Estimating Exchange Rate Exposures:

Issues in Model Structure*

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Abstract

We show that both return measurement horizon and model specification have noticeable impacts on estimates of exposure from equity prices for U.S. firms. Although increasing the return horizon increases marginally the precision of the estimates, the inclusion of a market return variable has a significant impact on the distribution of the exposure estimates. We demonstrate that the construction of the market variable dramatically influences the sign and size of the exposures due to a strong relation between firm size and exposure for U.S. firms. We propose using CRSP cap-based portfolios as the control for market factors and show that this produces exposures with stronger relation to foreign cash flows and correlations with firm size.

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I. Introduction

For the past decade, researchers have been empirically investigating the exchange rate exposure of firms. Much of this research measures the exposure as the elasticity between changes in firm value and exchange rate measures. Empirically, the exposure elasticity is obtained from a regression of stock returns on an exchange rate change, often with additional control variables such as a market portfolio return. The resulting exposure estimates for firms (or industries) tend to be very noisy and suffer from much lower levels of statistical significance than suggested by researchers' priors. It has been the case, however, that further tests have uncovered patterns of cross-sectional variation in the exposure estimates that is broadly consistent with the predictions of cash flow models of firms with particular characteristics (see, e.g., Bodnar and Gentry, 1993; Jorion, 1990).

The difficulty in obtaining statistically significant and economically meaningful point estimates of exchange rate exposure casts some doubt on the usefulness of these market-based estimates as measures of the exchange rate exposure desired by participants in the firm. Users of exchange rate exposure estimates, whether investors looking to hedge their portfolios or managers attempting to make corporate risk management decisions, are understandably put off by the lack of statistical significance and the questionable economic interpretation of these estimates. Moreover, from an academic perspective, this problem draws into question the basic premise of how significantly and in what fashion exchange rate changes impact firm performance and value.

The majority of exposure studies on U.S. firms share some common methodological characteristics. Generally, they estimate an empirical specification that includes a market portfolio return as a control variable, and in keeping with the standard practice in the asset pricing literature, they typically use a one-month horizon for measuring returns. The purpose of this paper is to investigate the importance of these features of model structure on the resulting estimates of exchange rate exposure using a large sample of U.S. firms over the period 1977–1996.

We show that the incorporation of a market portfolio return variable in the exposure model plays an important role in ensuring that the estimated exposures are not unduly influenced by correlated macroeconomic events, especially over short horizons. However, the definition of the market portfolio variable has a significant influence on the results, making the estimates of the exposures model dependent and difficult to interpret as cash flow sensitivities for corporate risk management decisions. This influence arises from an anomalous relation between exchange rate sensitivity and firm size for U.S. firms. As for the length of the return measurement horizon, we find, consistent with recent evidence (see, e.g., Chow, Lee, and Solt, 1997a, 1997b), that exchange rate exposure

estimates are more statistically significant at longer horizons. However, lengthening the horizon beyond one month does not reduce the model sensitivity of the exposure estimates arising from the relation between exposure and firm size.

In response to the question of how to control for confounding macroeconomic influences without imparting undue influence of firm size on the exposure estimates, we propose an empirical approach that uses returns to market-capitalization-based portfolios as the control for macroeconomic factors. The resulting cap-based exposure estimates are distributed slightly negatively, so they are more consistent with aggregate corporate cash flow exposures. Tests also indicate that unlike standard exposure estimates, the cap-based exposures show significant correlation with firms' foreign sales and virtually no correlation with firm size. As a result, we argue that these cap-based exposure estimates are better candidates for interpretation as a measure of firms' underlying cash flow exposure to the exchange rate.

The paper is organized as follows: Section II discusses the background of exposure estimates. Section III examines the methodological issues facing the researcher in the estimation of exchange rate exposure and describes the data. Section IV presents results of the impacts of these methodological choices on the estimates of exposure and demonstrates the resulting relation between standard exposure estimates and firm size. Section V proposes our alternative approach to estimate exposures to reduce the exposure-size relation. Section VI summarizes and discusses the implication of the paper's findings for exchange rate exposure research.

II. Exchange Rate Exposure

A. Measurement of Exchange Rate Exposure

The estimation of exchange rate exposure is a relatively recent area of research in international finance.[1] In response to the onset of fluctuating exchange rates in 1973, managers became concerned about the impact of exchange rate fluctuations on firms. The early papers discussing exchange rate exposures (e.g., Flood and Lessard, 1986; Hekman, 1985; Hodder, 1982; Levi, 1993; Shapiro, 1974) examine the impact of the exchange rate on firms by modeling its impact on cash flows. From this work came the predictions that the cash flow sensitivity of a firm to the exchange rate should depend on the nature of the firm's activities, such as the extent to which it exports and imports, its involvement in foreign operations, the currency denomination of its competition, and the

competitiveness of its input and output markets.[2] Most theoretical models of exchange rate exposures, such as Marston (2000), suggest that the firm's exchange rate exposure is a function of its net foreign currency revenues.[3]

This theoretical examination of exposure coincides with the interest of firm managers in understanding how their cash flows are affected by exchange rate changes and how best to manage those effects. Most of the theoretical justifications for a firm managing its currency risk come directly from cash flow volatility arguments (see, e.g., Froot, Scharfstein, and Stein, 1993; Smith and Stulz, 1985; Stulz, 1984). Thus, for the purposes of making optimal risk management decisions, managers are interested in an exposure measure that gauges their firm's cash flow sensitivity to exchange rate changes.[4]

This suggests measuring exchange rate exposure by modeling the actual cash flows of the firm. Lewent and Kearney (1990) demonstrate this approach using the pharmaceutical firm Merck. From this model, the impact of exchange rate changes on the firm can be simulated and hedging decisions made. Such a method, however, suffers from the difficulty of incorporating other complexities into the model, such as competitive reactions and impacts of market parameters and structure. For example, Marston (2000) shows the complexity of determining the demand and cost derivatives necessary for estimating the exact exposure for the simple case of a Cournot duopoly with constant elasticity demand functions. In general, these approaches require significant amounts of firm-specific and competitor-specific information that is available, if at all, only to those inside the firm. Consequently, this cash-flow–based method of determining exposure, while useful in identifying the determinants of exposure, is good only for specific situations and not easily applicable to multifirm studies or large-scale cross-firm comparisons of exchange rate exposures. For these sorts of studies, a methodology that uses easily accessible information is needed.

Adler and Dumas (1984) suggested an alternative to the cash flow modeling approach. They utilized the fact that the market value of the firm is by definition the present value of all future cash flows. Under this assumption, the exposure can be determined from the elasticity of firm value with respect to the exchange rate, which in turn can be obtained from a simple regression. This approach, which only requires the researcher to obtain

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[1] See Stulz and Williamson (1997) for a discussion of the various ways in which exchange rate exposure can be measured.

[2] Of course, the exposure of the firm also depends on the extent to which the firm offsets the remaining risk from these activities through financial hedging.

[3] For example, Marston demonstrates that the exposure of an exporting monopolist is exactly its net foreign currency revenues. Even under other competition structures, the exposure is generally proportional to the net foreign currency revenue position.

[4] Such a view is consistent with the results of survey data (e.g., Bodnar, Hayt, and Marston, 1996, 1998; Bodnar, Hayt, Marston, and Smithson, 1995), which overwhelmingly suggest that managers' primary goal of hedging is to reduce volatility in cash flows, and that the goal of reducing volatility in firm value is much less important.

market data, greatly simplifies the estimation of exchange rate exposures and gives rise to the possibility of large-scale empirical studies on exchange rate exposure.

B. Regression Models for Exposure Estimation

Adler and Dumas (1984) define the exposure elasticity as the change in the market value of the firm resulting from a unit change in the exchange rate. This is the definition of exposure that an investor is interested in, and it can also be the definition of exposure that the risk manager of the firm would be interested in if the change in the value of the firm is directly related to the change in the firm's expected cash flows. The beauty of the Adler-Dumas approach is that the exposure elasticity of the firm can be obtained from the coefficient on the exchange rate variable in the following regression:

$$R_j = \alpha_j + \delta_j XR + \varepsilon_j, \tag{1}$$

where R_j is the stock return for firm j, XR is the percentage change in an exchange rate variable, defined as the home currency price of foreign currency (HC/FC), and δ_j is the elasticity of firm value to the exchange rate change. This elasticity indicates the firm's average exposure over the estimation period, in home currency units, as a percentage of the firm's market value.[5] As they point out, this definition of exchange rate exposure is simply a variance decomposition of a firm's returns into a component that was correlated with the exchange rate change and a component that was orthogonal to exchange rate changes. We refer to δ_j as the *total exposure elasticity* of firm j.

This total exposure of a firm comprises two effects. One effect is the average change in the present value of cash flow caused by a unit exchange rate movement. This is the exposure predicted by corporate finance/industrial organization optimizing models of the firm. The other effect is the nonexchange-rate–related phenomena that affect valuations and are spuriously correlated with the exchange rate variable over the sample period. While some portion of this latter effect is idiosyncratic, a portion of it includes "macroeconomic" effects that influence the valuation of all firms, such as changes in the risk-free rate, the market risk premium, and investor sentiment that happen to be correlated with the exchange rate. If these value-relevant influences have nonzero correlation with the exchange rate

[5] In mathematical terms, the exposure of the firm as defined by Adler and Dumas is the derivative of firm value with respect to the exchange rate, dV/dS. The regression coefficient, as an elasticity then becomes dV/dS(S/V). To obtain the actual exposure, the elasticity estimate from the regression must be multiplied by V and converted into foreign currency by dividing by S.

over the estimation period, they influence the estimate of "total" exposure and confound the interpretation of the estimated exposure as the cash flow effect predicted by optimizing models of firm behavior.[6] If the correlation of these "macroeconomic" effects with exchange rates could be modeled, it would be possible to adjust the total exposure estimates to remove this impact. However, previous research has limited success in identifying a consistent relation between exchange rates and observed proxies for these macroeconomic factors.[7]

To control for other macroeconomic influences on realized returns, most empirical studies include a return to a market portfolio in the empirical model. This market portfolio return not only controls for macroeconomic influences but also dramatically reduces the residual variance of the regression compared with equation (1). This improves (somewhat) the precision of the exposure estimates, which has been a serious concern to prior researchers.

Thus, the commonly estimated exposure model looks like

$$R_j = \alpha_j + \gamma_j XR + \beta_j R_M + \varepsilon_j, \tag{2}$$

where R_j is the stock return for firm j, XR is the percentage change in an exchange rate variable, R_M is the return on the domestic market portfolio, γ_j is the exchange rate exposure elasticity of firm j, β_j is the beta of the firm with respect to the market portfolio. Equation (2) is generally preferred by researchers (see, e.g., Allayannis, 1997a, 1997b; Allayannis and Ofek, 2001; Bodnar and Gentry,1993; Choi and Prasad, 1995; Jorion, 1990, 1991; Williamson, 2001; Wong, 2000).[8]

It is important to note, and often overlooked or undermentioned in the empirical literature, that the definition of the exposure coefficient from equation (2) is now different from before. The new exposure coefficient, γ_j, measures the exchange rate exposure elasticity of the firm as the difference between the firm's total exposure elasticity and the market's exposure elasticity adjusted by the firm's market beta.[9] Therefore, we refer to γ_j as the

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[6] This problem does not affect cross-sectional evaluation of the exposure estimates, because the effect is common to all firms and fall out when considering the relative exposures as opposed to the absolute exposure.

[7] Most studies trying to consistently link exchange rate changes with other macroeconomic variables have limited success. This is consistent with the common view that exchange rates evolve as random walks. The literature that investigates the pricing of exchange rate risk suggests that any risk premium of exchange rates is significantly time varying and difficult to predict.

[8] An alterative is to control for confounding macroeconomic events using predetermined variables. Chow et al. (1997a) apply the three Fama-French factors in their studies. However, it should be noted that this approach only controls for the expected part of future confounding macroeconomic events. Nevertheless, our results to be discussed in Section IV remain qualitatively similar when this alternative approach is adopted.

[9] This can be shown as follows: Using matrix notation, where $\boldsymbol{F}$ is a T by 2 matrix of the constant term and the exchange rate change variable and $\boldsymbol{R}_j$ is a T by 1 vector of stock returns for firm j, the statistical definition of the coefficients from equation (1) is

residual exposure elasticity of the firm. The reason for this is that the incorporation of the market return in the model also controls for the market portfolio's own exchange rate exposure. The estimated "residual" exposure elasticity differs from the "total" exposure elasticity whenever the market portfolio has a nonzero exposure to the exchange rate. In such a case, the distribution of "residual" exposure elasticities is shifted relative to the "total" exposure elasticities.

