The Time-Variation of the Exchange-Rate Exposure: An Industry Analysis

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Abstract

This paper examines the time-variation of the exposure of monthly U.S. manufacturing industry returns (at the 4-digit SIC level) to exchange rate movements. We argue that the lack of signi¯cant evidence of exchange-rate exposure documented in the literature is due to the assumption that exchange-rate exposure is constant. We reject the hypothesis that industry exchange-rate exposure is constant; in contrast, we ¯nd evidence that exposure is time-varying and that this time-variation is driven by the monthly share of imports and exports in total industry production. In line with predictions of various theoretical models, we ¯nd that an appreciation of the dollar reduces the value of an industry through exports and increases the value of an industry through imports between 1978 and 1986. On average, during this period, a 1% appreciation of the dollar reduces the value of an industry through exports by 0.46% and increases its value through imports by 0.37%, and hence in total, reduces its value by 0.09%. Finally, the level at which exposure is examined matters; our ¯ndings indicate that signi¯cant exposure at the 4-digit SIC level is often masked at the more aggregate 2-digit level.

1. Introduction

Exchange rate movements affect firms' (industries') expected future cashflows, and therefore their returns, by changing the terms of competition for exporters, importers, and multinationals in general. Hung (1992) finds that on average, during the eighties, U.S. manufacturing industries lost due to the dollar's movements $23 billions per year, or approximately 10 percent of total manufacturing profits. In light of this, it is surprising that, at an aggregate level (2-digit SIC), Bodnar and Gentry (1993) find that during 1979-88, only 3 out of the 19 U.S. manufacturing industries are significantly affected by exchange rate movements. Similarly, at the firm level, Jorion (1990) finds that during 1971-87 only 15 out of 287 U.S. multinationals have a significant exchange-rate exposure.

All of the studies so far have assumed that a firm's (industry's) exposure to exchange rates is constant. However, a direct implication of numerous theoretical models [e.g., Shapiro (1975), Adler & Prasad (1993), and Levi (1994)] is that a firm's exposure to exchange rates should vary over time. Moreover, several authors have conjectured in empirical studies, by testing for constant exchange-rate exposure in different subperiods, that the exchange-rate exposure of U.S. firms may be time-varying.[1] It is important to capture this time-variation of the exposure, since it may increase our ability to detect exchange-rate exposure in long periods. As the above models suggest, one important source of time-variation in the exposure is due to the changes over time in the real operations (i.e., imports and exports) of the firms. An examination of trade data for U.S. manufacturing industries between 1978 and 1990 reveals how pervasive these changes have been: approximately 43 percent of the U.S. manufacturing industries have switched during this period from being net exporters to being net importers or vice-versa.

[1] See, for example, Jorion (1990), Amihud (1994), and Allayannis (1996).

In this paper we examine whether the exposure of U.S. manufacturing industries to exchange rates varies through time and, more specifically, whether it varies systematically with the share of imports and exports in total industry production. We use monthly returns for all U.S. manufacturing industries at the 4-digit SIC level for the period between 1978 and 1990. The choice of the level at which we examine exchange-rate exposure (4-digit SIC) is important in correctly identifying exposure. Using as an example the transport equipment industry (SIC 37), we show that significant exposure at the 4-digit level is often masked at the 2-digit level rendering the underlying exposures undetected.[2]

We find evidence that the exchange-rate exposure of U.S. manufacturing industries varies systematically over time with the monthly share of imports and exports in the industry. In particular, for the period between 1978 and 1986, 30 out of 137 (22 percent) U.S. manufacturing industries are significantly exposed to exchange-rate movements through the share of imports or exports. For the period between 1987 and 1990, in 39 out of 124 (32 percent) industries, the exchange-rate exposure varies systematically with the variation of the import or export share.[3] In contrast, we find little support for a constant exposure to exchange rates for U.S. manufacturing industries at the 4-digit SIC level. Only 13 out of the 137 industries (9 percent) show significant constant exchange-rate exposure for the period between 1978 and 1986 and 14 out of the 124 industries (11 percent) for the period between 1987 and 1990. This percentage of significance is similar to what could have been obtained by chance. Our findings suggest that the time-varying exposures are also economically significant in a number of industries. For example, a 1 percent appreciation of the dollar in the period 1978-86 increases on average the value of the industrial chemicals industry (SIC 2819) through

[2] The transport equipment industry (SIC 37) is not significantly affected by exchange rate movements, although three out of eight 4-digit SIC industries (the motor vehicle (SIC 3711), the aircraft engines (SIC 3724) and the railway equipment (SIC 3743) industries) are significantly exposed to exchange-rate movements through imports and exports.

[3] Due to a significant change in the industry classifications in 1987, we perform all tests in two separate periods, 1978-86 and 1987-90.

exports by 2.4 percent and the value of the telephone and telegraph industry (SIC 3661) by 1.3 percent.

Results employing the sign-test suggest that during 1978-86, an appreciation of the dollar generally increases the value of the industries through imports and decreases the value of the industries through exports. This is consistent with the predictions of various theoretical models [e.g., Levi, and Shapiro]. Across all U.S. manufacturing industries, the average exposure related to exports is 0.469 and the average exposure related to imports is -0.376. These two opposite exposures produce an average total exposure of 0.093, which implies that a 1 percent appreciation of the dollar decreases the value of the average U.S. manufacturing industry by 0.09 percent. The e®ect of exchange-rates on industry returns is larger for the largest importers and exporters than for the smallest ones. For example, the largest thirty exporters have an average export-exposure of 0.83, while the smallest thirty an average of 0.16. For the period between 1987 and 1990, the association between exchange-rate movements and industry value through import and export share is mixed. The sign-test cannot reject the equal probability of positive and negative import or export exposure. This may be attributed to the shorter time-series that are employed in this latter period.

These ¯ndings have important implications for corporate risk management. We ¯nd that much of U.S. manufacturing industry exchange-rate exposure comes from the variation of imports and exports, namely the industries' real activities. It is unfortunate that during the period of our tests, data on industry ¯nancial hedging activities is generally not available, making an examination of the impact of these activities on industry exchange-rate exposure not possible.[4] It is also unfortunate that data on sales from foreign subsidiaries is also

[4] There are several theories which suggest that ¯nancial hedging is an optimal strategy for a ¯rm [e.g., Stulz (1984), Smith and Stulz (1985), Froot, Scharfstein, and Stein (1993), and DeMarzo and Du±e (1995)]. Allayannis and Ofek (1997) examine empirically whether the use of foreign currency derivatives by S&P 500 non-¯nancial ¯rms during 1993 a®ects their exchange-rate exposures, and ¯nd that on average, the use of derivatives signi¯cantly reduces a ¯rm's exchange-rate exposure.

unavailable at the monthly level. Even so, this study provides evidence that real activities are an important component of industry exchange-rate exposure of which managers should be aware. Finally, our results have equally important implications for the international asset pricing literature, given that several studies in this area are performed using industry portfolios at the 2-digit SIC level and the sensitivities (exposures) to exchange rates are estimated via a model of constant exposure (e.g., Jorion (1991)).

