 2.107 | 0.406*** | 0.404*** | 0.117 | -0.114 | 0.765 |
| Guns | 0.829*** | 0.076 | 1.116 | -4.601 | 5.592 | 0.342*** | -0.266*** | 0.319 | -1.228 | 1.385 |
| Gold | 0.894*** | -0.875*** | 0.482 | -2.124 | 0.351 | 1.107*** | -1.107*** | 0.167 | -1.515 | -0.862 |
| Mines | 0.324*** | -0.270*** | 0.274 | -1.077 | 1.137 | 0.705*** | -0.705*** | 0.199 | -1.108 | -0.250 |
| Coal | 0.426*** | -0.366*** | 0.350 | -1.967 | 0.647 | 0.116*** | 0.114*** | 0.046 | -0.138 | 0.207 |
| Comps | 0.460*** | -0.159*** | 0.563 | -2.753 | 1.462 | 0.269*** | -0.212*** | 0.211 | -0.548 | 0.640 |
| Chips | 0.681*** | -0.360*** | 0.789 | -3.915 | 2.312 | 0.205*** | -0.101*** | 0.238 | -0.535 | 0.686 |
| LabEq | 1.152*** | -0.974*** | 0.960 | -4.755 | 1.592 | 0.100*** | 0.078*** | 0.099 | -0.230 | 0.459 |
| Paper | 0.205*** | 0.085*** | 0.278 | -1.285 | 1.263 | 0.196*** | -0.196*** | 0.060 | -0.277 | -0.029 |
| Boxes | 0.360*** | -0.027 | 0.505 | -3.145 | 2.252 | 0.272*** | -0.270*** | 0.116 | -0.448 | 0.111 |
| Rtail (n) | 0.379*** | 0.254*** | 0.415 | -2.245 | 1.372 | 0.185*** | 0.185*** | 0.072 | 0.060 | 0.334 |
| Meals (n) | 0.256*** | -0.136*** | 0.317 | -1.120 | 1.384 | 0.199*** | -0.080*** | 0.222 | -0.414 | 0.471 |
| Banks (n) | 0.238*** | 0.213*** | 0.177 | -0.469 | 0.985 | 0.135*** | 0.135*** | 0.039 | 0.059 | 0.222 |
| Average | 0.492 | -0.109 | | | | 0.246 | -0.131 | | | |
| STD | 0.209 | 0.358 | | | | 0.197 | 0.269 | | | |
| T-statistic | | | | | | | | | | |
| **H**$_0$: Avg = 0 | 14.141 | -1.823 | | | | 7.472 | -2.927 | | | |

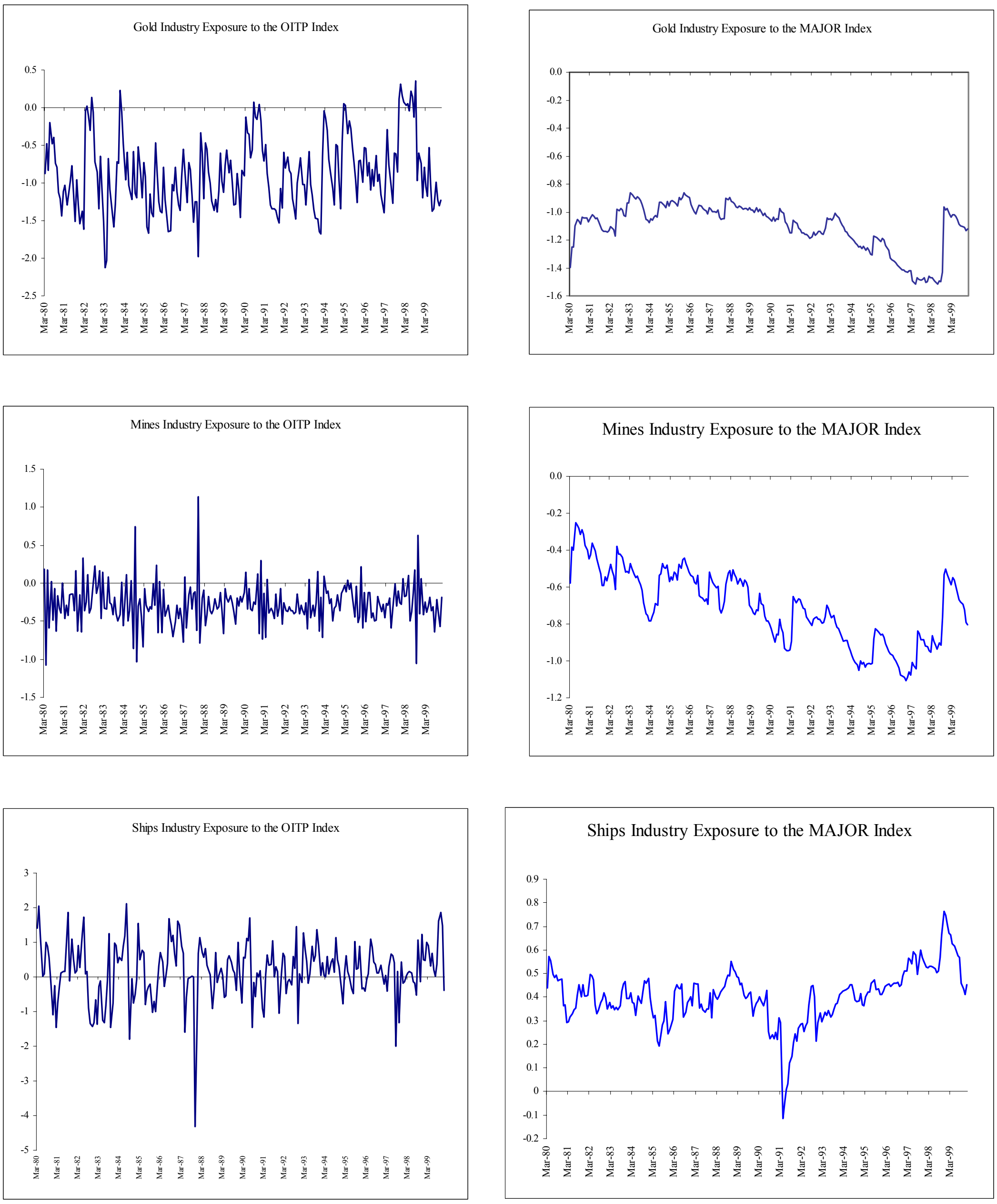
It is also noteworthy that the non-traded goods industries individually display statistically significant sensitivity to both currency risks and in some cases their mean or mean absolute currency beta appears economically larger than that for some traded industries. A characteristic of non-traded goods is that cross-border transportation costs are prohibitively high (Bodnar and Gentry, 1993). As such, exchange rate changes may affect non-traded goods industries via all the channels previously noted except for the export (of physical goods) channel. Furthermore, all firms and industries can be affected by exchange rate movements through exchange rate effects on aggregate demand. More generally, exchange rate changes are likely to have a different effect on non-traded industries relative to the effect on traded industries. This is because macroeconomic models predict that, if capital is more sector specific than the other inputs to production, then the relative price changes arising from the appreciation of the domestic currency causes a reallocation of capital from traded to non-traded industries. This provides a short-run increase in the market value of capital in non-traded industries relative to the market value of capital in the traded industries. Thus, exchange rate changes may cause a greater short-term sensitivity of non-traded industries relative to traded industries (see Bodnar and Gentry, 1993). Consistent with this, Bodnar and Gentry find that in the US, heavy construction, motor freight transportation, air transport, and business services industries have exposure coefficients that are statistically significant and in many cases larger than those for traded industries.

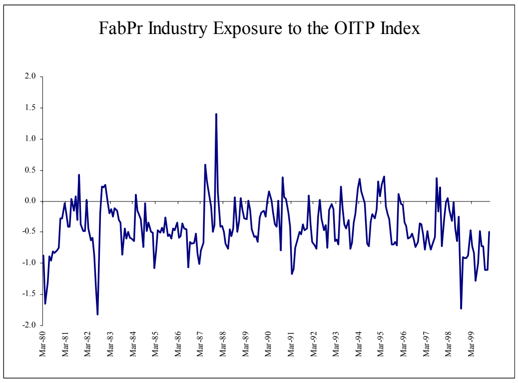
To provide a picture of the time variation in the currency betas, Figure 4.1 displays plots of the OITP and MAJOR betas for six of the industries reported in Table 4.2. We select the three industries on which currency risk had the largest effect and the three on which it had the least effect, where the magnitude of the currency risk premium (see below) as a proportion of total risk premium determines the effect of currency risk. The industries with the greatest impact from currency risk are the gold (precious metals), mines (non-metallic and industrial metal mining), and ships (shipbuilding and railroad equipment) industries, while those that experience the least impact are fabricated products, fun (entertainment), and household (consumer goods).[12] A cursory glance at the graphs confirms that there is significant variation in the currency beta over the sample period. A closer inspection indicates that, although for some industries there are changes in the sign of the currency betas over the sample period, the more frequent changes occur in the magnitude of the betas.

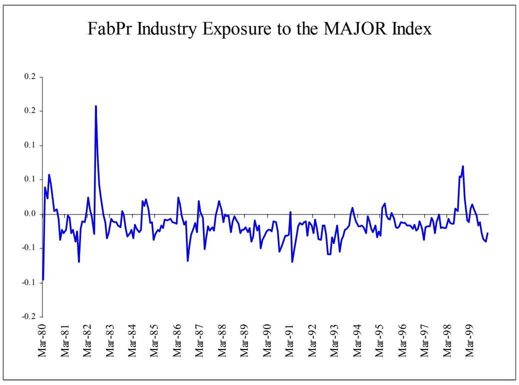
Thus far, our results indicate that US industries display significant time-varying sensitivity to exchange rate changes. Importantly, this sensitivity appears economically large. What remains to be determined is whether currency risk is statistically significantly priced and economically meaningful. If so, then exchange rate risk would be important for industry cost of capital. We turn to this next.

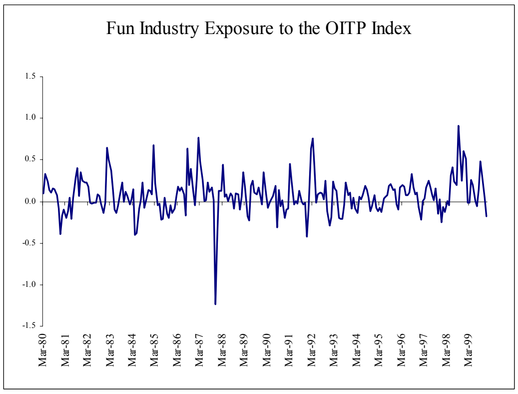
[12] Plots of the currency exposures of the other industries are broadly similar and are available on request.

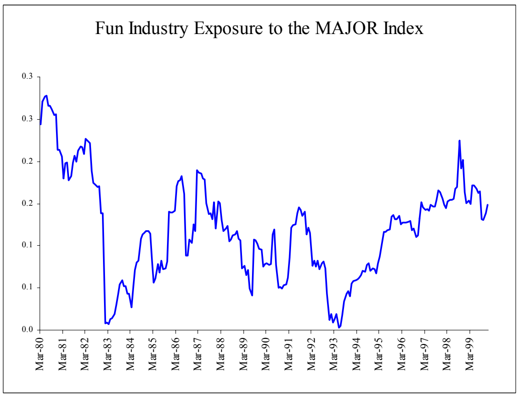
Figure 4.1 **Time-varying currency betas for a sub-sample of industries**

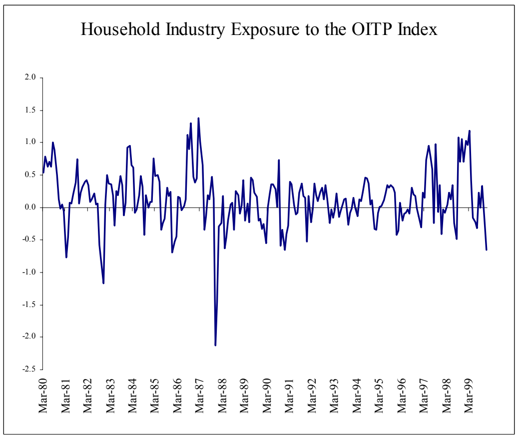


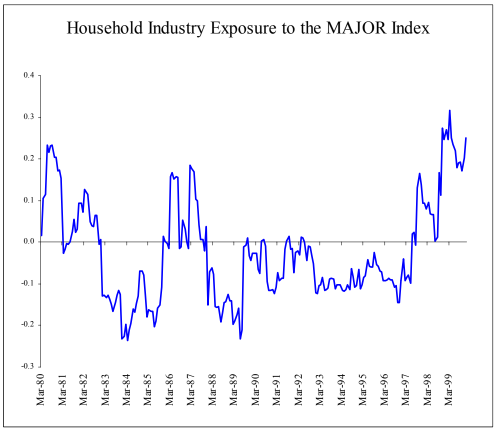



## 4.3 Is currency risk priced and how important is it to industry cost of capital?

The significance of the currency betas does not imply the existence of a significant currency risk premium in industry expected returns. We first need to examine whether or not currency risk is a priced factor and then determine the economic importance of currency risk premium to the industry expected returns (cost of equity). It is also worth noting that even if currency risk is priced in industry returns it is possible that it plays only a relatively minor economic role in industry returns. This is because there are three other risk factors in addition to the currency risks in our model and in the extant literature currency risk has been the least successful in explaining stock returns. On the other hand, if indeed it contributes an economically important component of expected returns then one implication is that the common practice of omitting currency risk from domestic asset pricing tests may lead to incorrect inferences.