The exposure of the market portfolio consists of two factors. One is the value impact of marketwide macroeconomic factors or other non-cash-flow-related value impacts common across all firms that happen to be correlated with the exchange rate over the sample period. The other factor is the weighted-average value impact of the exchange rate changes on the firms' cash flows. Thus, the "residual" exposure estimates are measured relative to both the common macroeconomic influence on value that happen to be correlated with the exchange rate *and* the changes to the weighted-average market cash flow arising from the exchange rate movement.

Because of this measurement of the firm exposure estimate, if the market portfolio used as a control for macroeconomic factors has a nonzero exposure, the interpretation of a firm having zero "residual" exposure does not mean the same thing as having zero "total" exposure. This is a significant point because the empirical result of having zero exposure is often given the economic meaning in analysis that the firm that is not affected by exchange rate changes. However, a zero "residual" exposure implies a firm has the same exposure as the market portfolio. Since it is unlikely that the exposure of the market portfolio used to control for macroeconomic effect will be zero, the choice of market portfolio in the exposure regression directly impacts the size and the interpretation of the resulting exposure estimates. This means that the choice of the market portfolio in the specification of equation (2) is a significant decision for the resulting firm-specific exposure estimates.

We might expect this to be a problem. The common practice of using a value-weighted market portfolio as the macroeconomic control in equation (2) gives more importance to large firms. Because these firms are more likely to be multinational and export oriented (net sellers in foreign currency), they should see their cash flows

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(E1) $\boldsymbol{\delta}_j = (\boldsymbol{F}`\boldsymbol{F})^{-1}\boldsymbol{F}`\boldsymbol{R}_j,$

where $\boldsymbol{\delta}_j$ is the vector coefficient estimates of the intercept term (α_j) and the total exchange rate exposure elasticity (δ_j). With the inclusion of the market return as a T by 1 vector $\boldsymbol{M}$ in equation (2), the statistical definition of the exposure coefficient (including the constant term) is

(E2) $\boldsymbol{\gamma}_j = (\boldsymbol{F}`\boldsymbol{F})^{-1}\boldsymbol{F}`\boldsymbol{R}_j - (\boldsymbol{F}`\boldsymbol{F})^{-1}\boldsymbol{F}`\boldsymbol{M}\,\beta_j.$

See partitioned regression in Greene (1990), among others. The first term of $\boldsymbol{\gamma}_j$ is the same as the $\boldsymbol{\delta}_j$ from (E1), but this is reduced by the second term. Since the term $(\boldsymbol{F}`\boldsymbol{F})^{-1}\boldsymbol{F}`\boldsymbol{M}$ is simply the coefficients from the regression of the market return on a constant and the exchange rate change (i.e., the exchange rate exposure elasticity of the market portfolio), if we define these coefficients as $\boldsymbol{\delta}_M$, we can rewrite (E2) as

(E3) $\boldsymbol{\gamma}_j = \boldsymbol{\delta}_j - \boldsymbol{\delta}_M\,\beta_j.$

increase when the home currency depreciates, thereby generating a more negative market portfolio exposure.[10] Alternatively, a more equally weighted market portfolio gives more importance to small firms. As these firms are more likely to be import oriented or non-traded-goods producers, they should see their cash flows rise when the home currency appreciates, thereby generating a more positive market portfolio exposure.

This suggests that we should expect differences in the exposures of value-weighted versus equal-weighted market portfolios.[11] If these differences in exposure are significant, then the choice of different market portfolios in the empirical model would lead to differences in the distributions of the "residual" exposures. This would lead to different interpretations about the impact of exchange rates on firms' cash flows conditional on the construction of the market portfolio used to control for macroeconomic events. In Section IV, we investigate the importance of this issue along with other issues previously discussed in the paper.

III. Data and Research Design

Our study covers the 20-year period from 1977 to 1996. We choose not to include the most recent years for several reasons. First, in 1997 and 1998, several major currency crises in the emerging markets generated significant economic turmoil that disproportionately affected certain U.S. firms. Second, 1999 saw the introduction of the euro as a currency with the locking of most European bilateral rates, which lead to the discontinuation of the classic benchmark G-10 exchange rate index. Third, late 1999 and 2000 saw a stock price bubble in the technology, media, and telecommunications sectors in the United States that makes meaningful exchange rate exposure estimation difficult for these firms. Finally, given the dramatic rise in merger activity in the late 1990s, the sample of firms with continuous history over the period drops off dramatically. Consequently, we select the firms for our study from the 1996 CRSP NYSE/AMEX monthly stock file. To be included in the final sample, a firm must have monthly stock prices/returns covering the period January 1977 through December 1996. This selection criterion results in 910 firms. Monthly return data on individual stock, value- and equal-weighted NYSE/AMEX market portfolios, and

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It is apparent that this modified exposure coefficient differs from the classic definition of exposure (Adler and Dumas, 1984) by the product of two easily identifiable terms: the exposure elasticity of the market and the market beta of the firm.

[10] This is true whether the market portfolio is domestic or global, although some large global firms may increase in dollar value when the U.S. dollar appreciates, so the impact might not be as significant.

[11] In support of this claim, Chow, Lee, and Solt (1997a) show that the CRSP value- and equal-weighted market portfolios exhibit different exposures to exchange rate movements, and Chow, Lee, and Solt (1997b) show that exposures of U.S. multinational firms flip signs as the horizon increases beyond 12 months. However, in both cases, they use an empirical specification that does not use a market portfolio return or any other variable as a control for contemporaneous macroeconomic events.

NYSE/AMEX size portfolios are retrieved from the CRSP files. The exchange rate change variable, *XR*, is computed as the return on the Federal Reserve's U.S. dollar trade-weighted index (Federal Reserve System, 1978). Figure 1 plots the exchange rate index over the sample period. By construction, an increase in the currency index corresponds to a real appreciation of the U.S. dollar. All nominal return data are converted to real measures using the monthly U.S. and G-10 foreign consumer price indexes taken from the International Financial Statistics Database of the International Monetary Fund.[12]

The estimation is undertaken for the full 20-year period and four 5-year subperiods. The four sub-periods are 77/01–81/12, 82/01–86/12, 87/01–91/12, and 92/01–96/12. For each of these sample periods, we estimate currency exposures over multiple return horizons. We begin with the standard empirical finance return horizon of one month, but we examine exposure estimates over longer return horizons because it is possible that exposures may be more accurately estimated over longer horizons due to the complexity of factors influencing exposures and the noise in high-frequency observations of exchange rates relative to the persistence of low-frequency movements.[13] The majority of a firm's cash flow exposure arises from changes in future as opposed to current cash flows in response to an exchange rate change, since these adjustments take time to become fully apparent; therefore, longer horizons should provide better estimates of exposure. For a horizon of one month, the estimation is based on nonoverlapping monthly observations. Long-horizon returns are continuously compounded over the corresponding interval, and the estimation is based on overlapping monthly observations. The use of overlapping observations is common in long-horizon regressions in which the variables of interests are generated by compounding the more finely sampled data to investigate the long-term relation among the variables. Efficiency is improved because overlapping observations allow the time-series properties of the finely sampled data to be incorporated into the estimation (Richardson and Smith, 1991). We correct for the serial correlation induced by the use of overlapping observations using the method of Newey and West (1987). Moreover, we conduct all significance tests at the 5% level for each tail, with the degree of freedom equal to the number of *nonoverlapping observations* (rather than the

[12] We run our tests on a sample period from 1997 to 2000; however, we have fewer firms (668 out of 910) in the sample due to mergers and acquisitions, and we are forced to use an alternative exchange rate measure because the Federal Reserve Board discontinued the classic G-10 index in 1999 due to EU monetary integration. Consequently, results from this period are not directly comparable to those in the paper. However, the same basic patterns for the total and residual exposure reported in the paper are found with the exposures in this subsample. Interestingly, the rolling market exposures for the value-weighted, equal-weighted, and global market portfolios continue the decline relative to those reported for the end of our sample period. This suggests that factors related to increased stock market valuation were increasingly negatively correlated with the value of the U.S. dollar over the 1997–2000 period.

[13] In support of a longer-horizon view, evidence by Chow, Lee, and Solt (1997b) suggests that the exposure of U.S. firms becomes much more detectable when the return horizon is extended beyond 12 months. Their paper looks at a measure of "total" exposure for a small set of U.S. multinational firms (N=213). We consider the impact of horizon issues in a variety of model specifications as well as for a much larger set of firms (N=910).

actual degree of freedom). This conservative approach makes it more difficult to reject the null hypothesis of no exposure to exchange rate fluctuations and is adopted to ensure that our findings are not driven by a limited number of nonoverlapping observations in long-horizon regressions, especially over the four 5-year subperiods.

IV. Empirical Findings

In this section, we examine the effect of possible differences in methodology (outlined in Section II.B) on the estimation of exposure elasticities. In doing so, we consider summary statistics for the distribution of exchange rate exposures at the various horizons as well as the percentage of firms with statistically significant exposure to exchange rates and the proportion of these firms that gain versus lose from appreciation of the U.S. dollar. In addition, we consider the stability of the exposure estimates across multiple subperiods.

A. Firm-Level Total Exchange Rate Exposures

We begin by considering the original approach suggested by Adler and Dumas (1984), in which market portfolio return is not included in the model and the exposure estimated is the "total" exposure elasticity. Panel A of Table I and the top plot in Figure 2 show that the mean and median total exposure estimates are positive for the 1-month-return horizon and increase through the 6-month horizon, only to fall and become negative for horizons of 15 to 24 months, and finally switching back to positive at the 36-month horizon and beyond. This shifting of the distribution of exposures over different return horizons is troubling because it suggests that the sign of the average total exposure elasticities is not independent of the return horizon. In addition, Panel A of Table I indicates that the percentage of firms with statistically positive and negative exposures varies noticeably over different horizons. For short horizons, the percentage of firms with significant positive exposures dramatically outnumbers the firms with significant negative exposures. Beyond 12-month-return horizons, we find more significant negative exposures than positive exposures, only to see them equal out beyond 24-month-return horizons. As for the overall percentage of significant exposures, we find only about 15% of firms with significant exposure elasticity at 1-month through 18-month horizons, with the percentage of significant exposures increasing from 20% to 50% as horizons increase from 24 to 60 months.

Another troubling finding on total exposure elasticities is the time variation in the estimates across subperiods. The lower plot of Figure 2 shows that the means are highly volatile across the four subperiods. The third

subperiod, especially, produces positive exposure estimates that defy belief in terms of cash flow sensitivities. Results (not tabulated) indicate that the mean exposure elasticities are generally significantly negative in the first two periods but statistically positive in the last two periods. Moreover, for horizons of three months and longer, two-thirds of the 910 firms had significantly positive exposures for the third subperiod, while less than 10% of these firms had positive exposures during the previous five-year period. The theoretical corporate finance models require us to explain this shift in terms of the international activities of the firms or changes in the competitive structure of their markets. However, this shift appears too large, too sudden, and too widespread to be explained by cash-flow-related changes in firm structures or changes in the competitive environment. This result highlights a drawback of the total exposure estimates, as discussed in Section II.B. In particular, total exposures capture not only the cash flow-related exchange rate exposure but also the relation between exchange rate changes and other "macroeconomic" factors that influence the market value of the firm.

B. Firm-Level Residual Exchange Rate Exposures

In practice, researchers have tended to estimate exposure elasticities by including a market portfolio return in the model specification. This modification to the basic Adler and Dumas (1984) specification has two beneficial effects. First, including the market return reduces the residual variance of the regression, thereby improving the precision of the exposure elasticity estimates. Second, and more importantly, the market return implicitly controls for the value-relevant macroeconomic factors that are correlated with the exchange rate. This improves our ability to interpret the resulting exposure elasticities in terms of the corporate-finance-based models as cash flow sensitivities important for risk management decisions. However, as discussed in Section II.B, the inclusion of the market portfolio changes the interpretation of the estimated exposure elasticity to a "residual" exposure. A zero exposure no longer implies that the firm's value is independent of exchange rates; rather, it implies that the firm value is affected to the same degree as the market portfolio. A similar logic applies when interpreting positive or negative residual exposure estimates.