The rest of the paper is organized as follows: section 2 motivates and formulates the hypothesis; section 3 describes the econometric modeling, the variable definitions and the data used; section 4 describes the tests and results; and section 5 concludes.

2. Hypothesis Formulation

An appreciation of the home currency makes the exporting goods more expensive in terms of the foreign currency and this may result in a decline in foreign demand, income from sales abroad, or both. Consequently, an exporter's value, as reflected in its stock return, should be adversely affected by an appreciation of the home currency. In contrast, an importer should benefit from an appreciation of the home currency, since the value of the imported goods in terms of the home currency is now lower.

Levi (1994) formalizes the above intuition and provides the framework for our empirical tests.[5] For a firm which produces goods domestically and exports in k separate destination markets, its value is given by the present value of the after-tax profit stream (assumed to be a perpetuity): $V = (TR - TC)\frac{(1-\tau)}{\rho}$ where, $TR = \sum_{i=1}^{k} \pi_i p_i q_i$, $TC = c \sum_{i=1}^{k} q_i$; and

[5] Note that this is a static model which does not explicitly incorporate the dynamics of exchange rates. However, as long as exchange rate changes are assumed to be permanent (i.e., exchange rates follow a random walk) the results should also hold in a dynamic setting. Our purpose in this section is to simply motivate the empirical part without adding complexity to the issue. Similar predictions are obtained in a more complicated model developed in Allayannis and Ihrig (1997).

where V is the market value of the ¯rm, TR is the total revenue, TC is the total cost, ½ is the risk-adjusted opportunity cost of capital, ¿ is the e®ective tax rate, $¼_i$ is the exchange rate in units of home currency per units of currency i, p_i is the product price in country i, q_i is the quantity sold in country i and c is the marginal cost of production at home, assumed constant. The exposure of the ¯rm to exchange rates is given by $\frac{\#V}{\#¼_j}$, or in terms of elasticities, by $(\frac{¼_j}{V})(\frac{\#V}{\#¼_j})$. The ¯rst order conditions for value (pro¯t) maximization imply the following exposure:

$$(\frac{¼_j}{V})(\frac{\#V}{\#¼_j}) = \frac{n_j(¼_j q_j p_j \ ¡ \ cq_j)\frac{(1 ¡ ¿)}{½}}{V}$$

where n_j is the elasticity of demand in country j. Note that for a pro¯t maximizing ¯rm, $n_j >$ 1. Therefore, the exposure of the ¯rm is a positive function of the export share in industry total value $(¼_j q_j p_j)/V$.[6] Given the de¯nition of the exchange rate in home currency per unit of foreign currency, this means that an appreciation of the dollar would hurt exporters. Clearly, several of the factors that a®ect the exchange-rate exposure could change over time, resulting in a time-varying exposure. In this paper, we focus on the variation of exports over time.

Similarly, the exposure of an importer of a homogeneous product that is produced in k countries and imported in the home country is given by:

$$(\frac{¼_j}{V})(\frac{\#V}{\#¼_j}) = \frac{(1 \ ¡ \ n)(q_j p \ ¡ \ (c_j q_j ¼_j))\frac{(1 ¡ ¿)}{½}}{V}$$

where, because the import is homogeneous, all demand elasticities are the same (n). Again, for a pro¯t maximizing ¯rm, $n > 1$; hence the exchange-rate exposure of the importer is negative. This means that an appreciation of the dollar would bene¯t the importer. The

[6] The exchange-rate exposure depends also on the elasticity of demand in country j (n_j), the e®ective tax rate (¿), the discount rate (½) and the cost for producing the output sold in country j (cq_j).

sensitivity of the importer to exchange rate changes is a negative function of the import share in total industry value $(q_j p)/V$.

If a ¯rm both exports and imports (produces domestically, imports from abroad and sells abroad), then the sensitivity of that ¯rm to exchange rate changes is a combination of the sensitivities of the exporting-only and the importing-only ¯rm. As shown in the respective expressions for exposure, the export-driven exposure may not be symmetric to the import-driven exposure; the former being related to the elasticity of demand in country j (n_j), whereas the latter being related to the elasticity of demand in the home country (n). In our main tests therefore, the total exposure consists of two parts, the import-driven and the export-driven, as opposed to only one part arising from the share of net exports. However, to examine the validity of the above intuition, we also conduct tests using the share of net exports as the driving factor of exchange-rate exposure. Formally, our main hypothesis is that:

\An appreciation of the real exchange rate of the U.S. dollar against the foreign currencies reduces the value of U.S. industries through exports and increases the value of U.S. industries through imports."

As discussed in the introduction, previous studies which assumed a constant exposure found a very weak relation between U.S. manufacturing industry value and exchange rate movements. In this paper we argue that there is a signi¯cant exposure of U.S. manufacturing industries to exchange rate movements which varies over time with the share of imports and exports.

3. The Model and Data

Dumas (1978), Adler and Dumas (1984) and Hodder (1982) de¯ne economic exposure to exchange-rate movement as the regression coe±cient of the real value of the ¯rm (industry) on the exchange rate across states of nature. There is no causality implied by the de¯nition, namely, that exchange rate changes cause changes in ¯rms' values, or vice versa. Indeed, in Adler and Dumas (1980), stock prices and exchange rates are both endogenous variables and determined simultaneously. However, for an individual ¯rm (industry), we can safely assume that exchange rates are exogenous.

In line with the above de¯nition, previous research used the following model to test for exchange-rate exposure:[7]

$$R_{it} \quad ¯_{i} + \quad _{1} R_{mt} + \quad _{i} FX \quad _{t} + ²_{t} \quad t = \quad ;::T \qquad 1)$$

w er ,

R_i s t e r te f r tu n o th it ¯r 's in us ry s) om on to k a ju te fo in at on n pe io t;

$_{mt}$ is he at of et rn n t e m rk t p rt ol o a ju te fo in at on n p ri d t

XI_t s t e r te f r tu n o a r al mo in , t ad -w ig te ex ha ge at , m as re in .S ol ar pe un t o fo ei n c rr nc es n p ri d t [8]

In hi pa er in in wi h t e e pi ic l p ed ct on of ev 's od l, e h po he iz

[7] See, for example, Jorion (1990), Bodnar and Gentry (1993), Amihud (1994), and Allayannis (1996).