Table 4.3 **Hypothesis tests of the pricing of currency and other risks**

This table reports p-values of tests of the null hypothesis that the conditionally expected returns of the risk factors are zero (the coefficients in equations (2.3) to (2.7) are zero) and so the risk factors are not priced. All hypotheses are based on Wald tests made robust to non-normality of the residuals. The instruments for the equity factors are the one-period lagged DEFAULT, TERM, and FED variables, as well as the lagged dependent variable (factor). For the currencies, the instruments are FED, EXPRATIO, IMPRATIO, and the lagged dependent variable (factor). All variables are defined in Table 3.1.

| **Industry** | $H_0$: **VWM** expected return = 0 | $H_0$: **SMB** expected return = 0 | $H_0$: **HML** expected return = 0 | $H_0$: **Equity factors** expected returns = 0 | $H_0$: **OITP** expected return = 0 | $H_0$: **MAJOR** expected return = 0 | $H_0$: **Currency factors** expected returns = 0 | $H_0$: **All risk factor** expected returns = 0 |
|---|---|---|---|---|---|---|---|---|
| Agri | 0.028 | 0.000 | 0.000 | 0.000 | 0.031 | 0.000 | 0.000 | 0.000 |
| Food | 0.025 | 0.000 | 0.009 | 0.000 | 0.073 | 0.000 | 0.000 | 0.000 |
| Soda | 0.017 | 0.000 | 0.008 | 0.000 | 0.007 | 0.000 | 0.000 | 0.000 |
| Beer | 0.000 | 0.000 | 0.000 | 0.000 | 0.022 | 0.000 | 0.000 | 0.000 |
| Smoke | 0.011 | 0.000 | 0.000 | 0.000 | 0.057 | 0.000 | 0.000 | 0.000 |
| Toys | 0.017 | 0.000 | 0.000 | 0.000 | 0.026 | 0.000 | 0.000 | 0.000 |
| Fun (n) | 0.219 | 0.000 | 0.045 | 0.000 | 0.038 | 0.000 | 0.000 | 0.000 |
| Books | 0.006 | 0.000 | 0.002 | 0.000 | 0.083 | 0.000 | 0.000 | 0.000 |
| Hshld | 0.013 | 0.000 | 0.000 | 0.000 | 0.102 | 0.000 | 0.000 | 0.000 |
| Clths | 0.006 | 0.000 | 0.000 | 0.000 | 0.188 | 0.000 | 0.000 | 0.000 |
| MedEq | 0.007 | 0.000 | 0.000 | 0.000 | 0.057 | 0.000 | 0.000 | 0.000 |
| Drugs | 0.020 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Chems | 0.131 | 0.000 | 0.010 | 0.000 | 0.012 | 0.000 | 0.000 | 0.000 |
| Rubbr | 0.014 | 0.000 | 0.047 | 0.000 | 0.014 | 0.000 | 0.000 | 0.000 |
| Txtls | 0.008 | 0.000 | 0.054 | 0.000 | 0.019 | 0.000 | 0.000 | 0.000 |
| BldMt | 0.000 | 0.000 | 0.020 | 0.000 | 0.354 | 0.000 | 0.000 | 0.000 |
| Cnst (n) | 0.014 | 0.000 | 0.002 | 0.000 | 0.060 | 0.000 | 0.000 | 0.000 |
| Steel | 0.067 | 0.000 | 0.002 | 0.000 | 0.011 | 0.000 | 0.000 | 0.000 |
| FabPr | 0.025 | 0.000 | 0.000 | 0.000 | 0.009 | 0.000 | 0.000 | 0.000 |
| Mach | 0.029 | 0.000 | 0.024 | 0.000 | 0.014 | 0.000 | 0.000 | 0.000 |
| ElcEq | 0.086 | 0.000 | 0.289 | 0.000 | 0.017 | 0.000 | 0.000 | 0.000 |
| Autos | 0.002 | 0.000 | 0.000 | 0.000 | 0.066 | 0.000 | 0.000 | 0.000 |
| Aero | 0.006 | 0.000 | 0.008 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |
| Ships | 0.008 | 0.000 | 0.013 | 0.000 | 0.028 | 0.000 | 0.000 | 0.000 |
| Guns | 0.001 | 0.000 | 0.000 | 0.000 | 0.015 | 0.000 | 0.000 | 0.000 |
| Gold | 0.000 | 0.000 | 0.000 | 0.000 | 0.077 | 0.000 | 0.000 | 0.000 |
| Mines | 0.010 | 0.000 | 0.001 | 0.000 | 0.017 | 0.000 | 0.000 | 0.000 |
| Coal | 0.029 | 0.000 | 0.000 | 0.000 | 0.009 | 0.000 | 0.000 | 0.000 |
| Comps | 0.006 | 0.000 | 0.000 | 0.000 | 0.010 | 0.000 | 0.000 | 0.000 |
| Chips | 0.229 | 0.000 | 0.076 | 0.000 | 0.007 | 0.000 | 0.000 | 0.000 |
| LabEq | 0.041 | 0.000 | 0.045 | 0.000 | 0.028 | 0.000 | 0.000 | 0.000 |
| Paper | 0.078 | 0.000 | 0.048 | 0.000 | 0.014 | 0.000 | 0.000 | 0.000 |
| Boxes | 0.044 | 0.000 | 0.050 | 0.000 | 0.033 | 0.000 | 0.000 | 0.000 |
| Rtail (n) | 0.023 | 0.000 | 0.004 | 0.000 | 0.137 | 0.000 | 0.000 | 0.000 |
| Means (n) | 0.012 | 0.000 | 0.161 | 0.000 | 0.068 | 0.000 | 0.000 | 0.000 |
| Banks (n) | 0.004 | 0.000 | 0.031 | 0.000 | 0.038 | 0.000 | 0.000 | 0.000 |

If exchange rate risk is a priced factor, then the null hypothesis that the conditionally expected factor returns are zero will be rejected. Table 4.3 reports the results of tests of this hypothesis. We report the results for the individual equity risk factors and the equity factors jointly. Similarly, we report the results for the individual currency factors and the currency factors jointly. Overwhelmingly, the evidence indicates that the currency risks, individually and jointly, are significantly priced. To our knowledge, this is the first evidence that currency risk is priced in US industry returns and that this holds for the risks of both developing and industrialized countries' currencies.

We take complementary approaches to highlight the importance of currency risk for industry cost of capital. To facilitate this, note that the currency risk premium for each period is the product of the estimated currency beta and the expected change in the currency factor in that period, while the total risk premium is the sum of the estimated expected risk premiums from the five risk factors. First, for both currency factors, we present the mean absolute value of the estimated expected currency risk premium. Second, we compare the currency risk premium to the risk premium of the equity-related factors. Third, we report the absolute currency risk premium as a percentage of the total absolute risk premium. The sample means of these values are reported in Panel A of Table 4.4.

The estimates provide strong evidence that currency risk is economically important for US industries. Panel A indicates that the mean absolute currency risk premiums range from 1.10 to 7.78 percentage points annualized, with 18 of the 36 industries having a mean absolute currency premium greater than 2 percentage points. All mean absolute currency risk premiums are statistically significantly different from zero at less than the 1% significance level. While there is no existing industry-level study with which to compare the magnitude of these currency risk premiums, it is worth noting that our average absolute risk premium is generally smaller in magnitude than the mean currency risk premiums reported by De Santis and Gerard (1998, p. 407), who study a number of aggregate equity markets from the industrialized world. This is especially the case for their sub-period results. Hence, it does not appear that these large currency premiums are due to a systematic overestimation of the relevant parameters.

Table 4.4 **Estimates of time-varying risk premiums**

Panel A of this table reports the sample mean risk premium associated with each risk factor, the sum of the individual currency premiums, the total risk premium, and the percentage of the total risk premium attributed to the currency risk premiums, respectively. The risk premium is the product of the respective beta and corresponding expected return on the factor for each period. The total risk premium is the sum of the three equity and two currency risk premiums, in each period. For comparison across premiums, all premiums are reported as the mean of the absolute period-by-period premium. The risk factors are returns on the Fama-French (1993) factors – market excess return (VWM), returns on 'small minus big' firms (SMB), and returns on 'high minus low' book-to-market value firms (HML). The currency factors are percentage changes in the Treasury MAJOR and OITP trade-weighted indices, expressed as foreign currency per dollar. Panel B reports summary statistics across all 36 industries. Significance at the 10%, 5%, and 1% levels are represented by *, **, and ***, respectively.