Panel B of Table I and Figure 3 show the results for the distributions of the residual exposure estimates for a model including the return to the CRSP U.S. value-weighted index as the market portfolio.[14] We see several

[14] Results, not tabulated, indicate that the average market beta of the sample firms is close to one and the majority of the firms have a significantly positive beta as expected. However, for horizons of 36 months or longer, a small number of the firms are found to have a statistically negative beta.

different features compared with the total exposure elasticities discussed earlier. First, the table indicates that the mean and median exposures are positive at all horizons and increase monotonically with the return horizon. Figure 3 illustrates that both the median and the spread of the distribution increase steadily with horizon; the same pattern holds in the subperiods. Second, the significant jump in the distribution of "total" exposures for subperiod three, seen in Figure 2, is not as apparent in Figure 3. This demonstrates that the "residual" exposure estimates are more stable than the "total" exposure estimates over time, which is consistent with the market portfolio, removing much of the influence of common "macroeconomic" value shocks correlated with the exchange rate. Third, the total percentage of firms with significant exposure estimates is higher than that for total exposure estimates reported in Panel A of Table I. The total percentage is around 20% to 25% for horizons of 1 to 21 months but increases up to 60% for the 60-month horizon. This is consistent with it taking a long time for the market to fully incorporate exchange rate changes into firm value. The finding of better exposure identification at long horizons is also consistent with the finding of Chow, Lee, and Solt (1997b) that much greater numbers of significant exposures occur over longer return horizons.[15]

A noticeable difference from Table I is that firms with significant positive exposures outnumber firms with significant negative exposures by more than two to one.[16] This finding is economically troubling because it implies that most U.S. firms experience gains (relative to the market) when the U.S. dollar appreciates. As a measure of the cash flow exposure of these firms to the exchange rate, this interpretation is at odds with the results of studies on the relation of reported profits of U.S. corporations with the exchange rate. For example, Clarida (1997) demonstrates that the U.S. dollar rise in the early 1980s reduced US manufacturing firms' profits by 25% while the subsequent fall boosted profits by 30%. Along these same lines, Hung (1992) reports that the upward swing in the dollar during the 1980s resulted in a profit loss to U.S. manufacturing firms of $23 billion per year. Finally, Uctum (1996) estimates that a 1% depreciation of the U.S. dollar leads to a nearly 1% increase in the dollar value of overseas profits of U.S. corporations. Taken together, these findings would lead one to expect that if stock prices were directly related to

[15] It is also interesting to note that the findings of a positive mean exposure and 20–25% of firms with significant exposure estimates for the United States are consistent with the results documented in previous studies that employed the same model specification and monthly returns (see, e.g., Allayannis, 1997a; Bodnar and Gentry, 1993; Jorion, 1990; Wong, 2000).

[16] Results, not tabulated, show that the mean and median exposures for the subperiods are similar to those for the full period. Except for a few cases, the mean and median estimates are positive in all periods and all horizons. In general, more firms are found to be significantly positively exposed to dollar appreciations than are found to be significantly negatively exposed. However, in subperiod 1 (January 1977 through December 1981), the percentage of firms with negative currency exposure elasticities is higher than that with positive exposures for the longer horizons. The subperiods do seem to improve the ability to estimate statistically significant exposures as, for horizons longer than three months, the percentages of firms with a significant exposure estimate (positive or negative) in the subperiods are higher than the corresponding numbers in the full period.

cash flows, the exchange rate exposures estimated from equity prices should also reveal this negative relation, on average. We address this counterintuitive finding through the measurement of the market portfolio.

Since most studies look at the average of the residual exposures, giving each estimate equal weight, it might make more sense to control for the average macroeconomic effect by giving each firm equal weight in the market portfolio included in regression model. The use of an equally weighted market portfolio treats each firm's exposure equally in terms of determining the market exposure. This choice also leads to the convenient fact that the residual exposures across all the firms in the market portfolio must sum to zero (as the average of the exposures in the market captured in the equal-weighted market exposure). Panel B of Table I reports summary results for the estimates of the U.S. equal-weighted (EW) market based exposures alongside the comparable results from the U.S. value-weighted (VW) market exposure model. First, both the mean and median exposure estimates are now negative, and they become more negative as the return horizon increases. Figure 4 depicts this finding graphically. Comparing Figure 4 with Figure 3, one can observe that, except for subperiod 1, the distributions are shifted downward and the median exposures are negative. Second, firms with significant negative exposures outnumber positive exposures by nearly two to one. These two findings appear more consistent with the results of aforementioned studies that relate profits and exchange rate changes. However, the use of the EW market does not improve the total number of firms with statistically significant exposures. As before, for return horizons out to 21 months, we find between 20% and 25% of firms with statistically significant exposure elasticities. Again, at 24 months and beyond, we see a greater ability to detect significant exchange rate exposures.[17]

Given that we are examining an exposure with international dimensions, an argument could be made that we should control for macroeconomic factors using a world market portfolio return. This creates another possible empirical specification for the exposure regression. Panel B of Table 1 reports the exposure elasticity estimates for our sample of U.S. firms using the U.S. dollar return to the Morgan Stanley Capital International (MSCI) world market portfolio return as the control for macroeconomic effects. As this is a value-weighted index of large firms in the world's major equity markets (including predominately U.S. firms), we would expect to see results similar to those for the VW U.S. market portfolio. In fact, we see that the distribution of firm-level exposures with this specification is shifted noticeably in the positive direction. The means and medians for the exposure elasticities are

[17] The subperiods tell a similar story. The mean and median exposures for most subperiods are negative, especially at short return horizons. As the return horizons grow, the means (and occasionally the medians) for the first subperiod become statistically positive. In all subperiods but the

in the 0.40 to 0.60 range for all horizons. Not surprisingly, the percentage of significant exposure is tilted strongly toward the positive side. Figure 5 displays the distributions of the firm-level exposures for the full period as well as the four subperiods. In all subperiods, we see a noticeable positive shift in the distributions relative to either the total exposures or the relative exposures controlling for macroeconomic factors with either of the U.S. market indices.

These comparisons, from Panel B of Table I and Figures 3, 4, and 5, are striking. We obtain a completely different economic interpretation regarding the exposures of the sample firms based on the choice of the market portfolio included in the empirical model. Clearly, the choice of the market portfolio does make a different in one's inference. While the estimation horizon also plays a role in the estimation of the exposure elasticity, the impact of the choice of including a market portfolio appears to have a much more substantive impact. In the next subsection, we examine the reason why the choice of a market portfolio to include in an exposure regression has such a significant effect on the resulting exposure elasticity estimates.

C. Portfolio-Level Exchange Rate Exposures

As we mention in Section II.B, a firm's residual exposure is the difference between its "total" exposure and the product of the market's exposure to the exchange rate and the firm's market beta. Thus, the difference in the sets of exposure estimates must arise from differences in the three market portfolios' exposure to the exchange rate index. Given that the entire distribution of firm-level exposure elasticities using the U.S. VW market and MSCI world market portfolio returns as control variables are more positive than are those using the U.S. EW market return, it must be the case that the U.S. EW market itself has a more positive exposure at all horizons than the two VW market portfolios.

In Panel A of Table II, we report the estimates of the currency exposures of all three market portfolios used previously over the full sample period. As we anticipated, the exposures of the markets portfolios are dramatically different. The exposure of the U.S. EW market portfolio is everywhere positive, the exposure of the MSCI world market portfolio is everywhere negative, and the U.S. VW market portfolio starts out a small positive but drifts negative as the horizon increases. The positive exposure for the U.S. EW market portfolio is consistent with the greater weight given to smaller firms that are more likely to be in nontraded sectors or be net importers and thereby gain when the U.S. dollar appreciates. The large negative exposures for the MSCI world market portfolio is

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first, the percentage of firms with statistically significant negative exposure to dollar appreciations is greater than that of those with significant

consistent with the greater weight placed on large firms with firms located in other countries whose U.S. dollar value rises purely as a result of the translation effect when the U.S. dollar depreciates. The exposure of the U.S. VW market portfolio is not surprisingly in between these, because it only contains U.S. firm but places most of its weight on the largest firms, which are also some of the U.S. firms contained in the MSCI world market portfolio.

Figure 6 plots five-year rolling estimates of the exposures of these three markets at horizons of 1, 3, 6, and 12 months. From the plots, it is apparent that the exposures of these markets are not very constant over time; instead, all display a similar time-varying pattern. The exposure elasticities of the markets are negative in the early part of the sample period and become positive in the mid- to late 1980s and decrease again into the 1990s. These changes in market exposure are quite dramatic, from an exposure elasticity of approximately –1 to +1. It would appear that these changes are too large and too sudden to be explained by changes in the foreign currency cash flow position of the firms. These changes in exposure elasticity suggest that within a decade, the net foreign currency cash flow position of the firms in the U.S. market changed from being net long foreign currency in an amount equal to total market capitalization (circa 1980) to being net short foreign currency in an amount equal to total market capitalization (circa 1990).[18] Interestingly, roughly the same change in exposure is apparent for the firms in the MSCI world market portfolio. This similar pattern for the world market supports the view that in addition to measuring the cash flow sensitivity of firms to exchange rates, these market exposures are capturing time-varying correlations between the changes in the exchange rate index and other determinants of market value, such as required rates of return and expected growth rates, or other common influences on firm cash flows that are spuriously correlated with exchange rate changes. Attempting to provide an economic explanation for these common patterns of market exposures is an interesting question but not the focus of this investigation. The important point to glean here is that controlling for these large changes in market exposure, which are not related to cash flow impacts of exchange rate, will be an important issue when estimating exposure elasticities of firms over longer sample periods.

Despite the common time variation, the figures reinforce the fact that the market exposures at any point in time have different levels of exposure. An obvious explanation for the difference in the exchange rate exposures of the different market portfolios is a systematic difference in the exposure of firms based on size. This explanation does have some intuitive appeal because of general differences in the operating structures of large and small firms.

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positive exposure to dollar appreciations.

In particular, large firms are more likely to be multinationals or large exporters, have net foreign currency revenues (long foreign currency position), and gain when the U.S. dollar depreciates. Moreover, foreign firms are mechanically likely to see their U.S. dollar values increase when the U.S. dollar depreciates (unless their values are significantly negatively affected by the real dollar depreciation). On the other hand, small firms are more likely to be non-traded-goods producers and therefore potential net importers (short foreign currency position) who gain when the U.S. dollar appreciates.

To explore this size explanation more generally, we estimate the total exchange-rate exposure elasticities of the CRSP U.S. capital-based decile portfolios. Summary statistics of the estimated exposure elasticities for the Size 1 (largest), Size 4, Size 7, and Size 10 (smallest) decile portfolios are reported in Panel B of Table II. Figure 7 displays the results in visual form. The portfolio exposures are monotonic in terms of the market capitalization at all horizons. The Size 1 (largest) portfolio starts with an exposure elasticity of zero and becomes progressively more negative, becoming significantly negative at the 21-month horizon. In contrast, the Size 10 portfolio starts off with a significantly positive exposure elasticity, which decreases slightly, becomes insignificant through 21 months, and then increases rapidly, becoming significant again at 24 months onward.[19] Panel B also reports tests on the significance of the difference between the exposure of each of the smaller portfolios and that of the Size 1 portfolio. Generally, the difference between the exposures of the Size 1 and Size 10 portfolios are statistically significant.

To investigate whether this size-exposure relation is due to systematic differences in foreign cash flow positions of different-sized firms arising from operational differences, we create portfolios with our own sizes from the subset of firms that appear on the Compustat geographic segment database. This sample is only a subset of the CRSP decile portfolios previously studied, because not all firms are reported on the Compustat geographic segment database and its data only begin in 1979. Nonetheless, we construct ten market capitalization portfolios from these firms based on their market capitalization in the beginning of the year. For each sample year and decile size, we further divide the firms into three subportfolios based on their reported foreign-and-export sales ratio. We denote these subportfolios as high, low, or zero foreign sales. We compute the foreign-and-export sales ratio as the sum of

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[18] This results from the fact that the actual cash exposure is equal to the exposure elasticity times the market value of the portfolio.

[19] The impressive monotonicity of the exposures across size breaks down somewhat when we look at subperiods. In the first subperiod, across return horizons of 9 to 18 months, we actually see the pattern reversed. Typically, the largest firms have the most positive exposures and the smallest firms have the most negative exposures (at least for return horizons beyond 6 months). One explanation for this reversal of the relation between size and exposure is that the first subperiod (1977–1981) was the noted small-cap market boom in the U.S. During this period, small-cap stocks significantly outperformed large-cap stocks. Moreover, during this period, the U.S. dollar depreciated on average, leading to the observed stronger negative exposure for the small-cap stocks. For the second subperiod, the Size 4 portfolio has the most negative exposure elasticities.

foreign sales and export sales scaled by total firm sales. We use this foreign-and-export sales ratio as a proxy for the underlying cash flow exposure of the firm. The portfolios' monthly returns are calculated as the value-weighted average of the returns for the firms in the subportfolios.