[8] This speci¯cation assumes that exchange rates and stock returns follow a random walk process, hence the rate of return captures the unanticipated movements. In this framework, there is little di®erence between nominal and real exposure, since the largest percentage of variation comes from exchange rates, rather than in°ation. Similarly, there is little di®erence in using excess returns (returns over the risk-free rate), since the variation in interest rates is also relatively small compared to the variation in exchange rates. For example, over the period 1971-1987, the annualized volatility of the dollar/mark exchange-rate change was 12% compared to a volatility of 3% for the U.S. Treasury bill rate and 1.3% for the U.S. in°ation.

that the exposure of industry stock returns to exchange-rate movements, $¯_{2it}$, is negatively related to the share of imports and positively related to the share of exports in total industry production. We model $¯_{2it}$ as follows:

$$¯_{2it} = ®_{2i}(IMP_{it}=V_{it}) + ®_{3i}(EXP_{it}=V_{it});\ t = 1;:::T \quad (2)$$

where,

IMP_{it} is the level of imports in industry i in period t;

EXP_{it} is the level of exports in industry i in period t;

V_{it} is the total product shipment in industry i in period t;

Combining equations (1) and (2) results in the following model:

$$R_{t} = ¯_{0} + ¯_{1i}R_{\ t} + °_{2}(IMP_{it}=V_{t})¤F \quad I_{t} + \quad _{i}(E \quad P_{i} = \ _{it})¤ \quad XI \quad ²_{it}; \quad = 1 ::;T \quad = 1 ::;n \quad 3)$$

n t e a ov sp ci ca io , w al ow he nd st y e ch ng -r te xp su e t va y o er im wi h t e i po t s ar ($°_{2}$ an th ex or sh re $°_{3i}$) n t ta in us ry ro uc io . A co di g o t e m de th t w s p es nt d e rl er we ho ld xp ct $_{i}$ to e n ga iv an $°_{3}$ t be po it ve

We st ma e t is od l u in se mi gl un el te re re si ns SU). iv n t e d ®e en re re so s f r e ch nd st y (nd st y i po t a d e po t s ar s) we an xp oi po si le ro s- qu ti n c rr la io s i th er or er s a d o ta n e ci nc ga ns Gi en ha th to al um er f i du tr es 13) i la ge th n t e t me se ie ob er at on (1 8 f r t e p ri d 1 78 86 , i wo ld e i ap ro ri te o s ac al th in us ri s i th sa e s st m o eq at on . W th re or es im te sy te of UR or ac in us ry t t e 2 di it IC by ta ki g t e r le an in us ri s a th 4- ig t S C. n t e a ov sp ci ca io , n s t e n mb r o 4- ig t S C i du tr es ha ar ag re at d u de an nd st y a th 2- ig t i du tr (e g. ei ht or he ra sp rt qu pm nt nd st y (IC 7) .

We also estimate an augmented model in which we allow for both time-varying exposure through the share of imports and exports, and constant exposure. In this model, the constant exposure may account for a potential missing variable, as for example, the exposure through revenues from operations abroad, through foreign debt, or other variables that were identified in Levi's model (e.g., cost of production), besides import and export shares. In this paper we have abstracted from these variables due to the unavailability of such data at the monthly level. The specification is as follows:

$$R_{it} = \beta_{0i} + \beta_i R_m + \delta_{1i} \cdot FXI + \delta_{2i}(IMP_t/V_i) \cdot FXI_t + \delta_3 (EXP_{it}/V_t) \cdot FXI_t + \epsilon_t; \; t = 1; \ldots; T \; i = 1; \ldots; n \quad ( )$$

S ec¯c ti n ( ) i ne te in pe i¯ at on 4) In he ex se ti n, e i pl me t a ik li oo ra io es s t di ti gu sh et ee th re tr ct d ( ) a d t e u re tr ct d ( ) m de .

3.1 The Data

3.1.1 The sample

e o s r c m n h y n u t y e u n f o i d v d a ¯ m e u n r t i v d r m h C S d t b s . i m a e o t d n o n u t y o t o i s n h b g n i g f a h a e d r e r a c r i g o h i 4 d g t I primary industry classification. Only firms trading for any full calendar year in the period 1978 to 1990 are considered. Industry returns are the equally-weighted average of the individual firms' returns within the portfolio. As mentioned earlier, we use two separate periods to perform our tests, (January 1978 - December 1986) and (January 1987 - December 1990) that reflect the changes in the industry classification. The total number of industries is 137 for the first period and 124 for the second period. The list of industries that we use in the paper is shown in the appendix. To adjust the nominal returns for inflation, we use the inflation index PUNEW (CPI-U) retrieved from the CITIBASE. We also use the CRSP monthly value-weighted market index as our market portfolio.

3.1.2 The exchange-rate index

We use a real, trade-weighted monthly dollar index (RX-101) put forth by the Federal Reserve Bank of Dallas. This index differs from those that have been used in previous studies in two ways: i) by the method used to construct trade weights and ii) by the selection of currencies against which to measure the dollar. In particular, moving trade weights are employed, rather than weights that are tied to particular years or trading flows and 101 U.S. trading partners are used, as opposed to 15 that are used in the construction of the Morgan Guaranty Trust Company of NY exchange rate index (used by Amihud (1994)) and 22 for the IMF's MERMA (used by Jorion (1990)).

3.1.3 Import and export shares

We use monthly figures of U.S. manufacturing industry exports and imports with the world as a whole, at the 4-digit SIC level. The source of this data is the Bureau of the Census-U.S. Department of Commerce, Foreign Trade Division. The information is compiled from forms and automated reports filed initially with the U.S. Customs Service for virtually all shipments leaving (exports) or entering (imports) the U.S.. These forms are required to be filed by qualified exporters, importers, forwarders or carriers at the port of exit (entrance) (Ch. 9, Title 13). In general, the statistics record the physical movement of the merchandise between the U.S. and foreign countries but exclude merchandise shipped in transit through the U.S. from one foreign country to another as well as shipments to and from the U.S. Armed Forces or furniture and equipment to government agencies.

Exports are by definition valued at the port of exportation. Export prices are the selling price and include expenditures for freight, insurance and other charges to the export point. The import data are based on Customs value, generally defined as the price actually paid or payable for merchandise when sold for exportation to the U.S., excluding U.S. import duties, freight and other charges incurred in bringing the merchandise to the U.S.. Import data to the U.S. include imports by foreign companies as well as imports by U.S. corporations. These two categories of imports have an opposite impact within the framework of our analysis. If there is a large percentage of imports from foreign competitors in the total industry imports, then an appreciation of the dollar may actually hurt domestic importers. Our maintained hypothesis is that imports by foreign competitors may be important in a few industries, but generally, imports represent activities on the part of U.S. corporations, either through their own foreign a±liates or through independent foreign suppliers.