Panel A: Summary of absolute time-varying risk premiums

| Industry | Market | SMB | HML | OITP | MAJOR | Total Currency | Total Premium | Currency % of Total |
|---|---|---|---|---|---|---|---|---|
| Agri | 10.309*** | 4.078*** | 4.768*** | 0.693*** | 1.949*** | 2.643*** | 21.798*** | 12.971 |
| Food | 8.917*** | 1.829*** | 2.024*** | 1.047*** | 1.198*** | 2.245*** | 15.015*** | 16.200 |
| Soda | 11.022*** | 2.194*** | 3.356*** | 1.364*** | 0.889*** | 2.252*** | 18.825*** | 13.161 |
| Beer | 9.056*** | 1.197*** | 4.024*** | 0.719*** | 0.790*** | 1.508*** | 15.786*** | 10.980 |
| Smoke | 10.441*** | 1.288*** | 2.269*** | 1.049*** | 0.646*** | 1.695*** | 15.692*** | 12.326 |
| Toys | 14.818*** | 4.082*** | 7.784*** | 1.345*** | 1.280*** | 2.625*** | 29.310*** | 9.145 |
| Fun (n) | 10.679*** | 2.508*** | 4.348*** | 0.365*** | 0.718*** | 1.083*** | 18.618*** | 6.013 |
| Books | 12.671*** | 1.282*** | 3.946*** | 0.633*** | 1.213*** | 1.846*** | 19.745*** | 9.757 |
| Hshld | 13.317*** | 1.121*** | 4.759*** | 0.585*** | 0.524*** | 1.110*** | 20.307*** | 6.061 |
| Clths | 12.900*** | 4.814*** | 6.225*** | 0.987*** | 0.751*** | 1.738*** | 25.678*** | 7.192 |
| MedEq | 11.363*** | 0.414*** | 7.028*** | 0.721*** | 0.937*** | 1.658*** | 20.463*** | 9.266 |
| Drugs | 12.437*** | 1.716*** | 4.936*** | 1.176*** | 1.721*** | 2.897*** | 21.986*** | 14.676 |
| Chems | 11.874*** | 1.032*** | 3.690*** | 1.165*** | 2.112*** | 3.278*** | 19.874*** | 17.052 |
| Rubbr | 13.637*** | 5.320*** | 3.868*** | 1.558*** | 1.332*** | 2.890*** | 25.715*** | 12.292 |
| Txtls | 13.811*** | 6.438*** | 3.351*** | 1.314*** | 0.662*** | 1.976*** | 25.576*** | 8.105 |
| BldMt | 16.213*** | 1.940*** | 3.806*** | 0.942*** | 1.021*** | 1.963*** | 23.922*** | 9.343 |
| Cnst (n) | 12.449*** | 5.374*** | 6.703*** | 0.991*** | 0.738*** | 1.729*** | 26.254*** | 6.909 |
| Steel | 11.913*** | 3.605*** | 4.975*** | 1.212*** | 1.642*** | 2.854*** | 23.347*** | 13.778 |
| FabPr | 12.112*** | 5.221*** | 4.945*** | 1.174*** | 0.141*** | 1.315*** | 23.593*** | 5.683 |
| Mach | 11.762*** | 3.668*** | 5.691*** | 1.223*** | 2.565*** | 3.788*** | 24.908*** | 15.681 |
| ElcEq | 12.531*** | 6.318*** | 4.170*** | 2.189*** | 1.773*** | 3.962*** | 26.981*** | 14.733 |
| Autos | 12.528*** | 2.099*** | 3.352*** | 0.968*** | 0.365*** | 1.332*** | 19.312*** | 7.859 |
| Aero | 12.601*** | 1.287*** | 5.068*** | 0.913*** | 0.785*** | 1.698*** | 20.654*** | 8.682 |
| Ships | 10.917*** | 2.790*** | 4.517*** | 1.516*** | 2.267*** | 3.782*** | 22.006*** | 17.538 |
| Guns | 17.742*** | 3.135*** | 7.050*** | 2.400*** | 2.095*** | 4.496*** | 32.423*** | 14.682 |
| Gold | 9.005*** | 5.313*** | 3.693*** | 1.869*** | 5.913*** | 7.781*** | 25.793*** | 32.937 |
| Mines | 12.235*** | 4.887*** | 5.227*** | 0.715*** | 3.979*** | 4.693*** | 27.043*** | 18.543 |
| Coal | 9.998*** | 3.251*** | 4.508*** | 0.942*** | 0.660*** | 1.602*** | 19.359*** | 8.488 |
| Comps | 12.801*** | 2.679*** | 8.353*** | 1.033*** | 1.409*** | 2.443*** | 26.275*** | 10.108 |
| Chips | 14.071*** | 4.037*** | 5.720*** | 1.552*** | 1.043*** | 2.595*** | 26.423*** | 9.808 |
| LabEq | 15.663*** | 6.070*** | 7.950*** | 2.265*** | 0.563*** | 2.828*** | 32.510*** | 8.895 |
| Paper | 11.248*** | 1.374*** | 4.129*** | 0.456*** | 1.046*** | 1.502*** | 18.254*** | 9.112 |
| Boxes | 10.166*** | 1.069*** | 3.513*** | 0.895*** | 1.417*** | 2.312*** | 17.060*** | 14.661 |
| Rtail (n) | 13.860*** | 2.329*** | 4.984*** | 0.743*** | 1.057*** | 1.800*** | 22.974*** | 8.580 |
| Meals (n) | 10.834*** | 2.021*** | 3.336*** | 0.680*** | 1.126*** | 1.805*** | 17.996*** | 11.292 |
| Banks (n) | 14.459*** | 0.390*** | 1.928*** | 0.502*** | 0.678*** | 1.180*** | 17.957*** | 8.946 |

Panel B: Averages across all industries

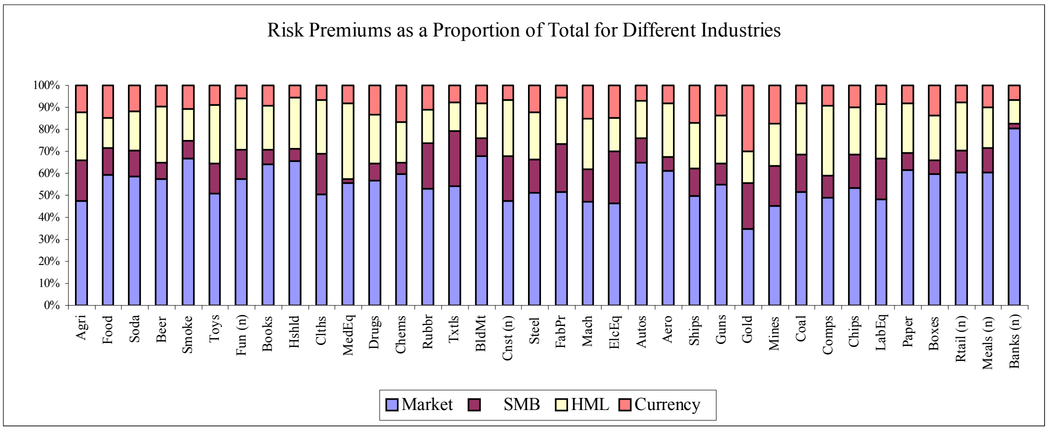
| | Market | SMB | HML | OITP | MAJOR | Total Currency | Total Premium | Currency % of Total |
|---|---|---|---|---|---|---|---|---|
| Average | 12.288*** | 3.005*** | 4.722*** | 1.108*** | 1.361*** | 2.470*** | 22.484*** | 11.707 |
| Std dev | 2.000 | 1.784 | 1.588 | 0.493 | 1.072 | 1.307 | 4.449 | 5.049 |
| Min | 8.917 | 0.390 | 1.928 | 0.365 | 0.141 | 1.083 | 15.015 | 5.683 |
| Max | 17.742 | 6.438 | 8.353 | 2.400 | 5.913 | 7.781 | 32.510 | 32.937 |

Unlike previous work that examines the effect of exchange rate movements on industry expected returns (eg Jorion, 1991), we separate the currency risk premium into two components – that due to exposure to the currencies of the industrialized countries and that due to exposure to the currencies of the developing countries. By doing so we are able to gain insights into which of the components is more important, and thus contributes more to industry cost of equity. There are 26 industries in which the risk premium of one or the other currency is greater than 100 basis points. For about half of the industries the currency premium related to the currencies of the developing economies is economically larger than that related to the industrialized countries' currencies, implying that omission of these currencies from the model would lead to significant understatement of the effect of currency risk. The significance of the developing countries' currency risk in our tests is consistent with the evidence at the aggregate market level reported by Carrieri et al (2006).

To provide another perspective on the importance of currency premium to these industries, we compare the currency premium to the equity risk premiums. While it is immediately clear that the mean currency premiums are smaller than the mean market premiums, this is not necessarily the case with the Fama-French factors. A comparison of the premiums in columns 2 and 6 indicates that for 16 of the 36 industries the mean of the absolute currency risk premium is economically larger than the mean of the absolute SMB risk premium. For the HML risk premium this is the case for two industries. Thus, also from this perspective currency risk premium is economically important for US industries.

As another measure of the importance of currency risk premium, we follow De Santis and Gerard (1998) and Carrieri et al (2006) and present currency risk premium as a percentage of total risk premium, based on absolute values. The last column of Panel A, and Figure 4.2, indicates that the average currency risk premium ranges from about 6% to about 33% of total risk premium. There are 18 industries in which the currency risk premium accounts for more than 10% of total premium. These results are consistent with the 20% that Carrieri et al (2006) report for the US stock market. Overall, the evidence in Panel B is that currency risk adds about 2.47 percentage points per year to the cost of equity of the average industry, accounting for about 11.7% of the total risk premium.

Figure 4.2 **Currency risk premium as a percentage of total risk premium for different industries**

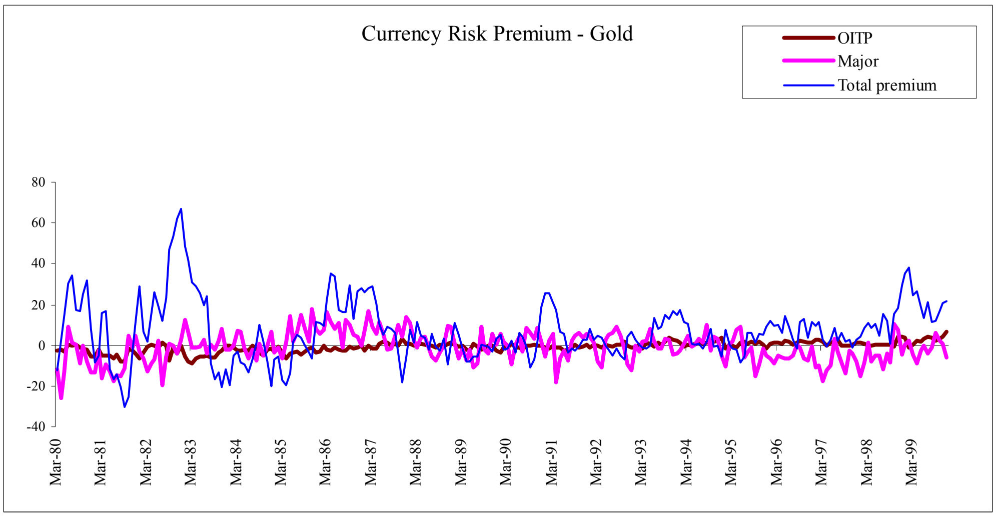


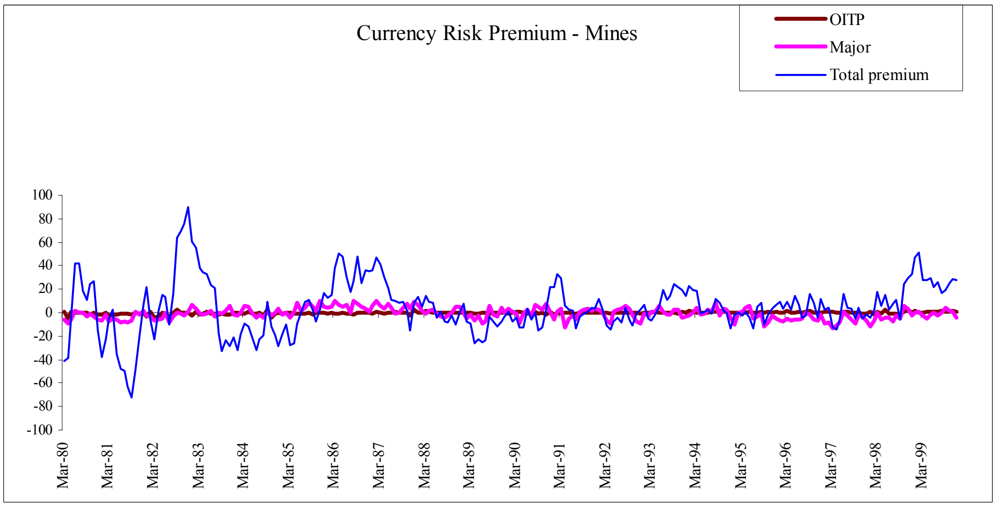

To provide a picture of the time variation in the currency risk premium, Figure 4.3 reports plots of the developing and industrialized countries' currency risk premiums as well as the total risk premium for six industries. The currency betas of these industries are plotted in Figure 4.1. To save space, we select the three industries with the highest and lowest currency risk premium as a percentage of total risk premium. An inspection of the graph indicates that currency risk premium experiences significant time variation and is generally a large component of the industries' total risk premium. As with the exposures, most industries experience both positive and negative currency risk premiums over the sample period.

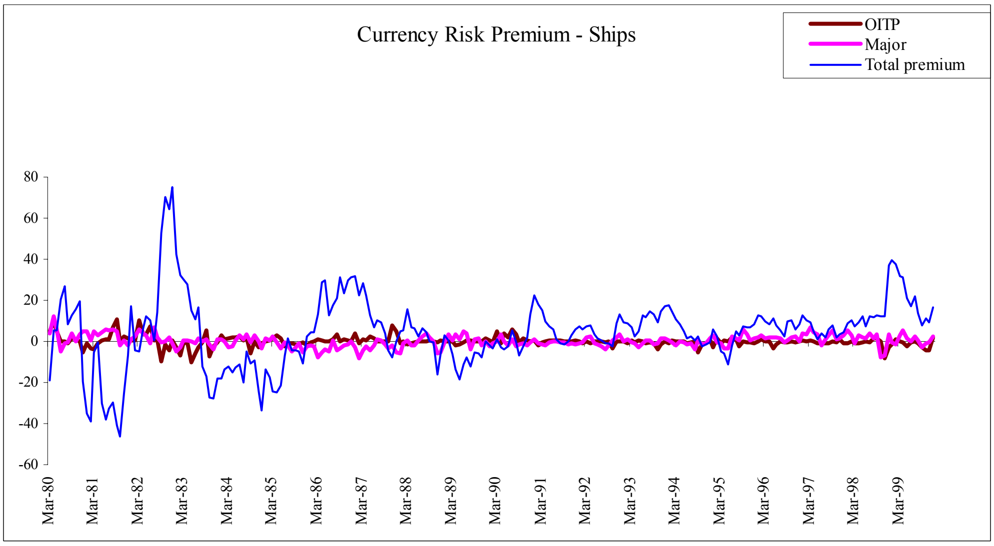
Taken together, these results indicate that currency risk plays a much more important role in US industry returns than had previously been attributed to it by others such as Jorion (1991). Our results are consistent with the finding by De Santis and Gerard (1998) and Carrieri et al (2006) that currency risk premium plays an important role in stock market expected returns. More important, we resolve the puzzle that, while these authors find that currency risk plays a significant role in the aggregate US market, researchers have failed to show the same at the industry level.