Table III reports selected statistics on 12 of these subportfolios; the full set of high, low, and zero foreign sales for groups of selected sizes: 1 (largest), 4, 7, and 10 (smallest). Results not tabulated show that the numbers of firms in each decile portfolios range from 103 firms in 1979 to 220 firms in 1996. Table III indicates that the (time-series) average number of firms without foreign activities (0% FGN sales) increases as we move from the large-cap (Size1) to the small-cap (size 10) group. For the high (or low) foreign-and-export sales portfolios, the value-weighted average of foreign-and-export sales ratio decreases from 50.4% (14.8%) in the size 1 portfolio to 31.5% (1.0%) in the size 10 portfolio. Taken together, these statistics are consistent with our earlier conjecture about the characteristics of the U.S. CRSP capital-based decile portfolios in that size is correlated with the extent of multinationality.

Table IV reports and Figure 8 displays the "total" exposure estimates for these 12 portfolios of different size and foreign-and-export-sales ratio. The cash flow model of exposure would suggest negative exposures among portfolios with high foreign sales and positive exposures among portfolios with zero foreign sales, regardless of firm size. However, the results show that the largest firms (Size 1) exhibit mostly negative exposure estimates, while the smaller firms (Size 7 and Size10) always exhibit positive exposure estimates regardless of the degree of foreign operations. The fanning of exposure estimates across size portfolios, shown earlier in Figure 7, still exists for all conditional foreign sales groupings shown in Figure 8. As a simple indication of the importance of firm size relative to the foreign sales ratio for exposure, notice that the large firm (Size 1) zero foreign sales portfolio exposures are everywhere more negative than the exposure elasticities of the smaller (Sizes 4, 7, and 10) high foreign sales portfolios, despite each of these subportfolios having average foreign sales ratios of more than 30%. Finally, as a simple test of whether firm size matters for the exposure once one controls for cash flow effect (using the foreign-and-export sales ratio), the Diff. columns in Table IV report the significance level of the test of each exposure relative to that of the corresponding size 1 portfolio. It is clear that, especially for the Size 10 portfolio, many of the exposure differences across firm sizes are statistically significant, even after controlling for the cash flow effect.

Finally, the monotonicity of the full sample pattern reappears in subperiods 3 and 4. However, in these subperiods, the exposures of portfolios of

V. Size Effect in Exchange Rate Exposures

A. Size Effect in Firm-Level Exchange Rate Exposures

To examine whether the portfolio-level size effect previously documented carries to the firm-level exposure estimates, we run a cross-sectional regression of our sample firms' exchange rate exposure estimates on the firms' foreign-and-export sales ratio and market value. Because the exposure estimates are estimated over a certain period, we use the average foreign-and-export sales ratio and average market value over the same period. The foreign-and-export sales ratio is an accounting proxy for the firms' cash flow exposure. While cash flow models of exposure suggest that the exposure should be related to "net" foreign currency position (see, e.g., Marston, 2000) because firms only report foreign currency revenues and not costs, we have no choice except to use this crude proxy for the underlying determinant of exposure.[20]

The results of this cross-sectional regression for the full period are displayed in Table V. It is immediately apparent that at all horizons, both the foreign-and-export sales ratio (% FGN sales) and firm size (MVE) are important for explaining cross-sectional differences in exposures. The foreign-and-export sales ratio is everywhere significantly negatively related to exposure. The negative relation implies that firms experience higher returns when the dollar depreciates, which is consistent with economic intuition because dollar depreciations increase the value of foreign cash flow streams. On the other hand, the significantly negative coefficient on MVE indicates that larger firms have exposures that are more negative, independent of their foreign sales ratio, just as we saw in the previous portfolio-level analysis. In all cases, however, these two variables only explain a small percentage of the total cross-sectional variability of exposure estimates. The adjusted R^2 is only about 5% to 6%.[21]

B. Controlling for the Size Effect in Firm-Level Exchange Rate Exposures

Having demonstrated a size effect in exposures that complicates their interpretation as measures of exchange-rate-related cash flow impact, we suggest a method of estimating exposures that mitigates this problem.

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all sizes are everywhere positive.

[20] Foreign-and-export sales ratios have been identified as an important determinant of exposures in previous cross-sectional tests (see, e.g., Jorion, 1990).

[21] The cross-sectional regression results should be interpreted with caution. First, we assume that the foreign sales ratio adequately captures firms' underlying cash flow exposures, an imperfect assumption without the addition of unreported foreign currency cost information. Second, we do not control for financial hedging because data on corporate use of derivatives are not available during most of the sample period 1977–1996. (Information about the notional amount of outstanding financial derivatives was first available in 1991, while improved disclosures were required in 1994. However, evidence in Wong, 2000, suggests that the usefulness of these disclosures is limited.) However, the finding of a negative coefficient on MVE cannot be due to the failure to control for hedging because it should have a positive effect on currency exposure.

Our approach is to use an appropriate size of portfolio as the control for the "macroeconomic" factors discussed earlier. Doing so allows us to control for both the macroeconomic factors that influence firm value and the size effect in currency exposure. For practical purposes, we use the CRSP U.S. capital-based decile portfolios as the size of portfolios. Thus, instead of using a common market portfolio return in the exposure regressions, we use a matching CRSP cap-based portfolio return as the macroeconomic control for each firm.

Table VI shows summary statistics of the distributions of the exposure elasticities for our original sample of 910 firms, controlling for the matching CRSP cap-based portfolio. The distributions of exposures are similar, albeit shifted slightly more to the negative side, compared with those reported in Panel B of Table I using the U.S. CRSP EW market portfolio. The mean and median cap-based exposures are moderately negative at most horizons and always statistically significant. Moreover, the percentage of firms with significant negative exposures is larger than that of firms with significant positive exposures. Given that our sample selection criterion biases us toward selecting mature firms more likely to be international, we expect our sample firms, on average, to display slightly negative residual exposure relative to their size-matched peers. This view is confirmed by the fact that regardless of horizon, the average exposure (beta) of our sample firms to their matching CRSP cap-based portfolios is slightly less than one. Further, most of the firms are significantly positively exposed to the size-matched portfolio, especially at short horizons.[22]

To demonstrate that the approach of using a size-based market control portfolio reduces the relation between the estimated exchange rate exposures and firm size, we cross-sectionally regress the exposures on foreign sales and firm size as previously. The results of this regression are shown in Table VII. From the table, one can immediately see that with the exception of the 1-, 3-, and 60- month horizons, MVE is no longer significantly related to the exchange rate exposure estimate. In all cases, the foreign sales ratio remains significantly negatively related to exposure, as previously. However, in comparing the results here with those of Table V, the foreign sales ratio is more strongly related to the exposures controlled by decile size than those controlled by the VW market.[23]

In sum, Tables VI and VII show that our proposed approach generates exchange rate exposure estimates that exhibit two appealing properties. First, they are less affected by the size effect that influences the traditional exposure estimates so that economically meaningful cross-sectional analysis can be carried out on them. Second,

[22] The subperiod results are similar to those for the full period. The mean and median exchange rate exposure estimates are always negative in all periods and all horizons, except for the fourth subperiod. With a few exceptions, the percentage of firms with statistically significant negative exposures to dollar appreciations is greater than the percentage of those with significant positive exposures.

their distributions are such that the means and medians as well as the majority of the significant estimates are in the negative range. As a result, these equity-based estimates of exposure are no longer at odds with the macroeconomic evidence on the relation between U.S. corporate profits and exchange rate changes.

VI. Summary and Concluding Remarks

We investigate the importance of model structure and return horizon on the empirical estimation of exchange rate exposure using stock return regressions on a large sample of U.S. firms over the 20-year period 1977–1996. The focus of these estimations is to obtain an estimate of firm-level exposure that can be interpreted as a measure of the sensitivity of the firm's cash flows to exchange rate changes. Such a measure is fundamental to making and understanding risk management and other corporate decisions of the firm.

First, we demonstrate the importance of some form of control for macroeconomic factors in the exposure regression. Exchange rate exposures from a simple model, where the firm return is regressed against an exchange rate change, display significant variability across return horizons and periods. While the variation across return horizons is a puzzling feature, we claim that the variation across subperiods is due to time-varying (possibly spurious) correlations of the exchange rate with macroeconomic factors, such as interest rates or the expected market risk premium, which affect the valuation of all firms.

Most researchers, recognizing this, include a market return variable in the regression model to control for common macroeconomic effects. However, the estimates of firm-level exposures in this case measure the exposure of the firm relative to the exchange rate exposure of the market. By construction, the exposure of the market will be a combination of the macroeconomic effects (previously discussed) and the average impact of the exchange rate on the cash flows of all the firms in the market. As a result, if different constructions of the market portfolio have different correlations with the exchange rate, the choice of the market portfolio in the exposure model will have a substantial impact on the resulting exposure estimates.

We demonstrate that different constructions of a market portfolio have different exposures to exchange rates due to a significant size effect in exchange rate exposures. We document a significant inverse relation between firm size and exchange rate exposure. Large firms, which are typically more internationally oriented, tend to have more negative exposures to the value of the U.S. dollar. In contrast, small firms tend to have a more positive

[23] The regression results should be interpreted with caution, as discussed in footnote 21.

exposure to the value of the U.S. dollar. This size effect remains even after we control for the extent of firms' involvement in exchange-rate–sensitive activities, using foreign and export sales as a percentage of total firm sales. The size effect is translated into different constructions of the market portfolio, with value-weighted portfolios having a more negative exposure and equal-weighted portfolios having a more positive exposure. As a result, the choice of the market portfolio in the exposure model has a strong impact on the resulting estimates of firm-level exchange rate exposures.

Finally, we suggest an alternative specification for exposure estimation to reduce the anomalous relation with firm size. To this end, we replace the market portfolio return in the exposure regression with the return on the CRSP cap-based decile portfolios. The cap-based exposures are predominantly negative. This is expected because our sample firms are mature and more internationally oriented, so they should exhibit a more negative exposure relative to their cap-matched peers. We demonstrate that these exposure estimates are less cross-sectionally related to firm size than the exposure estimates obtained using the value-weighted market return as a control variable. Although we do not completely eliminate the relation between exposures and firm size at all horizons using this new approach, we demonstrate that these exposures are more closely related to foreign sales ratios, as is predicted by the fundamental cash flow models of the firm.

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Table I
Descriptive Statistics on Alternative Equity Return Exchange Rate Exposure Estimates (N=910)

Currency exposures for 910 U.S. firms are estimated using monthly overlapping observations over the period from January 1977 through December 1996, with the number of overlapping observations for each horizon shown in column T. The table reports the mean and median exposure from the cross section of estimates. The percentages of significantly negative and positive estimates are based on a two-sided *t*-test at the 5%-significance level for each tail, with the degree of freedom equal to the number of nonoverlapping observations.

Panel A: Distributions of Total Exchange Rate Exposure Estimates

$$R_j = \alpha_j + \delta_j XR + \varepsilon_j$$

	Total Currency Exposure, δ_j				
Horizon (months)	T	Mean	Median	Negative (%)	Positive (%)
1	240	0.132[a]	0.098	3.6	11.0
3	238	0.256[a]	0.202	3.0	24.3
6	235	0.241[a]	0.188	2.5	18.9
9	232	0.107[a]	0.075	4.8	10.0
12	229	0.031[c]	0.012	6.9	7.5
18	223	-0.050[b]	-0.073	10.5	5.6
24	217	-0.050[b]	-0.093	14.0	9.5
36	205	0.097[a]	0.005	15.5	16.8
48	193	0.082[b]	-0.030	23.3	20.5
60	181	0.186[a]	0.031	24.4	28.1

Table I (cont.)
Descriptive Statistics on Alternative Equity Return Exchange Rate Exposure Estimates (N=910)

Panel B: Distributions of Residual Equity Return Exchange Rate Exposure Estimates Using the Value-Weighted (VW) U.S. Market Portfolio Returns, the Equal-Weighted (EW) U.S. Market Portfolio Returns, and the U.S. Dollar MSCI World Market Portfolio Returns to Control for Macroeconomic Factors

$$R_j = \alpha_j + \gamma_j XR + \beta_j R_M + \varepsilon_j$$

		XR Exposure with the VW Market, γ_j				XR Exposure with the EW Market, γ_j				XR Exposure with the MSCI Market, γ_j			
Horizon (months)	T	Mean	Median	Negative (%)	Positive (%)	Mean	Median	Negative (%)	Positive (%)	Mean	Median	Negative (%)	Positive (%)
1	240	0.104[a]	0.071	6.7	15.8	-0.065[a]	-0.090	19.4	4.0	0.601[a]	0.578	0.3	76.2
3	238	0.132[a]	0.076	8.6	22.6	-0.046[a]	-0.085	18.1	8.0	0.613[a]	0.559	1.0	65.4
6	235	0.157[a]	0.104	5.9	18.4	-0.045[a]	-0.065	13.5	8.5	0.575[a]	0.508	0.8	56.5
9	232	0.139[a]	0.105	6.7	16.8	-0.049[a]	-0.049	12.3	8.4	0.477[a]	0.412	1.6	40.0
12	229	0.143[a]	0.116	7.3	16.2	-0.063[a]	-0.066	13.1	8.3	0.455[a]	0.385	2.2	33.6
18	223	0.183[a]	0.149	6.9	17.0	-0.085[a]	-0.104	16.3	9.2	0.487[a]	0.423	2.9	31.8
24	217	0.232[a]	0.196	8.2	21.3	-0.106[a]	-0.141	19.3	10.9	0.484[a]	0.404	4.5	30.9
36	205	0.316[a]	0.245	12.4	31.2	-0.142[a]	-0.185	26.7	13.3	0.591[a]	0.485	5.3	33.6
48	193	0.424[a]	0.311	15.8	38.7	-0.206[a]	-0.268	36.1	14.2	0.647[a]	0.533	9.7	31.4
60	181	0.460[a]	0.326	17.5	43.6	-0.253[a]	-0.350	42.6	15.3	0.690[a]	0.574	4.2	20.0

* a, b, and c denote statistical significance at the 1%, 5%, and 10% levels, respectively, using a two-sided -test.