There is no direct source for monthly data on the share of imports and exports in total industry production at the 4-digit SIC. Annual import and export shares at the 4-digit SIC are provided through the U.S. publication \U.S. Commodity Exports and Imports as Related to Output". Data on industry value (as proxied by total sales or value of product shipment) are also available only on an annual basis through the U.S-Census publication \Annual Survey of Manufactures". We construct the monthly import and export ratios for each industry, by dividing the monthly industry imports (exports), by one-twelfth of the annual value of product shipment. Where feasible, we cross-check whether the annual average of the constructed monthly import/export ratios for a given industry matches the annual import/export ratios that are reported in the publication \U.S. Commodity Exports and Imports as related to Output". We ¯nd that they are very similar.

4. Tests and Results

In this section we test our hypothesis and report results on the statistical and economic signi¯cance of the time-varying exchange-rate exposure, and the signs of the export-driven and import-driven exposure. To gain a better understanding of exchange-rate exposure, we examine further whether the size of the exposure is related to the level of import and export share; whether exposure is pronounced in industries with more volatile imports and exports; whether one factor (the net-export share) drives the time-variation of the exchange-rate exposure instead of two factors (import share and export share); and, whether signi¯cant exposure at the 4-digit level is masked at the 2-digit level.

4.1 The statistical signi¯cance of the exchange-rate exposure-The Likelihood ratio test

First, we estimate model (1) where we only allow for constant exposure using the monthly returns of all U.S. manufacturing industries at the 4-digit SIC. Similar to previous studies which have assumed exposure to be constant [e.g., Jorion (1990), Bodnar and Gentry (1993), and Bartov and Bodnar (1994)] we ¯nd that for the period between 1978 and 1986 (1987-90), only 13 out of 137 (14 out of 124) industries in our sample have a signi¯cant constant exposure (Table 1). This percentage of signi¯cant exposure is not di®erent from what could have been obtained by chance, given that the level of signi¯cance in our tests is 10%.

Next, we test our hypothesis using model (3), in which we only allow for time-varying exposure. We ¯nd that for the period between 1978 and 1986, in 30 out of the 137 (22 percent) U.S. manufacturing industries, the exchange-rate exposure varies signi¯cantly over time with the monthly share of imports and exports. More speci¯cally, in 22 out of the 137 (16 percent) industries the exchange-rate exposure varies signi¯cantly with the monthly share of imports in total industry production and in 27 of 137 (17.5 percent) industries with the monthly export share. For the period between 1987 and 1990, in 39 out of the 124 (32 percent) of the U.S. manufacturing industries, the exchange-rate exposure varies signi¯cantly over time with the industry import and export share (Table 2a).

The substantial increase in the number of industries that are signi¯cantly a®ected by exchange-rate movements is attributed to the fact that in our model, the exposure captures the time-variation of the imports and exports. But, how much variation in imports and exports do we see in the data? We examine this issue by constructing the time-series of the net-export share in total production for each industry in our sample. These series are simply calculated by subtracting an industry's import share from its export share. Examples of such series are shown in Figure 1a, where we plot the net-export share for the motor vehicle parts industry (SIC 3714), and in Figure 1b, where we plot the net-export share for the aircraft engines industry (SIC 3724) during 1978-86. The motor vehicle parts industry is a net exporter between 1978 and the middle of 1983 (at the maximum, which occurred in the beginning of 1982, its export share exceeds its import share by more than 12 percent), while it becomes a net importer after that and for the remaining of our sample period (at the minimum, its import share exceeds its export share by more than 14 percent). Although the aircraft engines industry remains a net exporter for the entire sample period, its net-export share is quite volatile, reaching a minimum of less than 4 percent at the end of 1980 and a maximum of close to 18 percent in the beginning of 1983.

In fact, these industries are quite representative of our sample of U.S. manufacturing industries. We ¯nd that approximately 43 percent of the industries in our sample switched from being a net exporter to being a net importer or vice-versa, and that the average standard deviation of the equally-weighted average of import and export share is 18.6 (the import and export shares are measured between 0 and 100). Given this strong variation in industry import and export shares, we can conclude that this improvement in the measurement of exposure is due to the inclusion of the time-varying imports and exports.

We also estimate the augmented model (model 4), where, in addition to the time-varying exposure, we also allow for constant exposure. In this model, the constant exposure factor captures exposure from sources other than imports and exports. Table 2b shows the results on the significance of the exchange-rate exposure using the augmented model. Overall, the results suggest an increase in the number of industries that are significantly affected by exchange rate movements. Specifically, 31% of the U.S. manufacturing industries are significantly affected through either the time-varying exposure or through the constant exposure during 1978-86, as opposed to 22%, when we only allow for time-varying exposure. The constant exposure appears to be significant in this specification in 24 (27) industries during 1978-86 (1987-90).

To gauge the improvement in the estimation of the exposure due to the constant term, we perform a likelihood ratio test. This test distinguishes between the augmented model (4) (unconstrained) and model 3 which allows for time-varying exposure only (constrained).[9] As shown in Table 3, the restriction that the constant exposure is equal to zero ($\delta_{1i} = 0$) is rejected —at the 10 percent level— in only 13.2 percent (14.5 percent) of the total number of industries for the period 1978-86 (1987-90). This means that in relatively few industries does the inclusion of a constant factor increase the accuracy of the estimated exposure. In the large majority of the industries, exposure is accurately captured by the time-varying exposure.

4.2 The economic significance of the exchange-rate exposure

We compute the average import (export) exposure by multiplying the industry import (export) exposure coefficient γ_{2i} (γ_{3i}) by the respective industry average import (export) share. The average total exposure is the sum of the average import and the average export exposure.

[9] The likelihood ratio test is based on

$$\lambda = -2(\ln L_c - \ln L) = n \ast \ln((\sigma_c)^2 / (\sigma)^2) \quad (5)$$

where $(\sigma_c)^2$ is the MLE for the constrained model and $(\sigma)^2$ is the MLE for the unconstrained model. The statistic is asymptotically distributed as chi-squared with J degrees of freedom, where J is the number of restrictions.

Our results suggest that the time-varying exchange-rate exposures are also economically signi¯cant in a substantial number of industries (Tables 4a-4b). In particular, a 1% appreciation of the dollar in the period 1978-86 increased the value of the industrial organic industry (SIC 2819) through imports by 2.38%. At the same time, a 1% appreciation of the dollar reduced the value of this industry through exports by 2.82%. As a result, the total exposure of the industrial organic industry is 0.438, indicating that a 1% appreciation of the dollar decreased the return on this industry by 0.438%. Several other industries were signi¯cantly a®ected through imports or through exports only. For example, for the industrial trucks and tractors industry (SIC 3537), a 1% appreciation of the dollar increased the industry returns through imports by 1.68% and for the telephone and telegraph industry (SIC 3661) by 1.28%. Similarly, a 1% appreciation of the dollar reduced the value of the motor vehicle industry (SIC 3711) through exports by 2.76% and the value of the railway equipment and parts (SIC 3743) by 2.28%.