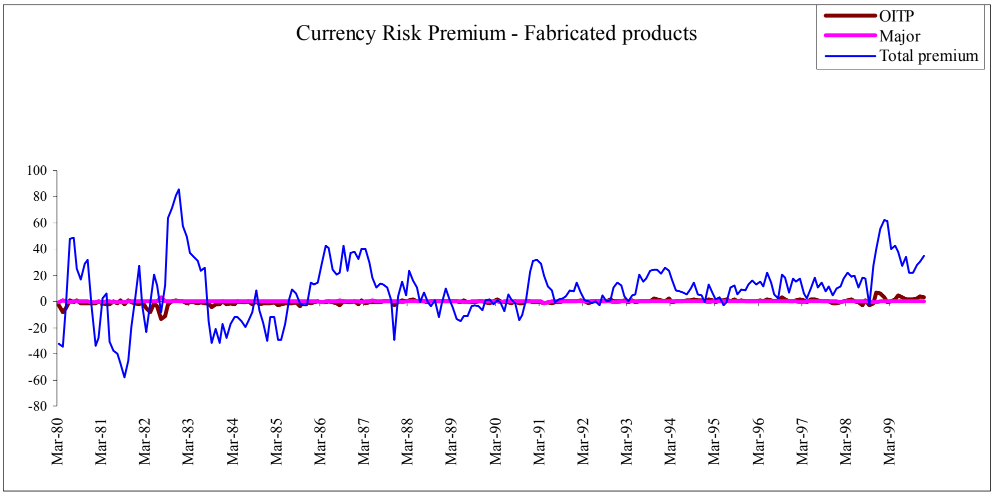
Our results have several implications. From the perspective of a corporate manager (or equity investor) the contribution of currency risk premium to industry-level cost of equity (or expected returns) cannot be regarded as trivial and, therefore, ignored. Importantly, this risk premium does not always increase the cost of equity (or expected returns), as it is sometimes negative. Thus, for the corporate manager (equity investor), currency risk also has a hedging component.

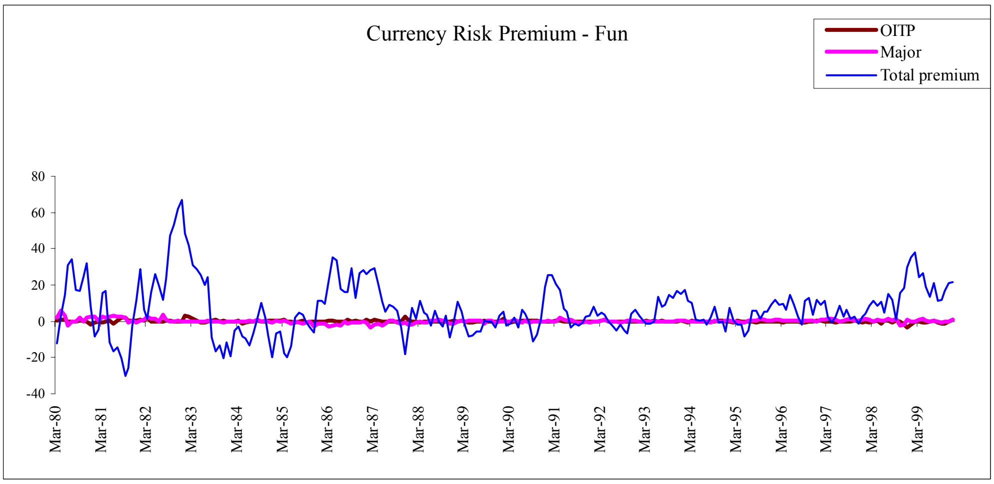
Figure 4.3 **Currency risk premium and total risk premium for different industries**

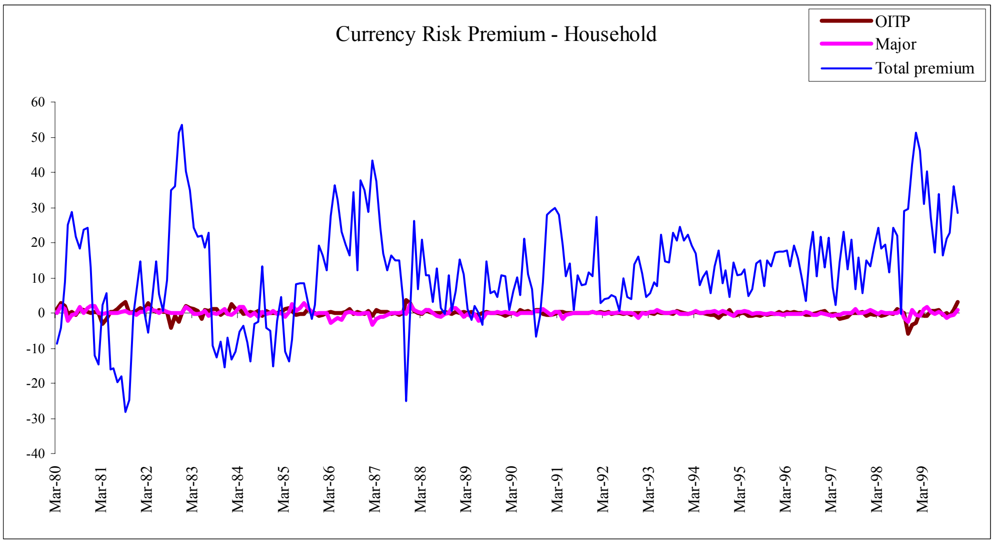



Currency Risk Premium - Fabricated products
OITP
Major
Total premium
100
80
60
40
20
0
-20
-40
-60
-80
Mar-80
Mar-81
Mar-82
Mar-83
Mar-84
Mar-85
Mar-86
Mar-87
Mar-88
Mar-89
Mar-90
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99


Currency Risk Premium - Fun
OITP
Major
Total premium
80
60
40
20
0
-20
-40
Mar-80
Mar-81
Mar-82
Mar-83
Mar-84
Mar-85
Mar-86
Mar-87
Mar-88
Mar-89
Mar-90
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99


Currency Risk Premium - Household
OITP
Major
Total premium
60
50
40
30
20
10
0
-10
-20
-30
-40
Mar-80
Mar-81
Mar-82
Mar-83
Mar-84
Mar-85
Mar-86
Mar-87
Mar-88
Mar-89
Mar-90
Mar-91
Mar-92
Mar-93
Mar-94
Mar-95
Mar-96
Mar-97
Mar-98
Mar-99

The results also have important implications for the competitiveness of US industries. Currency movements, via their cost-of-equity effects, may reduce (improve) US companies' ability (especially those in industries more dependent on external financing) to raise capital at reasonable rates to, for instance, acquire foreign competitors and increase or establish market share in foreign markets. Similarly, if during periods when the dollar is strong currency movements reduce the ability of the most exposed exporting industries to raise capital at reasonable rates, then they may not be in a position to offer competitive terms of trade to importers in the developing economies. Unfortunately, it is precisely during periods of a strong dollar that exporting firms would desire a boost in their foreign sales and the time when foreign importers facing a strong dollar (weak local currency) would most welcome a good deal. It is possible that industry rivals from foreign countries who are less affected by exchange rate movements could offer better deals and acquire US market shares.

There is, therefore, a clear case for the management of currency risk on the part of corporate managers. There may also be a clear case for strategic intervention by the authorities in targeted industries if US industries are to remain competitive. Perhaps cognizant of this, the US Ex-Im Bank provides special export loans, pre-export working capital, loan guarantees, and other assistance to exporters in an attempt to increase the competitiveness of US products.

The results also have significance for other asset classes than equities. For example, fixed income securities also bear a currency risk premium. De Santis and Gerard (1998, p. 384, 409) report an annualized mean currency premium (these are not absolute values) for Euromark, Euroyen, and Europound deposits over the period 1989 to 1994 as 6.23%, 5.10%, and 5.55%, respectively. They do not report the betas of these positions. However, assuming that exchange rate changes have a one-for-one effect on the returns of fixed-income securities (a currency beta close to 1), the results in our Tables 4.2 and 4.4 indicate that the imputed currency premiums for fixed-income positions with a currency beta of 1 are 2.25% and 5.5% for the developing and the industrialized countries' currencies, respectively.[13] In general, these results indicate that failing to account for the developing countries' currencies understates the significance of currency risk. Finally, at least at the industry level, it seems reasonable that domestic asset pricing models should consider currency risk.

[13] Using absolute betas of 0.492 and 0.246 and absolute premiums of 1.108 and 1.361, respectively, for the developing and industrialized countries' currencies (Tables 4.2 and 4.4), we obtain 1.108/0.492 = 2.25 and 1.361/0.246 = 5.5, a total of 7.75%.

## 4.4 Can hedging explain the previous weak industry-level results?

Our results present evidence against the hedging hypothesis. As argued above, if hedging were the reason for the results that currency risk is not priced and currency premium is immaterial, then we should find no significant premium for the currencies of the industrialized countries, which are easy to hedge. To the contrary, both currency factors contribute to the currency risk premium, thus providing support for the methodological hypothesis. To more sharply distinguish between these hypotheses we also report sub-period results for 1980–1989 and 1990–1999. During the first sub-period there was an absence of hedging instruments for the currencies of the developing countries and operational hedges were unlikely to be able to successfully eliminate exposure to these currencies. The importance of this is that if the previous results by Jorion (1991) and others were due to effective currency hedging and not weakness in the methodology, then we should observe significant currency risk premium for the currencies of the developing countries. On the other hand, the availability of hedging instruments as well as greater ability to use operational hedges should lead to insignificant currency risk premium for the currencies of the industrialized countries.

Table 4.5 reports the sub-period results. It is clear that the results hold up over both sub-periods, as the mean absolute currency betas, risk premiums, and risk premium as a percentage of the total premium are significant in both periods and substantially indistinguishable across periods. Therefore, the overwhelming evidence is that hedging cannot explain the insignificance of currency risk premium.

## 4.5 Diagnostic and robustness tests

To ensure the validity of our results, the models are estimated subject to a battery of diagnostic and robustness tests. For each industry, we standardize the residuals from the conditional mean model in equation (2.2) by dividing them by the conditional standard deviation from equation (2.9) and test the null hypotheses that the mean of the standardized residuals is equal to zero, that the standardized residuals are not autocorrelated (and, hence, not predictable), and that the squared standardized residuals are not autocorrelated (no remaining heteroscedasticity). The results in the first four columns of Table 4.6 indicate that in all cases we cannot reject the first hypothesis and for more than 30 (33) industries we cannot reject the other two hypotheses. Because we use the QML estimation, the rejection of the null hypothesis that the residuals are normally distributed (column 2) poses no problem for our inferences.

Table 4.5 **Sub-period exchange rate risk**

Panel A of this table reports the sample mean of the absolute currency betas and absolute currency risk premiums for each industry in the periods January 1980 to December 1989 and January 1990 to December 1999. The risk premium is the product of the currency beta and expected change in the currency factor for each period. Panel B is a summary across all 36 industries. Significance at the 10%, 5%, and 1% levels are represented by *, **, and ***, respectively.