Table II
CRSP Market and Cap-Based Portfolios Exchange Rate Exposure

Currency exposures are estimated using monthly overlapping observations over the period January 1977 through December 1996. Panel A reports the exposure estimates of the CRSP value-weighted (VW) and equal-weighted (EW) portfolios, and MSCI world market portfolio. Panel B reports the exposure estimates of the CRSP cap-based size 1 (largest), size 4, size 7, and size 10 (smallest) portfolios.

Panel A: CRSP Value-Weighted and Equal-Weighted Market Exchange Rate Exposures and MSCI World Market Exchange Rate Exposures to U.S. Dollar Index

$$R_M = \alpha_j + \eta\, XR + \varepsilon_j,$$

		VW Market		**EW Market**		**MSCI World Market**	
Horizon (months)	T	Currency exposure, η	t-ratio	Currency exposure, η	t-ratio	Currency exposure, η	t-ratio
1	240	0.028	0.215	0.219	1.299	-0.141	-4.106
3	238	0.116	0.702	0.342	1.723	-0.178	-2.641
6	235	0.080	0.459	0.327	1.612	-0.204	-2.591
9	232	-0.032	-0.165	0.179	0.828	-0.208	-2.006
12	229	-0.113	-0.555	0.109	0.466	-0.245	-2.136
18	223	-0.242	-1.187	0.042	0.185	-0.331	-3.016
24	217	-0.303	-1.774	0.066	0.362	-0.385	-3.440
36	205	-0.223	-1.885	0.278	1.929	-0.366	-3.058
48	193	-0.307	-4.134	0.322	2.940	-0.369	-4.035
60	181	-0.260	-3.287	0.455	3.533	-0.337	-4.373

Table II (cont.)
Market and Cap-Based Portfolio Exchange Rate Exposures

Panel B: Descriptive Statistics on CRSP Cap-Based Portfolio Exchange Rate Exposure

$$R_{CAP\ BASED\ PORT} = \alpha_j + \varphi_j XR + \varepsilon_j ,$$

Horizon (months)	T	Size 1 (Largest) Currency exposure	Size 1 (Largest) *t*-ratio	Size 4 Currency exposure	Size 4 *t*-ratio	Size 4 Diff.[2]	Size 7 Currency exposure	Size 7 *t*-ratio	Size 7 Diff.[2]	Size 10 (Smallest) Currency exposure	Size 10 (Smallest) *t*-ratio	Size 10 (Smallest) Diff.[2]
1	240	-0.004	-0.032	0.082	0.535		0.210	1.138		0.408	2.010	b
3	238	0.065	0.403	0.206	1.174		0.341	1.606		0.574	2.460	b
6	235	0.003	0.018	0.188	1.058		0.351	1.664	c	0.535	2.164	b
9	232	-0.107	-0.545	0.067	0.331		0.225	0.988		0.332	1.254	
12	229	-0.189	-0.916	-0.017	-0.075		0.156	0.630		0.281	0.970	
18	223	-0.324	-1.559	-0.149	-0.684		0.068	0.290		0.274	0.990	
24	217	-0.405	-2.257	-0.184	-1.013		0.081	0.484		0.360	1.670	c
36	205	-0.344	-2.725	-0.072	-0.482		0.280	2.429	c	0.685	3.799	a
48	193	-0.455	-5.496	-0.127	-1.297		0.302	3.044		0.837	5.045	a
60	181	-0.438	-5.142	-0.049	-0.541		0.417	3.568	c	1.040	5.054	a

[1] a, b, and c denote statistically significantly differences at the 1%, 5%, and 10% levels, respectively, using a two sample *t*-test (two-sided).
[2] a, b, and c denote statistically significantly differences from the exposure estimate of the Size 1 portfolio at the 1%, 5%, and 10% levels, respectively, using a two-sample *t*-test (two-sided).

Table III
Descriptive Statistics on the Self-Constructed Portfolio by Size and Foreign Sales Percentage

The time-series means (1979–1996) of the selected portfolio characteristics are reported in the table. The portfolios are constructed as follows: (1) Firms are selected if they have nonmissing data in the Compustat industry annual or full coverage files, the Compustat geographic segment files, and CRSP monthly stock file. (2) For each sample year, the selected firms are divided into ten deciles according to their market capitalization in the beginning of the year. (3) For each sample year and size of decile, we further divided the firms into three subportfolios: high, low, and zero foreign-and-export sales. We compute foreign-and-export sales (% FGN Sales) as the sum of foreign sales and export sales, scaled by total firm sales.

% FGN Sales		**Size 1**	**Size 4**	**Size 7**	**Size 10**
	Portfolio MV ($)	557,862,546	15,420,159	2,658,751	193,030
High	Firms in Portfolio	49.2	32.8	29.4	21.7
	Firm Market Value	10,717,066	439,583	82,317	8,441
	% FGN Sales (VW)	50%	34%	31%	31%
	Portfolio MV ($)	399,160,539	15,256,485	2,639,744	173,016
Low	Firms in Portfolio	49.8	33.2	29.7	21.9
	Firm Market Value	7,479,602	429,588	81,240	7,513
	% FGN Sales (VW)	15%	5%	3%	1%
	Portfolio MV ($)	401,108,522	39,130,370	8,106,513	832,778
Zero	Firms in Portfolio	50.2	83.2	90.2	104.1
	Firm Market Value	7,052,258	434,620	83,551	7,662
	% FGN Sales (VW)	0%	0%	0%	0%

Portfolio MV = pooled time-series cross-sectional mean of market value ($) of all firms in the portfolio.
Firms in Portfolio = pooled time-series cross-sectional mean of number of firms in the portfolio.
Firm Market Value = pooled time-series cross-sectional mean of firm market value in each portfolio.
% FGN Sales = value-weighted average of foreign-and-exports sales as a percentage of total firm sales.

Table IV
Exchange Rate Exposure of Cap-Based Portfolios at Various Horizons by the Extent of Foreign Operations

The portfolios are constructed as follows: (1) Firms are selected if they have nonmissing data in the Compustat industry annual or full coverage files, the Compustat geographic segment files, and CRSP monthly stock file. (2) For each sample year, the selected firms are divided into ten deciles according to their market capitalization in the beginning of the year. (3) For each sample year and size of decile, we further divided the firms into three subportfolios: high, low, and zero foreign-and-export sales. We compute foreign-and-export sales (% FGN Sales) as the sum of foreign sales and export sales, scaled by total firm sales.

		Size 1		Size 4			Size 7			Size 10		
% FGN Sales	Horizon (months)	Currency exposure	Std error	Currency exposure	Std. error	Diff.*	Currency exposure	Std error	Diff.*	Currency exposure	Std. error	Diff.*
High	1	-0.092	0.106	0.062	0.155		0.111	0.182		0.340	0.208	c
	3	-0.005	0.158	0.305 c	0.209		0.416	0.241		0.553 a	0.242	
	6	-0.072	0.166	0.321 c	0.218		0.409	0.244	c	0.465 a	0.224	
	9	-0.180	0.166	0.183	0.238		0.313	0.265		0.385	0.238	
	12	-0.268 c	0.167	0.085	0.255		0.272	0.291		0.333	0.268	
	18	-0.342 b	0.171	0.014	0.254		0.235	0.301		0.217	0.301	
	24	-0.392 a	0.154	0.012	0.207		0.285	0.272	c	0.127	0.273	b
	36	-0.266 b	0.122	0.274 a	0.168		0.509 a	0.226	a	0.326	0.186	a
	48	-0.323 a	0.084	0.319 a	0.135		0.576 a	0.240	a	0.366 b	0.206	a
	60	-0.316 a	0.072	0.408 a	0.119		0.766 a	0.233	a	0.556 a	0.234	a
Low	1	0.033	0.124	0.082	0.159		0.240	0.183		0.477 a	0.226	c
	3	0.178	0.177	0.392 c	0.210		0.633	0.232		0.582 b	0.300	c
	6	0.156	0.189	0.381 c	0.231		0.670	0.244		0.485	0.319	c
	9	0.072	0.199	0.255	0.246		0.517	0.275		0.336	0.363	c
	12	0.003	0.207	0.130	0.260		0.451	0.311		0.351	0.411	c
	18	-0.100	0.215	-0.027	0.256		0.423	0.314	c	0.438	0.422	
	24	-0.160	0.175	-0.110	0.198		0.486 a	0.283	b	0.649 b	0.359	c
	36	-0.077	0.099	0.034	0.159	a	0.847 a	0.272	a	1.241 a	0.252	a
	48	-0.156 a	0.069	-0.028	0.115	a	1.006 a	0.250	a	1.424 a	0.199	a
	60	-0.087	0.091	0.024	0.110	a	1.181 a	0.205	a	1.526 a	0.246	a
Zero	1	0.018	0.099	0.043	0.118		0.123	0.135		0.363 a	0.176	c
	3	0.076	0.132	0.306	0.162		0.430 a	0.182		0.750 a	0.236	b
	6	0.071	0.143	0.416 a	0.172		0.549 a	0.186	b	0.738 a	0.257	b
	9	0.024	0.173	0.382 b	0.213		0.526	0.223	c	0.599 a	0.287	c
	12	-0.050	0.187	0.332 c	0.249		0.500 b	0.258	c	0.594 a	0.326	c
	18	-0.159	0.189	0.252	0.264		0.493 b	0.264	b	0.596 b	0.340	c
	24	-0.242 b	0.157	0.235	0.260		0.536 a	0.241	a	0.646 a	0.299	a
	36	-0.234 a	0.093	0.364 b	0.228	b	0.804 a	0.219	a	0.939 a	0.230	a
	48	-0.351 a	0.070	0.329 a	0.147	a	0.915 a	0.198	a	0.942 a	0.137	a
	60	-0.329 a	0.087	0.416 a	0.104	a	1.096 a	0.178	a	1.069 a	0.161	a

Notes: a, b, and c denote statistical significance at the 1%, 5%, and 10% levels, respectively, using a two sample *t*-test (one-sided). The Diff. column indicates exposures that are significantly different from the exposure estimate of the Size 1 portfolio.

Table V
Regressions of Exchange Rate Exposure Estimates on Foreign-and-Export Sales and Size
(Residual Currency Exposure Estimates Using U.S. Value-Weighted Market Portfolio Control)

Currency exposures are estimated using monthly overlapping observations over the period January 1977 through December 1996. We measure foreign-and-export sales (% FGN Sales) and size (MVE) using, respectively, the mean annual foreign-and-export sales and mean market value of equity over the period January 1977 through December 1996.