On average, for all the 137 manufacturing industries during 1978-86, the exchange-rate exposure through exports is 0.469 with a standard deviation of 1.16 and through imports -0.376 with a standard deviation of 1.272; and hence, the total exchange-rate exposure is 0.093 (standard deviation of 0.55). This means that during 1978-86, a 1% appreciation of the dollar reduces the value of the \average" industry through exports by 0.469%, increases the value of the industry through imports by 0.376% and in total, reduces the value of the \average" industry by 0.093% (Table 4c). This total exposure of the \average" industry is small and may be the reason why several studies (e.g., Jorion (1991)) have found that exchange rates are not priced in the economy at large. However, to the extent that individual industries di®er vastly from the \average" industry regarding their imports and exports, this average exposure is misleading. For instance, a primarily exporting industry has a substantial exposure through exports (0.478) and a primarily importing industry has a substantial exposure through imports (-0.376).

For the period 1987-90, the average export and import exposures across all 124 industries are much smaller (-0.056 and 0.154 respectively) than the ones during 1978-86 and have the opposite sign from what was expected. At the same time, the standard deviations are almost four times bigger than those during 1978-86, indicating that exposures during this period may have been estimated less precisely. We explore this further in the next section where we examine in detail the signs of the exposures.

4.3 The signs of the exchange-rate exposure-The Sign test

According to our hypothesis, we expect a negative sign for the import-driven exposure and a positive sign for the export-driven exposure. A negative (positive) import-driven (export-driven) exposure indicates that an appreciation of the dollar increases (reduces) the value of the industry. Results are shown on Table 5a for the signs of the coe±cients that are estimated using model (3), in which we allow for time-varying exposures only, and on Table 5b for the coe±cients that are estimated using model (4), in which we also allow for constant exposure.

For the period 1978-86, 17 out of 22 (20 out of 24) signi¯cant import-driven (export-driven) exposures were negative (positive). The number of signs that are consistent with our hypothesis is substantially larger when we estimate the model without allowing for constant exposure than when we allow for constant exposure. In this latter case, in only 13 out of 22 (18 out of 24) industries, the import-driven (export-driven) exposures are negative (positive). For the period between 1987 and 1990 the results are weak: only 16 out of 36 (15 out of 32) signi¯cant import-driven (export-driven) exposures were negative (positive).

To statistically test what is the probability that the underlying \true" import-driven (export-driven) exchange-rate exposure is negative (positive) when "x" out of "y" coefficients are negative (positive), we employ the sign test.[10] Tables 5a-5b present the sign-test results. As mentioned earlier, we find that 17 out of 22 significant import-driven exposures are negative in the period 1978-86. The null hypothesis of equal probability of positive and negative exposure is rejected at the 1 percent level in favor of the alternative that the import-driven exposures are negative. Similarly, for the significant export-driven exposures for the period 1978-86, we reject the null hypothesis of equal probability of positive and negative export-driven exposure in favor of the alternative that export-driven exposures are positive at the 1 percent level. These results also hold when we consider all exposures and not merely the significant ones.

In contrast with the results for period 1978-86, in period 1987-90, the null hypothesis of equal probability of positive and negative exposure cannot be rejected. One explanation for the weak results of the second period is that the statistical power in the 1987-90 period is much smaller than in the 1978-86 period given the smaller time-series in the second period. Also, the use of seemingly unrelated regressions (SURs) substantially improved the results for this latter period compared to the results we obtained using simple OLS regressions for each industry (OLS results not reported). SURs are more powerful than OLS regressions because they exploit possible cross-equation (industry) correlations in the error terms. For example, for the period 1987-90, the percentage of significant negative import-exposures for the time-varying model increases from 27 percent to 44 percent and the percentage for

[10] The sign test is a nonparametric test which does not require any distributional assumptions (e.g., normality) for its coefficients. Consider a random sample of paired observations: $(x_1,y_1),\ldots,(x_n,y_n)$. Let $p = p(y_i > x_i)$. The test of the hypothesis that the x's are shifted in location relative to the y's reduces to the hypothesis ($H_0\!: p = 1/2$, $H_1\!: p \neq 1/2$). Let each $(x_i; y_i)$ pair be replaced by either a plus sign or a minus sign: a plus sign, if $y_i > x_i$ and a minus sign, if $y_i < x_i$. It follows that if H_0 is true, each $(x_i; y_i)$ pair constitutes a Bernoulli trial and Y_+, the number of plus signs will have a binomial pdf with parameters n and 1/2. H_0 should be rejected if Y_+ is either less than or equal to Y_+^{*} or greater than or equal to Y_+^{**}, where $P(Y_+ <= Y_+^{*}) = P(Y_+ >= Y_+^{**}) = a/2$. For large n, we could apply the DeMoivre-Laplace limit theorem and approximate, for example, Y_+^{**}, by solving $z_{1-a/2} = (Y_+^{**} - (1/2)n)/\sqrt{(n/4)}$.

the significant positive export-exposures increases from 28 percent to 47 percent when we employ SURs. For the period 1987-90 the null hypothesis of equal probability of positive and negative exposure cannot be rejected when the exposures are estimated using SURs. This is in contrast to the OLS estimates, where the null hypothesis of equal probability of positive and negative exposure was rejected in favor of the alternative that the import-driven (export-driven) exposures are positive (negative), which is the opposite from our hypothesis.

4.4 Exchange-rate exposure and the level of import and export shares

We investigate further whether our results become sharper when we control for the magnitude of import and export shares. The model suggests that the import (export) exposure coefficient is larger in absolute value, the larger the magnitude of import and export shares. As a result, if the exposures of some of the smaller importers or exporters have been estimated with error, they may have affected their sign. We compute the average import (export) exposures by multiplying the estimated import (export) coefficients γ_{2i} (γ_{3i}) by the average of the industry import (export) share during the two periods that we examine, 1978-86 and 1987-90. We present the evidence in the form of a histogram.

In Figure 2, we present histograms of the distribution of the export-driven exchange-rate exposure for the thirty largest exporters (top) and the thirty smallest exporters (bottom) of the U.S. manufacturing industries for the period 1978-1986. There is a substantial difference in the distribution of the signs of the export-driven exposures between the largest and the smallest exporters. The average exposure of the largest exporters (+0.826) is much larger than the average exposure of the smallest exporters (+0.157). This means that on average, a 1% appreciation of the dollar reduced the value of the largest exporters by 0.826%, while a similar appreciation of the dollar reduced the value of the smallest exporters by only 0.157%. In total, 22 out of the 30 largest exporters have a positive export exposure, compared to only 17 out of the 30 smallest exporters.