Panel A: Mean time-varying exchange rate betas and risk premiums

| | 1980 to 1989 | | | | | 1990 to 1999 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Industry | OITP Beta | MAJOR Beta | Total cur prem | Total prem | % of total prem | OITP Beta | MAJOR Beta | Total cur prem | Total prem | % of total prem |
| Agri | 0.378*** | 0.345*** | 3.009*** | 23.719*** | 14.025 | 0.371*** | 0.362*** | 2.283*** | 19.910*** | 11.934 |
| Food | 0.635*** | 0.221*** | 2.707*** | 16.048*** | 19.206 | 0.505*** | 0.216*** | 1.791*** | 13.999*** | 13.245 |
| Soda | 0.353*** | 0.187*** | 2.632*** | 19.303*** | 15.880 | 0.430*** | 0.134*** | 1.879*** | 18.356*** | 10.488 |
| Beer | 0.389*** | 0.109*** | 1.540*** | 18.011*** | 9.823 | 0.281*** | 0.206*** | 1.478*** | 13.598*** | 12.118 |
| Smoke | 0.563*** | 0.101*** | 1.761*** | 16.544*** | 13.613 | 0.584*** | 0.130*** | 1.630*** | 14.855*** | 11.060 |
| Toys | 0.622*** | 0.227*** | 2.943*** | 32.894*** | 9.622 | 0.573*** | 0.250*** | 2.312*** | 2.312*** | 8.676 |
| Fun (n) | 0.177*** | 0.132*** | 1.359*** | 21.057*** | 7.009 | 0.162*** | 0.107*** | 0.812*** | 16.219*** | 5.033 |
| Books | 0.381*** | 0.228*** | 2.444*** | 23.368*** | 11.433 | 0.258*** | 0.177*** | 1.258*** | 16.182*** | 8.110 |
| Hshld | 0.390*** | 0.113*** | 1.373*** | 20.957*** | 7.726 | 0.290*** | 0.093*** | 0.851*** | 19.667*** | 4.423 |
| Clths | 0.568*** | 0.144*** | 2.132*** | 30.748*** | 8.086 | 0.515*** | 0.094*** | 1.351*** | 20.692*** | 6.313 |
| MedEq | 0.361*** | 0.166*** | 1.925*** | 20.130*** | 11.144 | 0.303*** | 0.180*** | 1.396*** | 20.791*** | 7.419 |
| Drugs | 0.440*** | 0.304*** | 3.281*** | 21.794*** | 16.824 | 0.372*** | 0.361*** | 2.520*** | 22.176*** | 12.564 |
| Chems | 0.513*** | 0.354*** | 3.767*** | 21.698*** | 18.537 | 0.400*** | 0.388*** | 2.796*** | 18.081*** | 15.592 |
| Rubber | 0.633*** | 0.166*** | 2.945*** | 27.811*** | 12.244 | 0.608*** | 0.338*** | 2.836*** | 23.654*** | 12.339 |
| Txtls | 0.621*** | 0.129*** | 2.519*** | 29.748*** | 9.679 | 0.580*** | 0.063*** | 1.441*** | 21.473*** | 6.557 |
| BldMt | 0.454*** | 0.155*** | 2.275*** | 27.222*** | 10.009 | 0.330*** | 0.212*** | 1.656*** | 20.677*** | 8.689 |
| Cnst (n) | 0.552*** | 0.125*** | 2.048*** | 30.298*** | 7.449 | 0.471*** | 0.162*** | 1.415*** | 22.278*** | 6.377 |
| Steel | 0.604*** | 0.251*** | 3.212*** | 26.482*** | 13.859 | 0.511*** | 0.350*** | 2.502*** | 20.263*** | 13.697 |
| FabPr | 0.487*** | 0.022*** | 1.516*** | 26.236*** | 6.236 | 0.461*** | 0.022*** | 1.117*** | 20.994*** | 5.139 |
| Mach | 0.630*** | 0.409*** | 4.240*** | 27.644*** | 16.163 | 0.549*** | 0.513*** | 3.343*** | 22.219*** | 15.206 |
| ElcEq | 0.942*** | 0.251*** | 4.283*** | 29.002*** | 15.311 | 0.842*** | 0.313*** | 3.646*** | 24.994*** | 14.164 |
| Autos | 0.501*** | 0.057*** | 1.415*** | 23.182*** | 7.232 | 0.452*** | 0.077*** | 1.251*** | 15.505*** | 8.475 |
| Aero | 0.391*** | 0.129*** | 1.929*** | 22.332*** | 9.591 | 0.349*** | 0.136*** | 1.471*** | 19.004*** | 7.788 |
| Ships | 0.731*** | 0.397*** | 4.665*** | 27.128*** | 17.913 | 0.516*** | 0.414*** | 2.914*** | 16.971*** | 17.170 |
| Guns | 0.873*** | 0.373*** | 5.527*** | 33.695*** | 17.949 | 0.787*** | 0.312*** | 3.482*** | 31.171*** | 11.470 |
| Gold | 1.000*** | 1.001*** | 8.926*** | 32.559*** | 31.172 | 0.790*** | 1.211*** | 6.656*** | 19.139*** | 34.673 |
| Mines | 0.341*** | 0.554*** | 4.738*** | 28.799*** | 18.561 | 0.306*** | 0.853*** | 4.650*** | 25.316*** | 18.525 |
| Coal | 0.449*** | 0.141*** | 2.079*** | 22.178*** | 9.955 | 0.404*** | 0.091*** | 1.134*** | 16.587*** | 7.045 |
| Comps | 0.498*** | 0.257*** | 2.847*** | 29.703*** | 10.771 | 0.423*** | 0.281*** | 2.046*** | 22.904*** | 9.455 |
| Chips | 0.699*** | 0.147*** | 2.569*** | 27.141*** | 9.872 | 0.664*** | 0.262*** | 2.621*** | 25.716*** | 9.744 |

| | | | 1980 to 1989 | | | | | 1990 to 1999 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Industry | OITP Beta | MAJOR Beta | Total cur prem | Total prem | % of total prem | OITP Beta | MAJOR Beta | Total cur prem | Total prem | % of total prem |
| LabEq | 1.201*** | 0.091*** | 3.268*** | 14.997*** | 9.347 | 1.103*** | 0.109*** | 2.394*** | 28.074*** | 8.452 |
| Paper | 0.227*** | 0.171*** | 1.609*** | 20.121*** | 9.214 | 0.182*** | 0.221*** | 1.396*** | 16.418*** | 9.011 |
| Boxes | 0.371*** | 0.259*** | 2.487*** | 19.174*** | 14.844 | 0.348*** | 0.285*** | 2.141*** | 14.982*** | 14.482 |
| Retail (n) | 0.411*** | 0.190*** | 2.151*** | 25.389*** | 9.738 | 0.348*** | 0.180*** | 1.454*** | 20.598*** | 7.440 |
| Meals (n) | 0.267*** | 0.170*** | 1.979*** | 20.591*** | 11.086 | 0.246*** | 0.227*** | 1.634*** | 15.445*** | 11.495 |
| Banks (n) | 0.250*** | 0.117*** | 1.278*** | 18.660*** | 10.199 | 0.227*** | 0.152*** | 1.084*** | 17.264*** | 7.714 |

Panel B: Summary results across all industries

| | | | 1980 to 1989 | | | | | 1990 to 1999 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Industry | OITP Beta | MAJOR Beta | Total cur prem | Total prem | % of total prem | OITP Beta | MAJOR Beta | Total cur prem | Total prem | % of total prem |
| Mean | 0.525*** | 0.227*** | 2.816*** | 24.343*** | 12.537 | 0.459*** | 0.263*** | 2.129*** | 19.402*** | 10.891*** |
| Std | 0.221 | 0.174 | 1.483 | 5.067 | 4.917 | 0.200 | 0.224 | 1.166 | 4.973 | 5.381 |
| | | | | | | | | | | |
| Min | 0.177 | 0.022 | 1.278 | 14.997 | 6.236 | 0.162 | 0.022 | 0.812 | 2.312 | 4.423 |
| Max | 1.201 | 1.001 | 8.926 | 33.695 | 31.172 | 1.103 | 1.211 | 6.656 | 31.171 | 34.673 |

Table 4.6 **Industry residual diagnostics**

This table reports diagnostic tests on the residuals of the conditional mean model of the industry portfolio, $\varepsilon_{it}$ from equation (2.2). The tests in the first four columns are conducted on the residuals standardized by the conditional standard deviation of the industry returns obtained from equation (2.9). JB is the Jarque-Bera test of the null hypothesis that the standardized residuals are normally distributed. Q(12) is the Q-statistic of the test of the null hypothesis that the standardized residuals are not autocorrelated up to the 12th lag, while $Q^2(12)$ tests for autocorrelation in the squared residuals (ie a test for remaining heteroscedasticity in the residuals). The test in the fifth column tests the null hypothesis that the raw residuals from the conditional mean equation of the industry returns are not predictable, using the lagged instruments DEFAULT, TERM, FED, and VWM defined in Table 3.1. The values reported under the first five columns are p-values. The sixth column reports the mean pricing error defined as the realized excess returns – estimated expected excess returns. ** and * represent significance at the 5% and 10% levels.

| | Industry portfolio residuals standardized by conditional standard deviation | | | | Unstandardized residuals | Realized excess returns – estimated expected excess returns |
|---|---|---|---|---|---|---|
| Industry | **$H_0$**: Mean = 0 | **$H_0$**: Not normal (JB = 0) | **$H_0$**: Not autocorrelated Q(12) | **$H_0$**: Squared residuals not autocorrelated $Q^2(12)$ | **$H_0$**: Residuals not predictable | Mean pricing error |
| Agri | 0.580 | 0.000** | 0.896 | 0.903 | 0.590 | 0.227 |
| Food | 0.327 | 0.000** | 0.614 | 0.028** | 0.160 | 0.281 |
| Soda | 0.085 | 0.000** | 0.499 | 0.881 | 0.088* | 0.485 |
| Beer | 0.117 | 0.002** | 0.038** | 0.001** | 0.371 | 0.512 |
| Smoke | 0.216 | 0.007** | 0.360 | 0.576 | 0.268 | 0.407 |
| Toys | 0.178 | 0.000** | 0.255 | 0.980 | 0.895 | 0.669 |
| Fun (n) | 0.390 | 0.000** | 0.139 | 0.760 | 0.758 | 0.398 |
| Books | 0.440 | 0.000** | 0.395 | 0.979 | 0.886 | 0.233 |
| Hshld | 0.589 | 0.000** | 0.376 | 0.952 | 0.542 | 0.116 |
| Clths | 0.669 | 0.000** | 0.315 | 0.983 | 0.506 | -0.180 |
| MedEq | 0.307 | 0.012** | 0.031** | 0.765 | 0.441 | 0.332 |
| Drugs | 0.593 | 0.005** | 0.478 | 0.869 | 0.609 | 0.106 |
| Chems | 0.868 | 0.000** | 0.318 | 0.946 | 0.783 | 0.075 |
| Rubbr | 0.722 | 0.000** | 0.522 | 0.992 | 0.999 | -0.105 |
| Txtls | 0.213 | 0.000** | 0.117 | 0.999 | 0.508 | -0.392 |
| BldMt | 0.318 | 0.000** | 0.316 | 0.847 | 0.856 | -0.298 |
| Cnst (n) | 0.902 | 0.000** | 0.157 | 0.767 | 0.774 | 0.028 |
| Steel | 0.799 | 0.000** | 0.056 | 0.598 | 0.418 | 0.006 |
| FabPr | 0.259 | 0.000** | 0.801 | 0.960 | 0.698 | -0.409 |
| Mach | 0.642 | 0.000** | 0.286 | 0.869 | 0.957 | 0.195 |
| ElcEq | 0.663 | 0.000** | 0.460 | 0.947 | 0.296 | 0.272 |
| Autos | 0.789 | 0.000** | 0.133 | 0.622 | 0.767 | 0.096 |
| Aero | 0.733 | 0.000** | 0.041** | 0.892 | 0.931 | 0.223 |
| Ships | 0.711 | 0.000** | 0.531 | 0.944 | 0.125 | 0.243 |
| Guns | 0.124 | 0.000** | 0.023** | 0.273 | 0.100* | -0.704 |
| Gold | 0.726 | 0.000** | 0.472 | 0.753 | 0.665 | -0.012 |
| Mines | 0.411 | 0.000** | 0.812 | 0.417 | 0.932 | -0.235 |
| Coal | 0.444 | 0.000** | 0.708 | 0.992 | 0.586 | -0.269 |
| Comps | 0.410 | 0.031** | 0.304 | 0.402 | 0.764 | 0.305 |
| Chips | 0.322 | 0.000** | 0.706 | 0.759 | 0.482 | 0.450 |
| LabEq | 0.474 | 0.029** | 0.027** | 0.447 | 0.918 | 0.379 |
| Paper | 0.613 | 0.000** | 0.097* | 0.001** | 0.808 | 0.216 |
| Boxes | 0.708 | 0.000** | 0.155 | 0.805 | 0.572 | 0.102 |
| Rtail (n) | 0.450 | 0.000** | 0.136 | 0.996 | 0.983 | 0.229 |
| Meals (n) | 0.915 | 0.000** | 0.239 | 0.988 | 0.868 | 0.062 |
| Banks (n) | 0.957 | 0.000** | 0.343 | 0.996 | 0.828 | -0.073 |

If the model is well specified, then the risk factors used to estimate the expected returns should remove all time variation in (ie predictability of) the industry returns. To complement the above test for residual autocorrelation, we also test if the instruments used to predict the risk factors in equations (2.3) to (2.5) have predictive power for the industry returns in the presence of the risk factors. This test is similar to the robustness test by De Santis and Gerard (1998) where the instruments are included as exogenous variables in equation (2.2). To avoid further complication of the model, rather than augmenting equation (2.2) with the instruments, we estimate an auxiliary regression of the unstandardized residuals from equation (2.2) on a constant plus the instruments.[14] Column 5 indicates that the residuals are not predictable. This is similar to results in Fama and French (1993, p. 43), where they state that, 'The fact that variables known to predict stock … returns do not predict the residuals from our … (model) supports our inference that the … risk factors capture the cross-section of expected stock … returns'.