Horizon	Constant	% FGN Sales	MVE	Adj. R^2
1	0.136	-0.215	-0.008	0.050
	(11.677)[a]	(-3.167)[a]	(-4.372)[a]	
3	0.172	-0.281	-0.009	0.042
	(11.378)[a]	(-3.187)[a]	(-3.771)[a]	
6	0.213	-0.454	-0.009	0.055
	(12.275)[a]	(-4.489)[a]	(-3.442)[a]	
9	0.204	-0.609	-0.008	0.054
	(10.266)[a]	(-5.247)[a]	(-2.432)[b]	
12	0.219	-0.722	-0.008	0.060
	(10.006)[a]	(-5.643)[a]	(-2.351)[b]	
18	0.269	-0.839	-0.009	0.061
	(10.675)[a]	(-5.697)[a]	(-2.343)[a]	
24	0.335	-1.07	-0.009	0.061
	(10.975)[a]	(-6.010)[a]	(-1.943)[b]	
36	0.431	-1.198	-0.011	0.058
	(12.124)[a]	(-5.764)[a]	(-1.997)[b]	
48	0.556	-1.447	-0.015	0.053
	(12.220)[a]	(-5.446)[a]	(-2.042)[b]	
60	0.600	-1.401	-0.02	0.056
	(12.936)[a]	(-5.174)[a]	(-2.714)[a]	

Notes: a, b, and c denote statistical significance at the 1%, 5%, and 10% levels, respectively, using a two-sided *t*-test.

Table VI
Summary Statistics on Exchange Rate Exposures
Estimated with Matching CRSP Cap-Based Portfolio as Macroeconomic Control Variable

$$R_j = \alpha_j + \gamma_j XR + \beta_j R_{CAP\ BASED\ PORT} + \varepsilon_j ,$$

Currency exposures are estimated using monthly overlapping observations over the period January 1977 through December 1996, with the number of overlapping observations reported under column T. The percentages of significantly negative and positive estimates are based on a two-sided *t*-test at the 10% significance level, with the degree of freedom equal to the number of nonoverlapping observations.

		Currency Exposure				**Matching CRSP Cap-Based Beta**			
Horizon (months)	T	Mean	Median	Negative (%)	Positive (%)	Mean	Median	Negative (%)	Positive (%)
1	240	-0.082 [a]	-0.121	25.3	4.8	0.758 [a]	0.748	0.0	99.5
3	238	-0.088 [a]	-0.127	24.2	6.8	0.757 [a]	0.748	0.0	96.9
6	235	-0.102 [a]	-0.103	17.0	6.3	0.752 [a]	0.725	0.0	92.7
9	232	-0.125 [a]	-0.112	15.8	5.3	0.746 [a]	0.703	0.0	89.7
12	229	-0.154 [a]	-0.142	16.0	5.4	0.729 [a]	0.666	0.0	81.0
18	223	-0.196 [a]	-0.192	18.9	5.3	0.675 [a]	0.594	0.0	64.0
24	217	-0.210 [a]	-0.202	20.7	6.7	0.606 [a]	0.499	0.9	45.7
36	205	-0.194 [a]	-0.206	22.2	10.9	0.584 [a]	0.447	2.4	38.1
48	193	-0.294 [a]	-0.324	34.6	11.9	0.637 [a]	0.465	3.6	43.3
60	181	-0.364 [a]	-0.454	41.6	13.1	0.692 [a]	0.566	3.4	51.2

Notes: a, b, and c denote statistical significance at the 1%, 5%, and 10% levels, respectively, using a two-sided *t*-test.

Table VII
Regressions of Exchange Rate Exposure Estimates on Foreign-and-Export Sales and Size
(Residual Currency Exposures Estimated Using CRSP Size Portfolio Control)

Currency exposures are estimated using monthly overlapping observations over the period January 1977 through December 1996. We measure foreign-and-export sales (% FGN Sales) and size (MVE) using, respectively, the mean annual foreign-and-export sales and mean market value of equity over the period January 1977 through December 1996.

Horizon	Constant	% FGN Sales	MVE	Adj. R^2
1	-0.042	-0.355	-0.006	0.065
	(-3.619) [a]	(-5.204) [a]	(-3.421) [a]	
3	-0.047	-0.416	-0.005	0.045
	(-3.248) [a]	(-4.928) [a]	(-1.970) [b]	
6	-0.050	-0.579	-0.003	0.051
	(-2.958) [a]	(-5.758) [a]	(-1.275)	
9	-0.066	-0.667	-0.002	0.048
	(-3.318) [a]	(-5.772) [a]	(-0.796)	
12	-0.081	-0.769	-0.004	0.055
	(-3.741) [a]	(-6.068) [a]	(-1.126)	
18	-0.109	-0.873	-0.006	0.060
	(-4.481) [a]	(-6.143) [a]	(-1.563)	
24	-0.109	-0.997	-0.006	0.059
	(-3.936) [a]	(-6.181) [a]	(-1.377)	
36	-0.091	-1.082	-0.001	0.042
	(-2.792) [a]	(-5.669) [a]	(-0.156)	
48	-0.183	-1.055	-0.005	0.034
	(-4.844) [a]	(-4.793) [a]	(-0.897)	
60	-0.237	-0.973	-0.013	0.032
	(-5.723) [a]	(-4.016) [a]	(-1.934) [c]	

Notes: a, b, and c denote statistical significance at the 1%, 5%, and 10% levels, respectively, using a two-sided *t*-test.

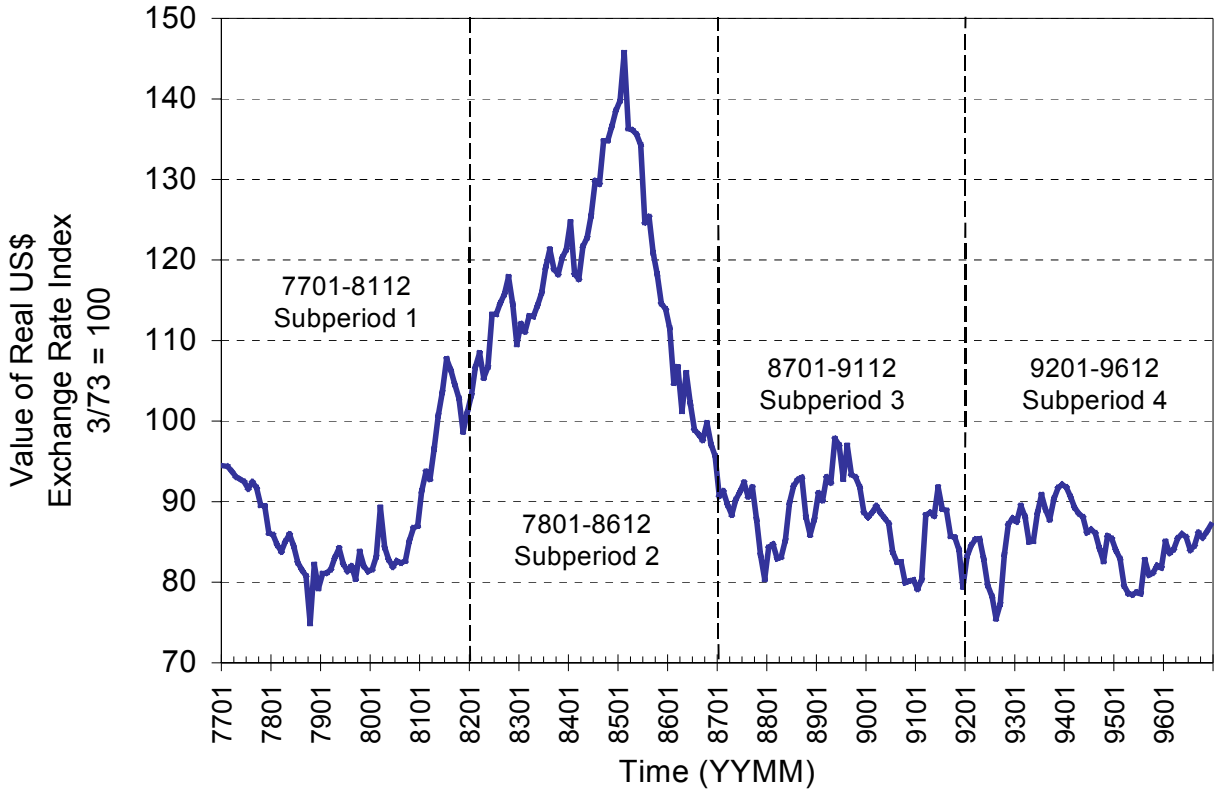


Figure 1
U.S. Dollar Trade-Weighted Real Index (March 1973 = 100)

The real currency index is calculated by subtracting a self-constructed trade-weighted inflation index of the G10 countries from the Federal Reserve's (1978) U.S. dollar trade-weighted nominal index. By construction, an increase in the currency index corresponds to an appreciation of the U.S. dollar in real terms.

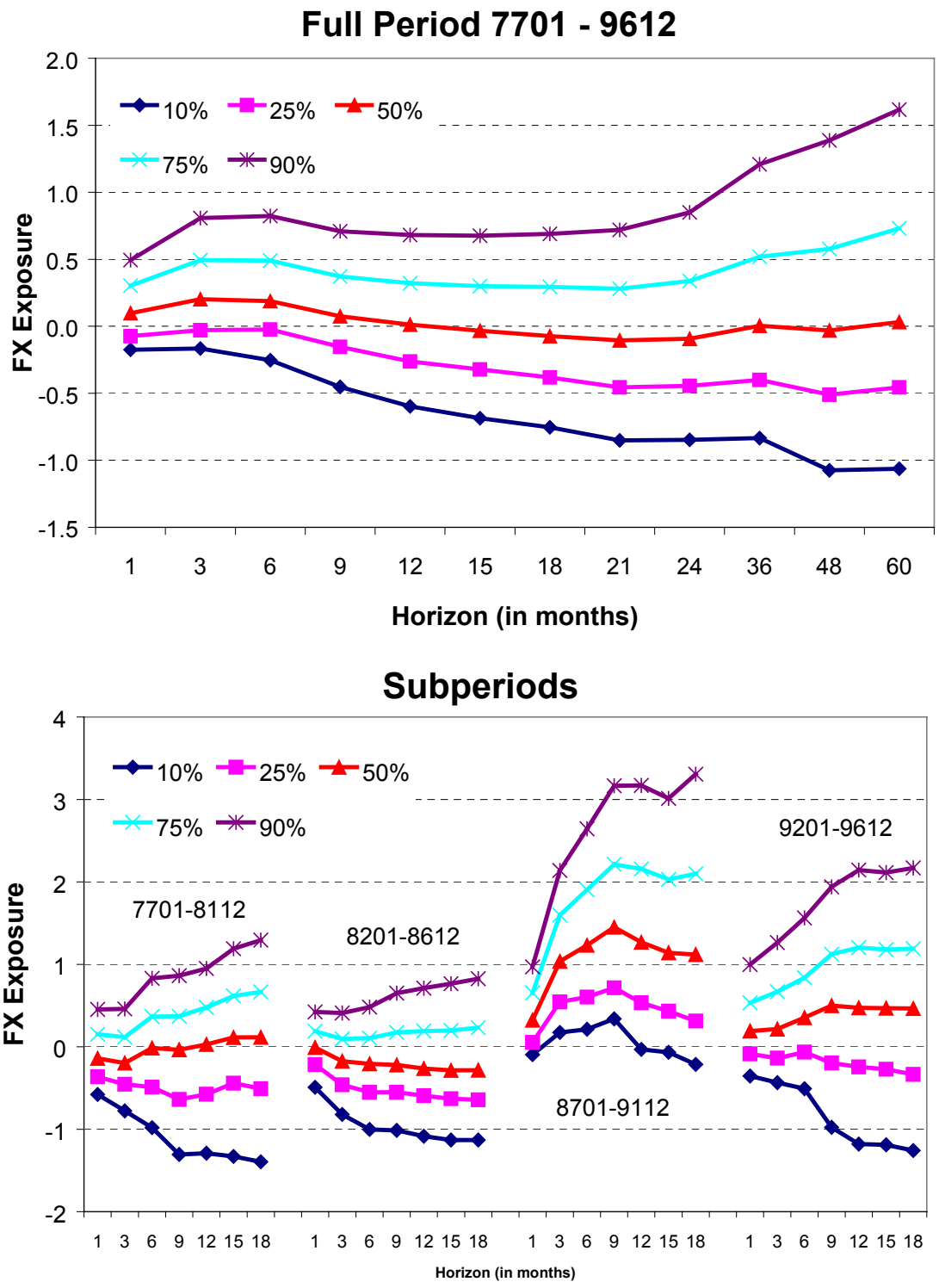


Figure 2
Distribution of Equity Return Total Exchange Rate Exposure Estimates
(No Control for Marketwide Effect)