Similarly, in Figure 3, we present histograms of the distribution of the import-driven exchange-rate exposures for the thirty largest importers (top) and the thirty smallest importers (bottom) of the U.S. manufacturing industries for the period 1978-1986. There is a small di®erence in the distribution of the signs of the import-driven exposures between the largest and the smallest importers. On average, a 1% appreciation of the dollar increased the value of the largest importing industries by 0.206% and the value of the smallest importing industries by 0.165%. In total, 20 out of the 30 largest importers have a negative import exposure compared to 17 of the smallest exporters.

As discussed in the previous section, for the period 1987-90, the sign-test cannot reject the equal probability of positive and negative exposure in favor of our alternative that export (import) exposure is positive (negative). The average exposure for all exporters (importers) is -0.056 (+0.154). In contrast, the thirty largest exporters have an average exposure of +0.32 during this period indicating that on average, a 1% appreciation of the dollar reduces the value of the largest exporters by 0.32%. For the smallest 30 exporters however, the average exposure is negative (-0.39), indicating that an appreciation of the dollar increased the returns of the smallest exporters. This result suggests that for the period 1987-90 the exposures of the smaller exporters may have been estimated with error.[11]

Finally, in contrast to our expectations that the larger importers have larger ¡ in absolute values ¡ exposures, the average exposure of the largest (smallest) 30 importers during 1987-90 is 0.2118 (-0.4768). In this case, the smallest 30 importers have an average sign, which is consistent with our hypothesis that an appreciation of the dollar increases industry returns through imports.

[11] However, for both the largest and the smallest exporters during this period, the sign-test cannot reject the null hypothesis of equal probability of positive and negative exposure.

Summarizing our results on the signs of the exchange-rate exposure, the following points emerge: a) regardless of the estimated model (augmented or time-varying only) for the period 1978-86, our findings are consistent with the hypothesis that import-exposures are negative and export-exposures are positive, indicating that an appreciation of the dollar increases the value of an industry through imports and decreases the value of an industry through exports. Results are weaker for the period 1987-90. The null hypothesis of equal probability of positive and negative exposure cannot be rejected; b) results in the second period are stronger when we employ SUR than when we employ OLS, indicating that the weak results for the period 1987-90 may be related to issues of power of the estimation technique; and, c) results are stronger for the larger exporters and importers which indicates that a filtering of our sample of industries may be warranted.

4.5 Exchange-Rate Exposure and the volatility of import and export shares

To further gauge the benefits of including the time-varying import and export share in the determination of exposure, we examine the differences in the size of the exposures that are estimated using our time-varying exposure model and those using a model of constant exposure. We expect that the differences in the estimated exposures will be larger in those industries where trade shares are relatively volatile. In those industries where trade shares are relatively stable, the error in the estimation of exposures using a model of constant exposure will be small. This is due to the fact that a stable import and export share can be captured in the regression coefficient without much error in the estimated regression. In high trade-share volatility industries however, assuming constant import/export share will over or underestimate exposure, as the actual values of import/export share lies below or above its mean value.

We classify our sample of 137 industries in two categories (high and low) according to the volatility of their trade shares. The trade-share volatility is the equally-weighted volatility of import and export shares. We ¯rst show the di®erences in the estimated exposures for the industry with the highest and lowest trade-share volatility and then present results on the signs and signi¯cance of exposures for the two categories.

In Figure 4a we present the estimates of the time-varying and the constant exposure for the industry furniture and ¯xtures (SIC 2599) which has the largest trade-share volatility. We compute the time-varying exposure by ¯rst multiplying the import and export exposure coe±cients (°$_{2i}$ and °$_{3i}$) estimated using model (3) by the respective industry import and export shares and then summing up the two components of exposure. The constant exposure is estimated using model (1). For this industry, the constant exposure estimate is -0.304. This exposure overestimates (underestimates) the time-varying exposure in the ¯rst (next) two and a half years. In the last four years of the sample period (1983-86), the constant exposure overestimates the time-varying exposure by a large amount. The time-varying exposure reaches a minimum exposure of -1.39 at the end of 1986. At that point, an appreciation of the dollar would increase the return of this industry by 0.304% (according to the constant exposure model) and by 1.39% according to the time-varying model.

We also compute a metric of the di®erence between the time-varying and the constant exposure which allows us to compare these di®erences across industries: the percentage average of the absolute value of the monthly di®erence between the two exposures.[12] On average, the constant exposure has misestimated exposure by 0.22 and in percentage terms, by 73% ($\frac{0:22}{0:304}$).

Similarly, in Figure 4b, we plot the time-varying and the constant exposure for the periodicals industry (SIC 2721), which has the lowest trade-share volatility during the period

[12] We compute this metric using the formula, $1=n(jTV_{it}$ ¡ $C_ij=jC_ij)$, where TV_{it} is the time-varying exposure of industry i at time t, C_i the constant exposure of industry i and n the number of observations.

1978-86. For comparison purposes, we keep the same scale in this ¯gure as in Figure 4a. In this case, consistent with our expectations, the di®erence in the estimated exposure using the time-varying and the constant exposure model is much smaller. Speci¯cally, we ¯nd that on average, the constant exposure has misestimated exposure by 0.067, which represents an average exposure error of 23% ($\frac{0:067}{0:29}$).

We examine further the results on the sign and signi¯cance of the time-varying exchange-rate exposure for the categories of high and low trade-share volatility industries. As noted above, we expect our time-varying model to provide more accurate estimates of exposure than the constant model when the volatility of trade shares is high. Results are shown on Table 6 for the industries with high (top panel) and low volatility of trade shares (bottom panel). In the high-volatility industries, 15 out of 69 (14 out of 69) industries are signi¯cantly a®ected by exchange-rate movements through imports (exports). This contrasts with only 6 out of 68 (10 out of 68) industries which are signi¯cantly a®ected by exchange-rate movements through exports (imports) in the low volatility industries.

In total, approximately 27.5% (19 out of 69) of the high trade-share-volatility industries are signi¯cantly a®ected by exchange-rate movements through imports or exports, compared to only 16.17% (11 out of 68) of the low trade-share-volatility industries. The signs of the exposures are also consistent with our hypothesis that an appreciation of the dollar increases (decreases) the value of an industry through imports (exports) in more high-volatility industries than in low-volatility industries. In particular, in 47 out of 69 (48 out of 69) high volatility industries, the sign of import (export) exposure is positive compared to 39 out of 68 (44 out of 68) industries for the low-volatility ones. In the high-volatility industries, the sign test rejects the null hypothesis of equal probability of positive and negative exposures in favor of the alternative of negative (positive) import (export) exposure. However, in the low-volatility industries, the sign test cannot reject the null hypothesis in the case of import exposures. Overall, the above results suggest that our time-varying model estimates more accurately the exchange-rate exposure, and particularly the exposure of those industries in which the volatility of imports and exports is high.