If the model explains the cross-section of average industry return, then the mean 'pricing error' (the difference between the realized and the estimated conditionally expected returns) should be equal to zero (Harvey, 1991). Hence, in addition to the above tests, we also test the null hypothesis that the pricing error is equal to zero.[15] The results reported in column 6 indicate that in all cases we cannot reject the null hypothesis that the mean pricing error is zero. This indicates that there are no important omitted risk factors and so our model does a very good job explaining the average portfolio return.

As a final diagnostic test, for each industry and risk factor within a model, the sum of the square of the coefficients in matrix A and B in equation (2.9) is less than one (Engle and Kroner, 1995). This, in addition to graphical evidence, indicates that the conditional volatilities in the GARCH estimation are stationary. The coefficients in A are smaller than those in B, as is typically the case with these models.

We also carried out several robustness tests, in addition to the sub-period results reported in Table 4.5. To be specific, we estimated the model for each industry using nominal exchange rates. As pointed out by Jorion (1990) and others, exchange rate volatility is much larger than the volatility of inflation rate. As such, the qualitative results should not be different if a nominal or a real rate is used. Though this may be reflective of the currencies of the industrialized countries, it may not be the case for the emerging market currencies. Importantly, we find no significant difference in the inferences using the nominal index. We

[14] The instruments are lagged TERM, DEFAULT, FED, and market factor. Note that all diagnostic tests, except for those related to the pricing error below, were also carried out on the residuals for the risk factors with similar results.

[15] Given the assumption that the mean of the residuals is equal to zero, the pricing error represents the models 'alpha'. For tractability, we did not estimate an alpha. Hence, the test is equivalent to: $\mathbf{H}_0$: $\alpha = 0$.

also augmented the model by including an interest rate factor. The motivation is that if the exchange rate factor were a proxy for another risk factor, it would most likely be interest rates, given the fact that interest rates reflect monetary policy and it has been shown that monetary policy affects exchange rates. We find no significant differences in the results for currency risk. Overall, we are confident about the validity of our approach and, hence, about the results and inferences drawn.

# 5 Further analyses of the currency risk premiums

## 5.1 Industry characteristics and the cross-sectional variation in currency risk premium

Thus far, the evidence indicates that there is wide variation in the level of currency risk premiums across industries. In this sub-section, we answer the question: Can industry characteristics explain the cross-sectional variation in the currency risk premiums?

We include a set of industry characteristics that intuitively should influence the level of currency risk borne by an industry and have been widely used in the exposure literature.[16] Given the linear relationship between the currency beta and the estimated currency risk premium, we specify the dependent variable as the currency beta rather than the currency risk premium.[17]

**Foreign trade:** The effect of an exchange rate shock on an industry is directly related to the level of the industry's foreign trade (see Allayannis, 1997, Allayannis and Ihrig, 2001, and Bodnar et al, 2002). We therefore expect a positive relationship between foreign trade and industry currency risk premium. We use foreign income/sales as a measure of foreign trade.

**Competition:** In industries with strong competition price is set close to marginal cost and so markup is low (see Allayannis and Ihrig, 2001). As a result,

[16] Because we do not find evidence that hedging plays a significant role in our analysis we do not specifically consider the effect of hedging on the expected signs of the estimated coefficients. For instance, more liquid firms may be more exposed because they tend to avoid the use of costly hedges (Froot et al, 1993). Similarly, leveraged firms may have lower exposure if the higher expected cost of financial distress motivates them to hedge. Finally, large firms have a greater capacity to use derivatives, but small firms may perhaps use more hedges because they have greater bankruptcy costs (see Nance et al, 1993).

[17] Because the currency risk premium is the product of the time-varying currency beta and the conditionally expected change in the currency factor and the latter is estimated with a set of instruments which are common across all industries, it is appropriate to use the estimated currency betas in these auxiliary regressions. This is also broadly consistent with the practice in the literature explaining the cross-section of exposures. Thus, it allows us to motivate the explanatory variables in line with this literature.

currency risk increases the probability of financial distress in these industries which should result in a higher currency risk premium. We use the Herfindahl index of net sales in the industry to measure the competitiveness of the industry.

**Growth opportunities:** Industries with higher growth opportunities should have higher currency risk premium. This is because the volatility of their cash flows, which is in part induced by currency movements, causes them to experience greater underinvestment costs (see Geczy et al, 1997) and are, therefore, riskier. Following He and Ng (1998) we use market-to-book ratio to represent growth opportunities.

**Leverage:** Industries with higher leverage are expected to have greater exposure to currency risk and, hence, have higher currency risk premium. This is because they are more sensitive to cash-flow volatility, as they face larger expected costs of financial distress. We represent leverage by the ratio of short- and long-term debt to total assets.

**Liquidity:** Firms with low liquidity may experience more adverse reaction to exchange rate shocks because a large fluctuation of its short-term cash flows can cause financial distress (see Starks and Wei, 2005). Nance et al (1993) note that firms can reduce the expected costs of financial distress with higher levels of liquidity. Hence, we expect a negative relationship between liquidity and currency risk premium. We use the quick ratio to proxy for liquidity.

**Firm Size:** There is an ambiguous relationship between currency risk premium and firm size. Large firms may have greater currency risk premium because they are more likely to engage in foreign trade and to have foreign-currency denominated assets. On the other hand, small firms may be more affected by currency risk because when they engage in foreign trade it involves a greater proportion of their total output. He and Ng (1998) find a positive relationship between cash-flow exposure and size, while Starks and Wei (2005) find the opposite. We use the log of market equity as a proxy for firm size.

Our dependent variable is the annual average of the within-year monthly currency betas. The industry characteristics are equally-weighted averages computed on an annual basis from the characteristics of individual firms within each of the Fama-French industry defined earlier, using data from Compustat. All variables are based on values at the end of the previous year.

The results from an OLS model that includes year dummies are reported in Table 5.1. All p-values are based on White's heteroskedasticity-consistent standard errors. Judging from the adjusted $R^2$s, the variables do a good job of explaining the cross-industry variation in currency risk premium. The estimated coefficient for each variable is statistically significant in several model specifications. They are also of the expected signs and are generally economically large. Together, these results indicate that industry characteristics affect currency risk premium in the manner posited.

Table 5.1 **Explaining the cross-sectional variation in currency risk premiums**

This table reports OLS tests of the explanatory power of industry characteristics for the cross-sectional variation in industry currency risk premium. The dependent variables are the annual averages of the estimated monthly time-varying OITP and MAJOR currency betas. The continuous independent variables are computed annually from firm-level variables within each industry. They are: book-to-market ratio, leverage, acid ratio, Herfindahl index of net sales, foreign income as a fraction of net sales, log of market equity. We also include dummy variables defined as 1 for each non-traded industry and zero otherwise. Non-traded industries are as defined in Bodnar and Gentry (1993). Significance is based on White standard errors. The sample period is January 1980 to December 1999, for a total of 720 industry years (20 years time 36 industries). However, foreign income is not available in some years, resulting in a total of 570 observations. The ***, **, and * represent significance at the 0.01, 0.05, and 0.10 level, respectively.

Panel A: Risk premium arising from developing countries' currencies

| Variables | OITP | OITP | OITP | OITP | OITP | OITP | OITP |
|---|---|---|---|---|---|---|---|
| Constant | 0.285* | -0.155 | -0.180 | -1.024*** | -2.501*** | -1.195*** | -1.876*** |
| Acid Ratio | -0.318*** | -0.331*** | -0.326*** | -0.437*** | | -0.430*** | -0.334*** |
| Foreign Income/ Total Sales | 2.723*** | 1.811*** | 1.815*** | 1.626*** | 0.940 | 1.048* | 1.009* |
| Herfindahl Index of Industry Sales | 0.151 | -0.060 | -0.061 | 0.620*** | 0.534*** | 0.385*** | 0.422*** |
| Market-Book Ratio | | 0.213*** | 0.213*** | | 0.157*** | 0.170*** | 0.161*** |
| Log (Market Equity) | | | | 0.125*** | 0.124*** | 0.107*** | 0.124*** |
| Leverage | | | 0.062 | | 1.940*** | | 1.299*** |
| Construction | 0.135 | 0.228** | 0.217* | 0.394*** | -0.109 | 0.433*** | 0.237* |
| Fun | 0.325*** | 0.277*** | 0.270*** | 0.328*** | 0.019 | 0.290*** | 0.138** |
| Retail | 0.266*** | 0.221*** | 0.223*** | -0.004 | 0.197*** | -0.002 | 0.012 |
| Meals | -0.106* | -0.111* | -0.113* | -0.126*** | -0.064 | -0.127*** | -0.161*** |
| Banks | 0.856*** | 1.045*** | 1.042*** | 0.854*** | 0.432*** | 1.006*** | 0.921*** |
| Year dummy | yes | yes | yes | yes | yes | yes | yes |
| Number of Observations | 570 | 570 | 570 | 570 | 570 | 570 | 570 |
| Adjusted R-Squared | 10.43 | 18.40 | 18.25 | 21.09 | 25.04 | 2596 | 27.12 |

Panel B: Risk premium arising from industrialized countries' currencies

| Variables | MAJOR | MAJOR | MAJOR | MAJOR | MAJOR | MAJOR | MAJOR |
|---|---|---|---|---|---|---|---|
| Constant | 0.068 | -0.039 | -0.255 | 0.335*** | 0.033 | 0.402*** | 0.098 |
| Acid Ratio | -0.101 | -0.104 | -0.032 | -0.068 | | -0.071 | -0.035 |
| Foreign Income/ Total Sales | 1.414* | 1.192 | 1.456* | 1.467* | 1.446* | 1.694*** | 1.453* |
| Herfindahl Index of Industry Sales | 0.134* | 0.082 | 0.111 | -0.078 | -0.053 | 0.014 | -0.065 |
| Market-Book Ratio | | 0.052*** | | 0.067*** | 0.063*** | | 0.064*** |
| Log (Market Equity) | | | | -0.039*** | -0.033*** | -0.032*** | -0.033*** |
| Leverage | | | 0.802*** | | 0.518* | | 0.451* |
| Construction | 0.226*** | 0.249*** | 0.086 | 0.175** | 0.071** | 0.160* | 0.107 |
| Fun | 0.348*** | 0.336*** | 0.252*** | 0.331*** | 0.266*** | 0.347*** | 0.279*** |
| Retail | 0.338*** | 0.327*** | 0.369*** | 0.408*** | 0.432*** | 0.407*** | 0.413*** |
| Meals | 0.000 | -0.001 | -0.019 | 0.005 | 0.003 | 0.005 | -0.007 |
| Banks | 0.486*** | 0.532*** | 0.439*** | 0.546*** | 0.466*** | 0.486*** | 0.517*** |
| Year dummy | yes | yes | yes | yes | yes | yes | yes |
| Number of Observations | 570 | 570 | 570 | 570 | 570 | 570 | 570 |
| Adjusted R-Squared | 13.71 | 14.57 | 14.74 | 16.52 | 16.79 | 15.03 | 16.69 |

In robustness tests, we use the Herfindahl index of total assets instead of total sales as a proxy for industry competitiveness. We find no qualitative differences in the results. We experimented with alternative specifications – yearly cross-sectional models with Fama-MacBeth t-stats and panel fixed effects models. In these specifications the results also generally hold.