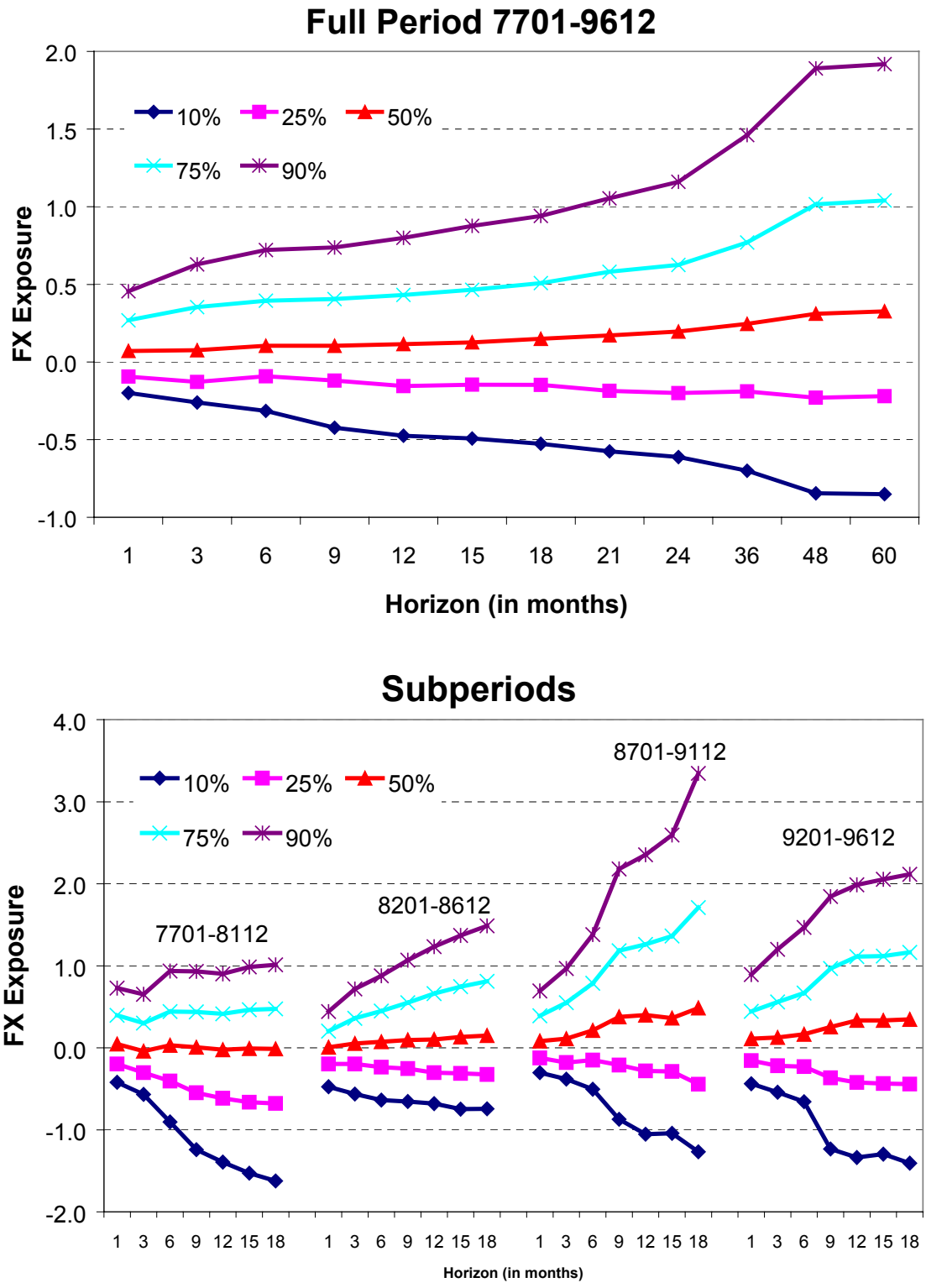


Figure 3
Distribution of Equity Return Exchange Rate Exposure Estimates
(Controlling for Macroeconomics Effects with U.S. Value-Weighted Market Portfolio)

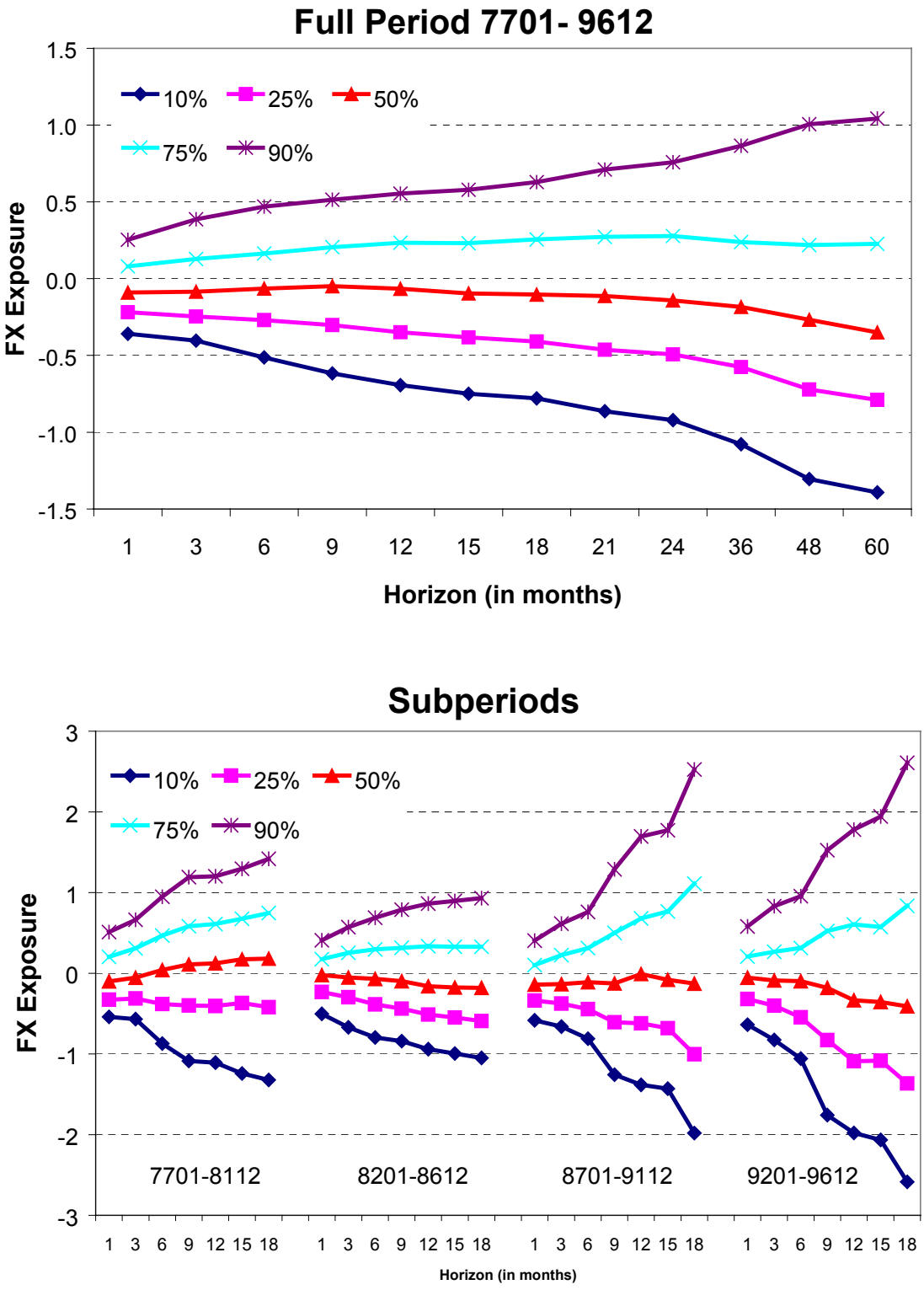


Figure 4
Distribution of Equity Return Exchange Rate Exposure Estimates
(Controlling for Macroeconomic Effects with U.S. Equal-Weighted Market Portfolio)

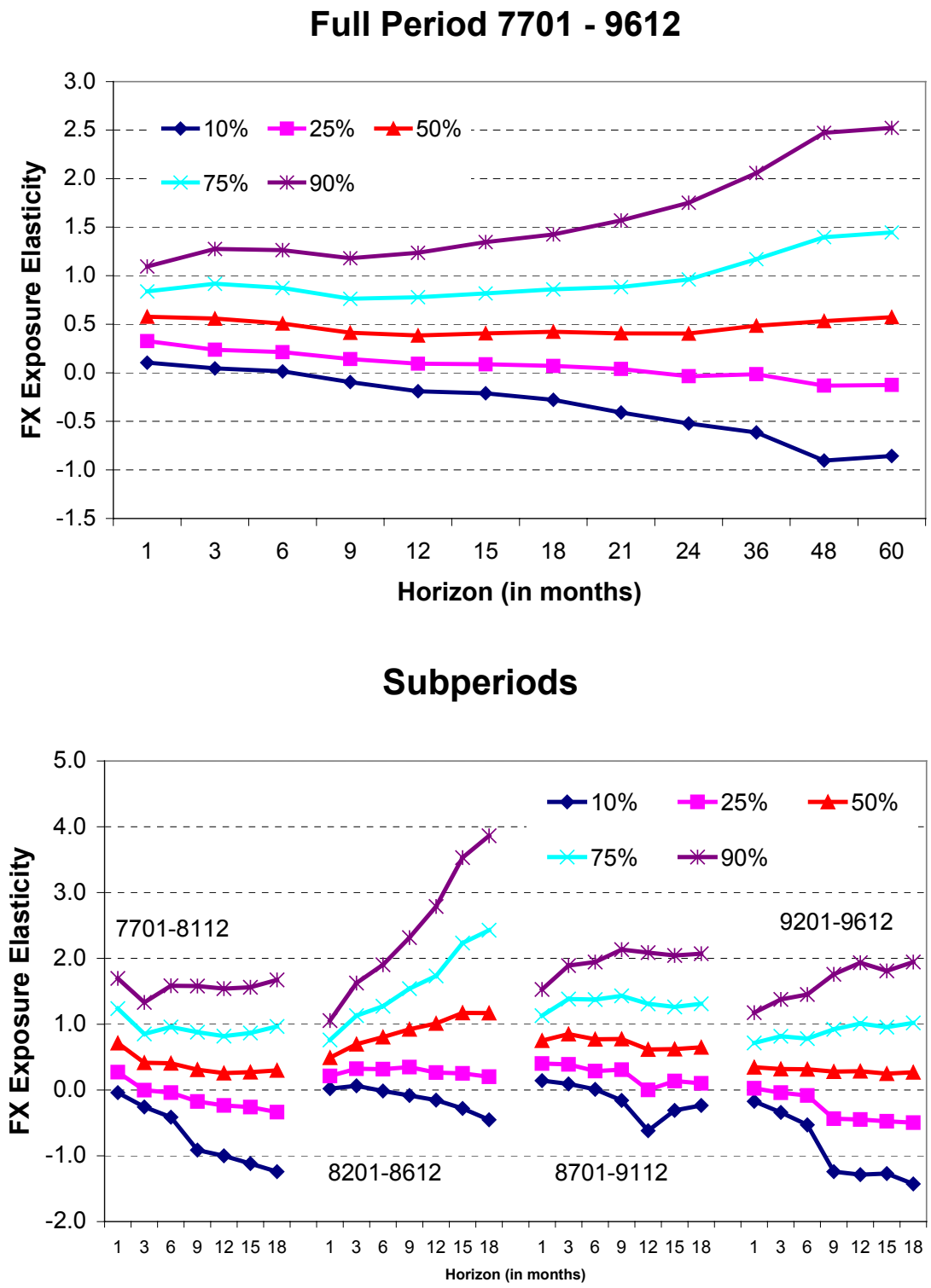


Figure 5
Distribution of Equity Return Exchange Rate Exposure Estimates
(Controlling for Macroeconomic Effects with MSCI World VW Market Portfolio)