4.6 Exchange-rate exposure and net exports

We also perform our tests using one aggregate regressor, the net-export share, instead of two separate regressors, namely the import and export share. Our hypothesis is that an unexpected appreciation of the dollar would hurt a net exporter. We therefore expect a positive sign for the interacted net-exports coefficient. In Table 7 we present results on the significance (top) and the signs (bottom) of the net-export share exposure. The results on the signs of the exposures are very similar to the previous cases. In particular, 88 percent of the significant exposures for the period 1978-86 are positive whereas only 21 percent are positive for the period 1987-90. Using the sign test, we reject (at the 3 percent level) the null hypothesis of equal probability of positive and negative net exposures in favor of the alternative that net exposures are positive for the period 1978-86, but we cannot reject the null for the period 1987-90. This means that an appreciation of the dollar generally hurt net-exporters, or alternatively, benefited net-importers during the period 1978-86.

The results on the significance of the net-export exposure are less strong than in the previous case in which import and export shares are used as two separate regressors. In particular, for the period 1978-86 (1987-90) in only 15 out of 137 (11%) of the industries (19 out of 124, or 15%) is the net-export exposure significant. We attribute this lack of significant exposure to the significant noise that is introduced when we aggregate the import and export share measures into one, net-export share measure. As Levi's model indicates, the export-exposure is related to the elasticity of demand in the various export-destinations whereas the import exposure is related to the (one) elasticity of demand in the home country.

To the extent that these elasticities di®er, the net-export share is not the appropriate variable to characterize the time-variation of the exchange-rate exposure.

4.7 Further evidence on the time-variation of the exchange-rate exposure; Exposure at the 2-digit vs. 4-digit using the Transport Equipment industry

In this section we provide further evidence on the time-variation of the exchange-rate exposure and the issue of the level at which exchange-rate exposure should be examined (i.e., ¯rm, industry at the 2-digit SIC or 4-digit SIC). As argued in Allayannis (1996), the use of industry portfolios may mask the exposure arising at the ¯rm level. In this paper, given the general lack of data of imports and exports at the ¯rm level, we can only compare the time-varying exposures at the industry level (2-digit SIC and 4-digit SIC level). To illustrate the issue, we consider as an example the transport equipment industry (SIC 37) and the 8 industries at the 4-digit SIC that comprise it.[13]

In Figure 5 we show the exchange-rate exposure of the transport industry (SIC 37) plotted against time, estimated in two di®erent ways: a) the time-varying exposure according to imports and exports shares, and b) the constant exposure. We constructed the above exposures in the following manner: a) we estimated the time-varying exposure by multiplying the estimates of the import-driven (export-driven) exposures by the corresponding monthly levels of import (export) shares and then by summing up these two components; b) we estimated the constant exposures by estimating model (1), where we do not allow for time-variation of the exposure, for the subperiods (1978-1980), (1981-1983), (1984-1986) and (1987-1990). We then plotted these estimates at the middle point in time for the di®erent subperiods and ¯nally join these points with a line.

[13] In particular, the industries at the 4-digit SIC are the motor vehicle industry (3711), the automotive parts industry (3714), the aircraft industry (3721), the aircraft engines industry (3724), the aircraft parts industry (3728), the pleasure boats industry (3732), the railway industry (3743) and the motor cycle industry (3751).

Two points emerge from Figure 5: i) the exchange-rate exposure of the transport equipment industry is largely not very di®erent from zero, regardless of the type of the exposure (time-varying or constant); ii) the time-varying exposure which is driven by the import and export shares tracks very closely the line that links the constant exposure estimates. The exposure of the transport equipment industry increases very little between 1978 and 1982, then declines for the period between 1982 and 1986 and then increases again in 1987 and remains stable around zero thereafter.

If we were to estimate the exchange-rate exposure of the transport industry at the 2-digit SIC we would conclude that the exposure is not signi¯cantly di®erent from zero. However, a di®erent picture is painted when we examine the exchange-rate exposure at the 4-digit SIC. In ¯gures 5a-5h we show the exchange-rate exposures estimated using the constant and the time-varying model plotted against time for the 8 industries that constitute the transport industry. Note that we have maintained the same scale on the exposure axis to facilitate comparisons. In contrast with the insigni¯cant exposure of the transport industry (SIC 37), the motor vehicle industry (SIC 3711), the aircraft engines industry (SIC 3724), and the railway industry (SIC 3743), all have exposures that are signi¯cantly di®erent from zero during 1978-86.

In particular, the time-varying exposure of the motor vehicle industry reaches a minimum around mid-1986 (exposure value: -3.25), indicating that on average, a 1 percent depreciation of the dollar at that time would decrease the value of the automotive industry by 3.25 percent. Similarly, the aircraft engines industry (SIC 3724) reaches its minimum exposure at about the same time, however, its exposure indicates that on average, a 1 percent depreciation at that time would reduce the value of the industry by 4.2 percent. Given the history of the dollar movements in the eighties, where the dollar was largely depreciating between 1978 and 1980 and between 1985 and 1990 and largely appreciating between 1981 and 1985, the exposure pro¯le of the automotive industry indicates that the industry bene¯ted from the dollar swings in the periods 1978-1980, 1983-1985, stayed relatively una®ected after 1987, while it was hurt during the periods 1980-1982 and 1985-1987.

In addition to the issue of the level at which exposure should be examined, ¯gures 5a-5h shed light on the time-variation of the exchange-rate exposure. The fact that the time-varying exchange-rate exposure that arises from the import and export shares tracks successfully the extrapolated constant exchange-rate exposure is important because it shows that imports and exports do in fact capture much of the fundamental exchange-rate exposure that is estimated when we are agnostic about its source. Figures 5a-5h provide also a possible answer to another issue that has been present since the infancy of this literature, namely that the exchange-rate exposure is largely insigni¯cant, when estimated over a long interval. In general, the constant exposures are small and switch signs over time, rendering the exposure over a large estimation period equal to zero. This shortcoming is alleviated when we use import and export shares as the determinant factors of exchange-rate exposure.

Our results on U.S. manufacturing exchange-rate exposure are in contrast with the results obtained previously by Bodnar and Gentry (1993) and Jorion (1991).[14] We ¯nd that the industries ¡ at the 2-digit SIC level ¡ with the largest percentage of signi¯cantly exposed industries at the 4-digit level are the fabricated metal products (SIC: 34), the petroleum re¯ning (SIC: 29), the electronic equipment (SIC: 36) and the lumber and wood (SIC: 24). None of these industries are exposed to exchange-rate movements according to Jorion (1991) and only the petroleum re¯ning industry is exposed according to Bodnar and Gentry (1993).

[14] Bodnar and Gentry (1993) ¯nd that only 3 (out of 19) US manufacturing industries have a constant exposure to exchange rate movements (SIC: 23, 29 and 37). Jorion (1991), in an APT study using as exogenous factors the market and the return on an exchange rate index, also ¯nds that 3 out of the 19 U.S. manufacturing industries have a signi¯cant constant exchange rate exposure, but two them are di®erent from Bodnar and Gentry's (SIC: 22,23(lumped), 28, 35).