These results are important for at least two reasons. First, they provide insights that are relevant for the competitiveness of US industries. By providing corporate managers and policymakers a better understanding of the link between industry (firm) characteristics and currency risk, they are better able to manage exposure. For instance, firms that engage in foreign trade and whose foreign income is a large proportion of total revenues face significant currency risk. However, the effect of currency risk can be mitigated, which in effect improves competitiveness, by limiting domestic leverage and increasing liquidity. With regards to the latter, cheaper loans and pre-export working capital by the US Ex-Im Bank represent a step in the right direction. Second, because economic theory links cross-sectional differences in industry-level currency premium to industry characteristics, we provide empirical evidence of such a link.

## 5.2 Determinants of time variation in currency risk premium

In this sub-section, we examine if macroeconomic variables that are usually associated with the determinants of exchange rates and/or currency exposure drive the time variation in the currency risk premiums. In the interest of space, we do not repeat the intuition behind those variables discussed previously.

**Foreign Trade:** We use monthly US firms' aggregate exports (EXPRATIO) and imports (IMPRATIO) relative to quarterly GDP in billions of dollars as a measure of foreign trade. The data are from the International Financial Statistics database of the International Monetary Fund.

**Monetary Policy:** During periods of low liquidity firms may experience more adverse reaction to exchange rate shocks because a large fluctuation in short-term cash flows can cause financial distress (see Starks and Wei, 2005). The supply of liquidity is related to the tightness of monetary policy. We therefore expect that for the average firm in an industry, tight monetary policy will exacerbate exchange rate risk. However, it is possible that some firms will have lower exposure during periods of tight monetary policy because they do less foreign trade. This may be more relevant for US firms that provide trade credit to clients in developing countries. Perhaps the period most widely accepted as having the tightest monetary policy is October 1979 to October 1982, a period characterized by the Volcker experiment. As such, we represent tight monetary policy by a dummy variable (VOLCKER) defined as 1 during this period and 0 otherwise.

**Growth opportunities:** We use the price-to-earnings ratio of the S&P 500 index to represent aggregate growth opportunities (GROWOPP) (Goyal et al, 2002). This variable is expected to be positively related to currency risk. The data are from CRSP.

**Economic Recession:** The asset market approach to exchange rate determination holds that the prospect for economic growth is an important determinant of exchange rate movements. Hence, ceteris paribus, during recessions the domestic currency is expected to be weak relative to foreign currencies. This implies that importers may face lower currency risk because they engage in less foreign trade, whereas the opposite holds for exporters. We use a dummy variable defined as 1 for the months that the NBER determined the US economy was in recession and 0 otherwise (BUSCYCLE).

**Currency Crises:** Carrieri et al (2006) find that during emerging market currency crises movements in the currencies of the developing countries have a greater effect on equity markets. We therefore include the Mexican currency crisis (MEXCRASH) represented as 1 during the period December 1994 to June 1995 and 0 otherwise and the Asian currency crisis (ASIACRASH) represented as 1 during the period June 1997 to December 1997 and 0 otherwise.

We implement the test by estimating the following regression for each of the 36 industries

$$\begin{aligned}\hat{\beta}^F_{it} = {} & a_i + \sum_{l=0}^{2} b_{il}\text{EXPRATIO}_{t-1} + \sum_{l=0}^{2} c_{il}\text{IMPRATIO}_{t-1} \\ & + \sum_{l=0}^{2} d_{il}.\text{GROWOPP}_{t-1} + e_i\text{BUSCYCLE} + f_i\text{VOLCKER} \\ & + g_i\text{MEXCRASH} + h_i\text{ASIACRASH} + \eta_{it}\end{aligned} \tag{5.1}$$

where $\hat{\beta}^F_{it}$ is the exchange rate exposure to index F (= OITP or MAJOR) for industry i over period t, and the regressors are the variables described above. The variables EXPRATIO, IMPRATIO, and GROWOPP are standardized (the mean is subtracted and the remainder divided by the sample standard deviation) so the coefficients can be interpreted as the effect of a one-standard deviation shock to the independent variable. Autocorrelation analyses indicate that the currency betas are autocorrelated. As a result, all p-values are based on Newey-West autocorrelation- (and heteroskedasticity-) consistent standard errors with one lag. Partial autocorrelation analyses indicate that a single lag is sufficient to account

Table 5.2 **Explaining the time variation in currency risk premiums**

This table reports OLS tests of the explanatory power of macro variables for the time-series variation in industry currency risk premium. The dependent variables are monthly OITP and MAJOR currency betas. The independent variables are: a dummy variable defined as 1 for the months identified by the NBER as a period of recession and 0 otherwise (BUSCYCLE); the Mexican currency crisis (MEXCRASH) represented as 1 during the period 199412 to 199506 and 0 otherwise; the Asian currency crisis (ASIACRASH) represented as 1 during the period 199706 to 199712 and 0 otherwise; the Volcker experiment in tight monetary policy represented as 1 for the period 197910 to 198210 and 0 otherwise; US monthly aggregate exports as a percentage of quarterly GDP (EXPRATIO); U.S. monthly aggregate imports as a percentage of quarterly GDP (IMPRATIO); aggregate growth opportunities (GROWOPP) represented by the price-to-earnings ratio of the S&P 500 index. The continuous variables are standardized (the mean is subtracted and the remainder divided by the sample standard deviation) and enter the regressions contemporaneously and with two lags. The reported coefficients are the sum of the three coefficients and the associated p-value tests the hypothesis that the sum is equal to zero. All p-values are based on Newey-West heteroscedasticity- and autocorrelation-consistent (with one lag) standard errors. The ***, **, and * represent significance at the 0.01, 0.05, and 0.10 level, respectively. The data are monthly, 197912–199912, but the asset pricing model used the first three observations in the estimation, hence, the betas are from 198003 to 199912 (237 observations). The degree of freedom is over 200.

| Industry | | Constant | Recession | Mexican crisis | Asian crisis | Volcker experiment | Total exports | Total imports | Growth opps. | $\chi^2(14)$ | Adj. $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Agri | OITP beta | -0.380*** | 0.082 | 0.209*** | -0.088 | 0.144* | 0.034 | 0.012 | 0.084*** | 0.001 | 9.80 |
| | MAJOR beta | -0.364*** | -0.012*** | 0.012* | -0.042*** | 0.095*** | -0.010*** | 0.011*** | 0.040*** | 0.000 | 68.41 |
| Food | OITP beta | 0.423*** | -0.158 | -0.409*** | 0.323** | 0.153 | -0.051 | 0.081 | -0.006 | 0.000 | 5.27 |
| | MAJOR beta | -0.234*** | -0.044 | -0.000 | -0.045** | 0.189*** | 0.023* | 0.019* | 0.041*** | 0.000 | 32.61 |
| Soda | OITP beta | -0.118*** | 0.198 | 0.000 | 0.092 | -0.273* | -0.066 | -0.087 | -0.126** | 0.047 | 8.97 |
| | MAJOR beta | -0.130*** | 0.100*** | 0.109*** | -0.013 | 0.121*** | 0.093*** | -0.068*** | 0.142*** | 0.000 | 36.09 |
| Beer | OITP beta | 0.223*** | -0.184** | -0.340*** | -0.112 | 0.252** | 0.0254 | -0.020 | 0.020 | 0.000 | 10.03 |
| | MAJOR beta | -0.177*** | -0.007 | 0.043** | -0.051** | 0.346*** | -0.050*** | 0.050*** | 0.093*** | 0.000 | 62.74 |
| Smoke | OITP beta | 0.298*** | -0.078 | -0.134 | -0.054 | 0.220 | 0.002 | 0.073 | 0.205** | 0.080 | 6.51 |
| | MAJOR beta | 0.089*** | 0.014 | 0.085*** | -0.084*** | 0.114*** | 0.051*** | -0.018** | 0.096*** | 0.000 | 50.15 |
| Toys | OITP beta | -0.179*** | 0.174 | -0.134 | -0.777** | -0.401* | 0.050 | 0.012 | -0.151 | 0.169 | 7.32 |
| | MAJOR beta | -0.231*** | -0.082** | 0.190*** | 0.005 | 0.501*** | 0.014 | 0.139*** | 0.181*** | 0.000 | 71.00 |
| Fun (n) | OITP beta | 0.068*** | 0.038 | -0.051 | -0.135** | -0.018 | 0.015 | -0.007 | 0.062* | 0.036 | 5.40 |
| | MAJOR beta | 0.096*** | -0.014 | 0.000 | 0.010 | 0.161*** | -0.014*** | 0.034*** | 0.020*** | 0.000 | 64.79 |
| Books | OITP beta | 0.136*** | -0.139 | -0.090 | -0.238** | 0.104 | 0.007 | -0.009 | 0.055 | 0.004 | 5.62 |
| | MAJOR beta | 0.155*** | -0.084*** | 0.055*** | 0.073*** | 0.377*** | -0.034*** | 0.054*** | 0.074*** | 0.000 | 70.83 |
| Hshld | OITP beta | 0.109*** | -0.086 | -0.175* | 0.078 | 0.030 | -0.018 | 0.005 | -0.002 | 0.010 | 5.95 |
| | MAJOR beta | -0.068*** | -0.017 | 0.082*** | 0.038 | 0.296*** | -0.009 | 0.048*** | 0.111*** | 0.000 | 65.83 |
| Clths | OITP beta | -0.080 | -0.376** | -0.226 | -0.592*** | 0.317 | 0.061 | 0.055 | 0.043 | 0.008 | 8.78 |
| | MAJOR beta | 0.013 | -0.098*** | 0.057* | 0.007 | 0.332*** | -0.064*** | 0.098*** | 0.014 | 0.000 | 52.16 |
| MedEq | OITP beta | 0.266*** | -0.013 | -0.382*** | -0.045 | 0.028 | -0.067 | 0.103*** | -0.077** | 0.010 | 5.90 |
| | MAJOR beta | -0.193*** | 0.003 | 0.050*** | -0.028** | 0.143*** | -0.029*** | 0.040*** | 0.037*** | 0.000 | 43.77 |