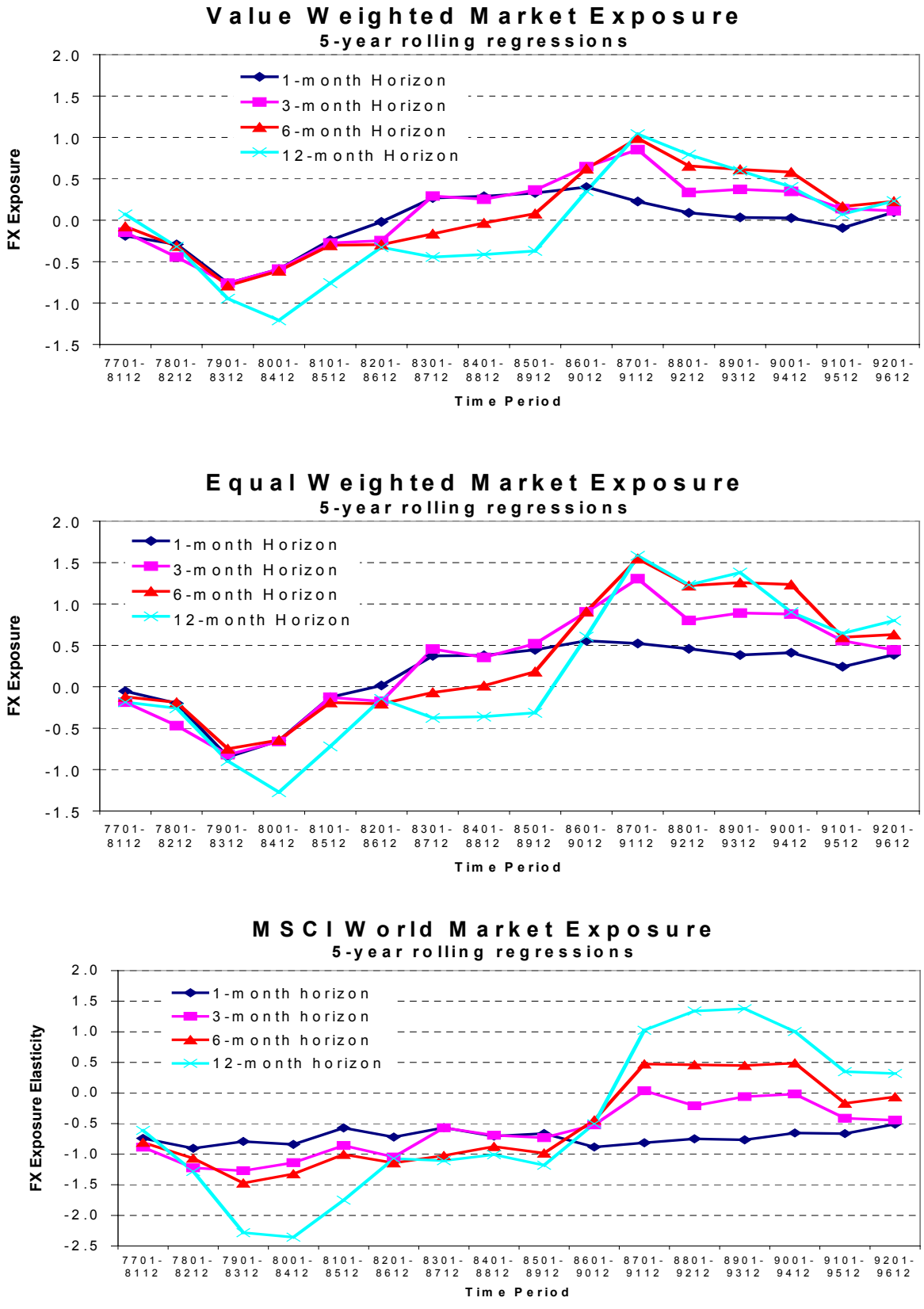


Figure 6
Equity Market Exchange Rate Exposure Estimates
(Five-year Rolling Window Estimation)

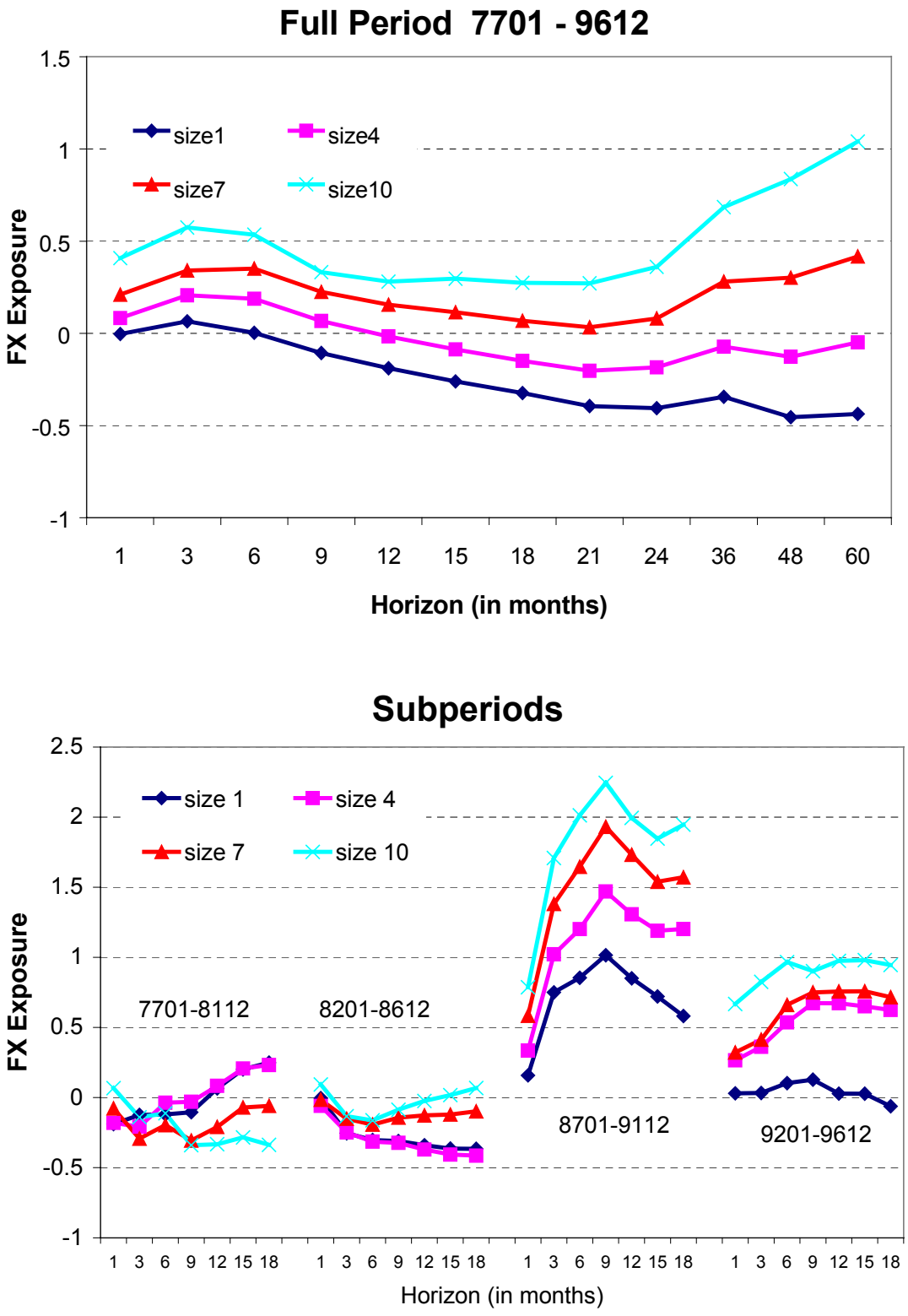
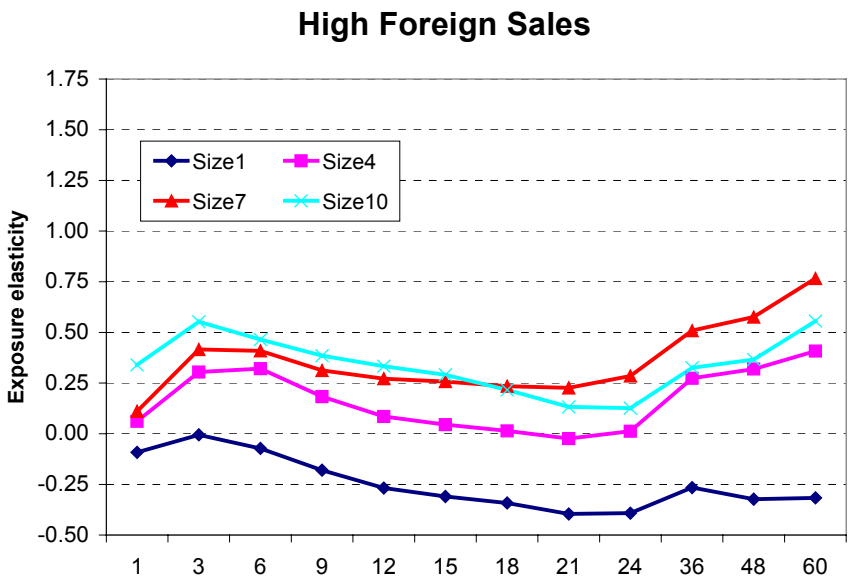
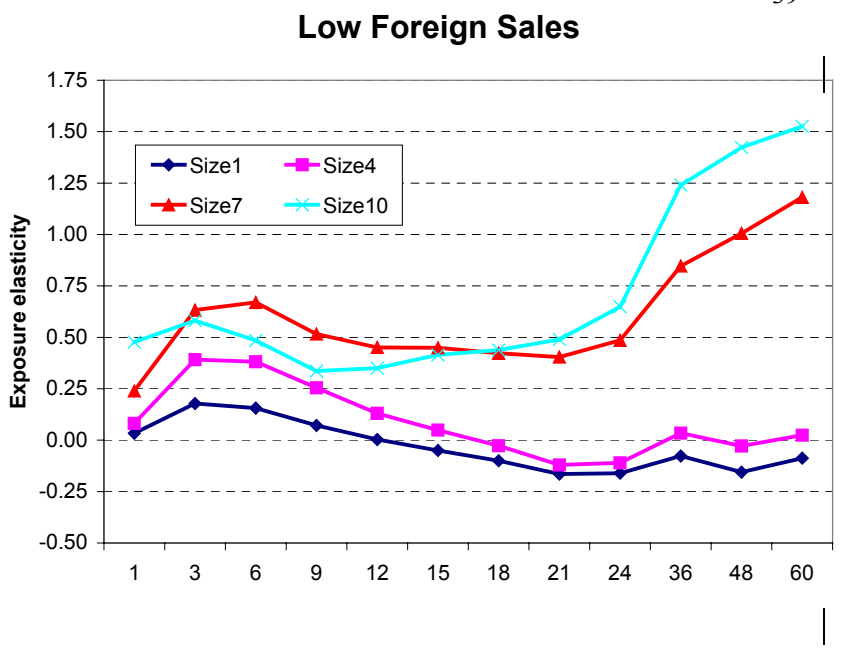


Figure 7
CRSP Cap-Based Portfolio Exchange Rate Exposure Estimates
Size 1 (10) Is the Largest (Smallest) Portfolio





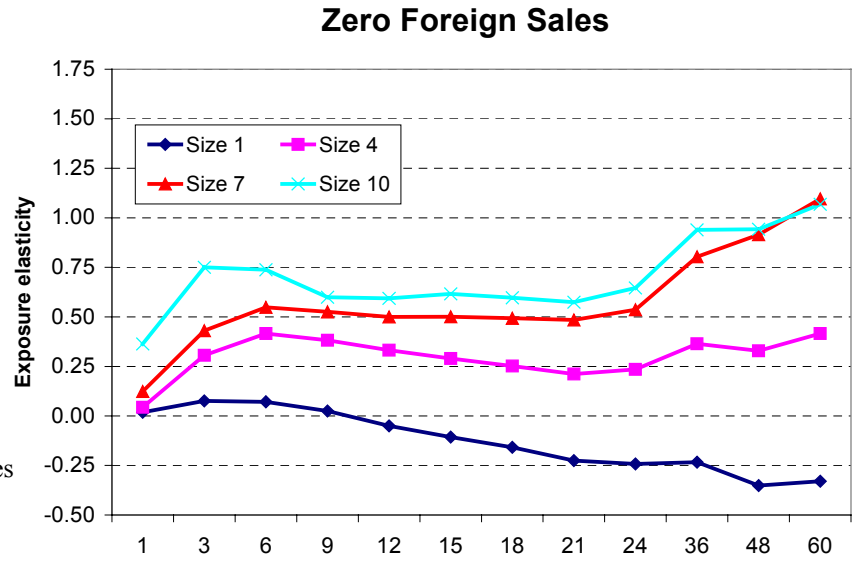


Figure 8
Exchange Rate Exposures of Portfolios of Four Selected Sizes by Relative Foreign Sales

The portfolios are constructed by first dividing our 910 firms into ten groups according to their market capitalization in the beginning of the year (1 = largest, 10 = smallest). For each sample year and size of decile, we further divided the firms into three subportfolios based on relative foreign sales: high, low, and zero foreign-and-export sales. We compute foreign-and-export sales as the sum of foreign sales and export sales, scaled by total firm sales. The figures display the exposure elasticities for four selected size groups by relative foreign-and-export sales of the portfolio.