| Industry | | Constant | Recession | Mexican crisis | Asian crisis | Volcker experiment | Total exports | Total imports | Growth opps. | $\chi^2(14)$ | Adj. $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Drugs | OITP beta | 0.368*** | -0.177 | -0.067 | -0.115 | 0.067 | -0.019 | -0.029 | 0.094* | 0.000 | 9.63 |
| | MAJOR beta | -0.383*** | -0.011 | 0.062 | -0.009 | 0.367*** | -0.007 | -0.026* | 0.149*** | 0.000 | 46.59 |
| Chems | OITP beta | 0.036 | 0.046 | -0.130 | -0.302 | 0.177 | 0.000 | 0.156** | 0.108 | 0.025 | 6.27 |
| | MAJOR beta | -0.389*** | -0.042** | 0.032* | 0.001 | 0.137*** | -0.019*** | 0.014* | 0.003 | 0.000 | 31.90 |
| Rubbr | OITP beta | -0.539*** | 0.038 | 0.336*** | 0.294 | -0.143 | 0.020 | -0.077 | -0.153* | 0.000 | 10.19 |
| | MAJOR beta | -0.298*** | -0.150*** | 0.051 | 0.176*** | 0.702*** | -0.127*** | 0.104*** | 0.069*** | 0.000 | 74.14 |
| Txtls | OITP beta | -0.209*** | 0.005 | 0.260 | -0.770*** | 0.441 | -0.003 | 0.186** | 0.207** | 0.007 | 8.13 |
| | MAJOR beta | -0.001 | 0.099*** | -0.064*** | -0.014 | -0.357*** | 0.042*** | -0.046*** | -0.030** | 0.000 | 48.15 |
| BldMt | OITP beta | -0.248*** | -0.003 | 0.247*** | 0.177 | 0.062 | -0.011 | -0.042 | -0.039 | 0.096 | 1.76 |
| | MAJOR beta | -0.160*** | -0.149*** | 0.081** | 0.076*** | 0.616*** | -0.078*** | 0.085*** | 0.138*** | 0.000 | 68.78 |
| Cnst (n) | OITP beta | -0.335*** | -0.006 | 0.235 | -0.244 | 0.189 | 0.079 | -0.015 | 0.165** | 0.190 | 3.62 |
| | MAJOR beta | -0.101*** | -0.125*** | 0.111*** | 0.086*** | 0.543*** | -0.089*** | 0.074*** | 0.130*** | 0.000 | 71.92 |
| Steel | OITP beta | -0.540*** | 0.254** | 0.385** | -0.177 | 0.150 | -0.003 | 0.114** | 0.121** | 0.008 | 9.53 |
| | MAJOR beta | -0.342*** | -0.059*** | 0.055*** | -0.045* | 0.348*** | -0.034*** | 0.024* | 0.084*** | 0.000 | 55.82 |
| FabPr | OITP beta | -0.396*** | 0.063 | 0.441*** | 0.297* | -0.181 | 0.020 | -0.079* | -0.087* | 0.000 | 7.85 |
| | MAJOR beta | -0.018*** | 0.000 | 0.010 | -0.001 | 0.031*** | -0.006 | 0.007** | 0.004** | 0.019 | 8.45 |
| Mach | OITP beta | -0.610*** | 0.221* | 0.372*** | -0.078 | 0.015 | 0.030 | 0.054 | 0.079* | 0.006 | 10.66 |
| | MAJOR beta | -0.491*** | -0.074*** | -0.002 | 0.004 | 0.253*** | -0.031*** | 0.015** | 0.025*** | 0.000 | 70.47 |
| ElcEq | OITP beta | -0.748*** | 0.270 | 0.518*** | 1.068** | 0.019 | 0.033 | -0.199** | 0.028 | 0.003 | 9.48 |
| | MAJOR beta | -0.203*** | -0.197** | 0.173** | 0.414*** | 0.729*** | -0.107*** | 0.194*** | 0.120*** | 0.000 | 45.49 |
| Autos | OITP beta | 0.321*** | -0.175 | -0.165 | -0.435** | -0.032 | 0.006 | 0.056 | 0.089 | 0.023 | 4.96 |
| | MAJOR beta | -0.058*** | -0.033*** | 0.027*** | -0.003 | 0.168*** | -0.007 | 0.032*** | 0.063*** | 0.000 | 63.12 |
| Aero | OITP beta | 0.284*** | -0.071 | -0.295*** | -0.142 | -0.033 | 0.002 | 0.062* | -0.013 | 0.010 | 2.06 |
| | MAJOR beta | -0.006 | 0.013 | -0.057** | 0.067** | -0.157*** | -0.101*** | -0.015 | -0.094*** | 0.000 | 58.59 |
| Ships | OITP beta | 0.168*** | 0.229 | -0.457** | -0.804*** | -0.166 | -0.018 | 0.170 | -0.046 | 0.229 | 2.54 |
| | MAJOR beta | 0.390*** | -0.030 | -0.024 | 0.055** | 0.106*** | -0.027 | 0.088*** | 0.011 | 0.000 | 33.49 |
| Guns | OITP beta | 0.082 | 0.046 | 0.157 | -0.221 | 0.041 | -0.008 | -0.009 | -0.100 | 0.504 | -2.08 |
| | MAJOR beta | -0.313*** | 0.038 | -0.054 | -0.037 | 0.224** | 0.034 | 0.071 | 0.120*** | 0.000 | 18.15 |
| Gold | OITP beta | -0.914*** | 0.487*** | 0.437** | 0.155 | -0.247* | 0.141*** | -0.007 | 0.017 | 0.000 | 13.89 |
| | MAJOR beta | -1.110*** | -0.036 | 0.026 | -0.174*** | 0.113*** | -0.100*** | -0.035** | 0.026 | 0.000 | 62.58 |
| Mines | OITP beta | -0.290*** | 0.046 | 0.259*** | 0.032 | 0.067 | 0.009 | -0.009 | 0.021 | 0.000 | 1.06 |
| | MAJOR beta | -0.762*** | -0.161*** | 0.028 | 0.025 | 0.513*** | -0.102*** | -0.021 | 0.082*** | 0.000 | 68.31 |
| Coal | OITP beta | -0.417*** | 0.368*** | 0.090 | -0.221 | 0.043 | -0.004 | 0.073** | 0.084** | 0.001 | 12.52 |
| | MAJOR beta | 0.104 | -0.012 | 0.039*** | 0.048*** | 0.083*** | -0.036*** | 0.013*** | 0.016*** | 0.000 | 50.52 |
| Comps | OITP beta | -0.185*** | 0.050 | 0.054 | -0.474 | 0.034 | 0.026 | 0.112 | -0.027 | 0.066 | 5.80 |
| | MAJOR beta | -0.261*** | -0.116*** | 0.128** | -0.023 | 0.396*** | 0.021* | 0.082*** | 0.221*** | 0.000 | 73.18 |
| Chips | OITP beta | -0.375*** | 0.204 | 0.161 | -0.697 | -0.195 | 0.084 | 0.068 | -0.053 | 0.269 | 6.42 |
| | MAJOR beta | -0.169*** | -0.084** | 0.087 | -0.151** | 0.555*** | -0.066*** | 0.189*** | 0.155*** | 0.000 | 67.50 |
| LabEq | OITP beta | -1.052 | 0.482 | 0.753*** | -0.676 | -0.054 | 0.050 | 0.129 | 0.100 | 0.002 | 7.34 |
| | MAJOR beta | 0.062*** | -0.053 | 0.091** | -0.071*** | 0.147*** | -0.032*** | 0.068*** | 0.040*** | 0.000 | 39.38 |

| Industry | | Constant | Recession | Mexican crisis | Asian crisis | Volcker experiment | Total exports | Total imports | Growth opps. | $\chi^2(14)$ | Adj. $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Paper | OITP beta | 0.072*** | -0.053 | 0.037 | -0.204* | 0.122 | -0.008 | 0.061** | 0.081** | 0.115 | 5.80 |
| | MAJOR beta | -0.217*** | -0.006 | 0.026*** | -0.030*** | 0.158*** | -0.032*** | 0.024*** | 0.047*** | 0.000 | 61.94 |
| Boxes | OITP beta | -0.059 | 0.134 | -0.082 | 0.077 | 0.000 | 0.009 | 0.104* | 0.093 | 0.004 | 6.81 |
| | MAJOR beta | -0.305*** | -0.053** | 0.067*** | -0.029* | 0.292*** | -0.054*** | 0.085*** | 0.095*** | 0.000 | 65.51 |
| Rtail (n) | OITP beta | 0.263*** | -0.203* | -0.275** | -0.385*** | 0.067 | -0.026 | 0.054 | -0.006 | 0.003 | 10.10 |
| | MAJOR beta | 0.157 | -0.013 | 0.021 | 0.009 | 0.202*** | -0.011** | 0.045*** | 0.032*** | 0.000 | 75.46 |
| Meals (n) | OITP beta | -0.142*** | 0.098 | 0.300*** | 0.248*** | -0.008 | -0.027 | -0.021 | -0.012 | 0.000 | 7.62 |
| | MAJOR beta | -0.174*** | -0.095*** | -0.003 | 0.031 | 0.738*** | -0.075*** | 0.094*** | 0.095*** | 0.000 | 78.32 |
| Banks (n) | OITP beta | 0.240*** | -0.065 | -0.174*** | 0.070 | -0.037 | -0.023 | -0.001 | -0.054** | 0.002 | 12.13 |
| | MAJOR beta | 0.151*** | 0.025*** | -0.027*** | 0.000 | -0.130*** | 0.028*** | -0.028*** | -0.020*** | 0.000 | 75.32 |

for the autocorrelation and, therefore, there is no unaccounted – for bias in the standard errors.[18]

Table 5.2 reports the results. For each industry, we report the results for the OITP exposure in the first row and those for the MAJOR index in the second. The adjusted $R^2$s reported in the final column indicate that the macroeconomic variables explain as much as 78% of the time variation in industry exposure. These high $R^2$s add validity to our estimates of the currency premiums. A closer inspection of the $R^2$s indicates that there is significant variation in the explanatory power of the variables across the industries, ranging from -2% to 14% for the OITP betas and 8% to 78% for the MAJOR betas.

An important implication of these results is that, from a policy perspective, they point to the macroeconomic conditions that influence the competitiveness of US products via their impact on the risk premiums in US industry returns. To the extent that some of these are controllable, our results could be of use to policymakers. For instance, consistent with the previous result for industry-level liquidity, the evidence indicates that tight monetary policy significantly increases the currency risk faced by some industries. In contrast, it appears to have the opposite effect on others, perhaps because it reduces their ability to conduct foreign trade. In either case, it may require targeting specific industries for assistance when the Fed imposes extended periods of tight monetary policy.

These results could have an important implication for how time variation of exposure is estimated. The results indicate that different combinations of variables are significant in explaining the expected currency risk premiums of the various industries. This suggests that models that estimate time-varying exposure by interacting a given set of determinants with ex post changes in the exchange rate factor (see Allayannis, 1997, Allayannis and Ihrig, 2001, and others) could understate the magnitude of exposure for some industries. This provides a possible explanation why the above papers find significant exposure for only a relatively few industries/firms, not considerably different from the results obtained from imposing constant parameters.

Overall, both the cross-sectional and the time-series tests of the currency risk premiums serve as a specification test of our models. This is the case because they relate the risk premiums extracted from the models to variables selected on the basis of economic theory. Thus, if our estimates of exchange rate premiums were unrelated to exchange rate movements (ie were instead simply a statistical artifact of our modeling technique), then the $R^2$s of these regressions would necessarily be

[18] The results are robust to variations in the number of lags for EXPRATIO, IMPRATIO, and GROWOPP, adjusting the standard errors using two lags, and an alternative measure of tight monetary policy (one minus the ratio of total commercial and industrial loans at all commercial banks to total bank assets). They are also robust to a measure of internal liquidity – aggregate 12-month dividend of S&P 500 firms as a percentage of their aggregate earnings – that He and Ng (1998) show is related to exposure.

uniformly low. While the models in section 4 are estimated with a battery of diagnostic and specification tests, the tests conducted in this section have not previously been conducted in the literature. These tests, and more so the results therefrom, provide us with a more complete understanding of the effects of exchange rate movements on US industries.

# 6 Summary and conclusions

In this paper, we investigate whether or not exchange rate movements are important to US industry expected returns. We hypothesize that the failure of previous studies to find that currency risk is priced and plays an important role in US industry returns is due to methodological shortcomings and/or the use of currencies or currency indices that are easily hedged, but which does not represent the broad cross-section of trading partners of US firms. The methodological shortcomings arise from the fact that, though theoretically it is well established that currency exposure and risk premiums change sign and magnitude over time, most empirical studies investigating the role of exchange rate movements in industry returns impose constant parameters on their model. Empirical evidence indicates that this significantly reduces the importance of exchange rate risk in equity returns. With regards to the hedging hypothesis, if US firms effectively hedge their currency exposure, as has been argued in the literature, then the use of a currency risk factor representing currencies that are easily hedged (those from the developed countries) should result in the finding that currency risk is not priced in US industry returns. However, given that the exposure to the currencies of some of the important trading partners of US firms (those from the developing economies) is not easily hedged, we should find that the developing countries' currency risk premium is significant in US industry returns.

To account for the methodological issue, we use a conditional asset pricing model that simultaneously estimates time-varying exchange rate betas, currency risk premium, and the cost of equity. To reduce the probability that inferences drawn about the importance of exchange rate risk is the result of exchange rates acting as a proxy for omitted factors we also include in the model, along with the currency factors, the market, SMB, and HML risk factors.

To overcome the issue of using a narrowly focused currency index that is not fully representative of the trading partners of the US, and which is easily hedged, we use the Treasury's trade-weighted index of the currencies of the top 16 developed economies and the index of the currencies of the 19 other important trading partners of the US, the larger developing economies. The asset pricing model is applied to 36 US industries that are commonly regarded as those most likely to be exposed to currency risk. Among the selected industries, 31 are in manufacturing (traded goods), while the other five are non-traded goods industries. The non-traded goods industries are selected on the basis that they are likely to be exposed to exchange rate movements because of foreign inputs, foreign clientele, or relationship(s) to industries that are exposed to currency risk.

We find that currency risk is a priced risk factor and that currency risk premium is a large part of the expected returns of all 36 US industries. The average currency risk premium is an economically large 2.47 percentage points, in absolute terms, accounting for 11.7% of the total risk premium of US industries. We find strong support for the methodological, but not the hedging, hypothesis as the industries are significantly exposed to both currency risk factors. This indicates that the failure of previous studies to find a significant role for currency risk in US industries cannot be explained by firms effectively hedging their currency risk. In contrast, the results indicate that the previously weak results are due to weakness in the methodology. We also show that the cross-industry and time variation in the currency risk premium is driven by industry characteristics and macroeconomic factors, respectively, that are in the control of corporate managers and the authorities. Overall, exchange rate risk plays a significant role in the competitiveness of US industries.

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Suomen Pankki
Bank of Finland
P.O.Box 160
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