We argue that this is attributed to the following two reasons: a) we acknowledge the existence of a time-varying exposure and explicitly incorporate this time-variation in our econometric specification, whereas previous authors assume a constant exposure only, and b) we use data at the 4-digit SIC level which allows us to identify exposures of the industries that comprise the industry portfolios at the 2-digit SIC level. As argued in the previous section, the exchange-rate exposure of an industry portfolio at the 2-digit SIC masks the exposures of the individual industries that comprise it.

5. Conclusions

Previous research which has assumed that the effect of exchange-rate movements on stock returns is constant, has found limited evidence that exchange-rate movements affect firm or industry value. In this paper we examine whether the exchange-rate exposure of U.S. manufacturing industries at the 4-digit SIC level is constant, or whether it varies systematically over time with the share of the imports and exports in the industry, as theory suggests.

We find strong evidence that the industry exchange-rate exposure varies over time in a systematic way with the share of imports and exports in the industry. Approximately 22% of the U.S. manufacturing industries are significantly affected by exchange-rate movements through imports and exports during 1978-86. This is consistent with the volatile behavior of imports and exports that we observe in the data for the period of our tests, where 43% of the U.S. manufacturing industries in our sample have switched from being net importers to net exporters or vice-versa.

Our results support the hypothesis that an appreciation of the dollar increases the value of an industry through imports and reduces the value of an industry through exports for the period 1978-1986, though less so for the period 1987-1990. On average, during 1978-86, a 1%

appreciation of the dollar increases the value of an industry through imports by 0.37% and decreases the value of an industry through exports by 0.45%. Larger exporters (importers) have a larger exposure in absolute value during 1978-86 than smaller exporters (importers).

The error in the estimation of exposure using a constant exposure model ¡ as previous research has ¡ , is particularly large in industries with very volatile imports and exports. In such industries, we show that the error in the exposure measurement could be up to 73%. Finally, the use of industry returns and import/export data at the 4-digit level is important in the examination of exchange-rate exposure. We show that signi¯cant exchange-rate exposures at the 4-digit level are masked at the more aggregate 2-digit level, rendering the exposure undetected.

As data become more available in international ¯nance, the impact of additional factors could be examined which may be relevant for exchange-rate exposure. One such factor is for example, the industry structure. This is currently pursued in Allayannis and Ihrig (1997). Similarly, an important issue for study is the link between a ¯rm's pricing strategy and its exchange-rate exposure, which is the issue investigated in Bodnar, Dumas and Marston (1997).

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Appendix

2011{Meat product and meat packaging 2022{Cheese, natural and processed 2026{Fluid milk and cream 2033{Canned fruits, vegetables and preserves 2037{Frozen fruits, fruit juices 2043{ Cereal breakfast foods 2062{Beet and cane sugar 2067{Chewing gum 2079{Shortening, table oils 2082{Malt beverages 2085{Distilled, recti¯ed, and blended liquors 2087{Flavoring extracts 2111{ Cigarettes 2121{Cigars 2131{Chewing and smoking tobacco 2211{Broad woven fabrics, cotton 2221{Manmade ¯bers 2231{Wool 2252{Hosiery 2258{Warp knit fabrics 2311{Men's and Boy's suits and coats 2321{Men's and Boy's shirts 2331{Women's blouses and shirts 2337{Women's suits 2342{Brassiers 2391{Curtains and Draperies 2421{Lumber 2435{Hardwood veneer and plywood 2436{Softwood veneer 2439{Structural wood members 2491{Wood products 2515{Mattresses and bedsprings 2599{Furnitures and Fixtures 2621{Paper mill products 2631{Paperboard mill products 2711{Newspapers 2721{Periodicals 2731{Books and pamphlets 2752{Printed matter 2761{ Manifold business forms 2782{Blankbooks, looseleaf 2812{Alkalies and chlorine 2816{Inorganic pigments 2819{Industrial inorganic chemicals 2821{Plastics, materials and resins 2823{Manmade ¯bers, cellulosic 2824{Manmade ¯bers, noncellulosic 2833{Medicinicals and botanicals 2842{Specialty cleaning 2843{Surface active agents 2851{Paints and allied products 2865{Cyclic crudes and intermediates 2869{Industrial organic chemicals 2874{Phosphatic fertilizers 2879{Agricultural pesticides 2891{Adhesives and sealants 2892{Explosives 2893{Printing inks 2895{Carbon black 2899{ Chemical preparations 2911{Petroleum re¯nary products 2999{Petroleum and coal products 3011{ Tires and inner tubes 3021{Rubber and plastics footwear 3143{Men's footwear 3144{Women's footwear 3149{Footwear, except rubber 3171{Women's handbags and purses 3172{Personal goods of leather 3199{Leather goods 3211{Flat glass 3229{Pressed and blown glass 3231{Products of purchased glass 3241{Cement, hydraulic 3253{Ceramic wall and °oor tile 3255{Clay refractories 3271{Concrete blocks and bricks 3275{Gypsum products 3291{Abrasive products 3292{Asbestos products 3296{Mineral Wool 3312{Blast furnace, cike oven 3313{Electrometallurgical products 3331{Smelter and re¯ned copper 3351{Rolled or drawn copper 3353{Rolled or drawn aluminum sheet 3421{Cutlery 3423{Hand and edge tools 3429{Hardware 3432{Brass plumbing goods 3452{ Bolts, nuts, screws, rivets 3499{Fabricated metal products 3511{Turbines and turbine generator 3519{Internal combustion engines 3523{Farm machinery and equipment 3531{Construction machinery and equipment 3537{Industrial trucks and tractors 3541{Metal-cutting machine tools 3545{Machine tool accessories 3553{Woodworking machinery 3555{Printing trades machines 3559{ Special industry machinery 3561{Pumps and pumping equipment 3567{Industrial furnaces and ovens 3569{Industrial machinery and equipment 3574{Calculating and accounting machines 3579{ O±ce machines 3585{Air conditioning 3621{Motors and generators and parts 3635{Vacuum cleaners 3636{Sewing machines 3639{Household appliances 3651{Radio and tv receiving sets 3661{ Telephone and telegraph instruments 3671{Electronic receiving tubes 3674{Semiconductors, recti¯ers 3675{Electrical capacitors 3679{Electronic components 3711{Motor vehicles and passengers cars 3714{Parts of motor vehicles 3721{Aircraft 3724{Aircraft engines 3728{Aircraft and spacecraft parts 3732{Yachts and Pleasure Boats 3743{Railway equipment and parts 3751{Motorcycles, bicycles and parts 3829{Measuring and controlling devices 3841{Surgical and medical instruments 3842{Orthopedic, prosthetic appl. 3861{Photographic equipment 3873{Watches and clocks 3911{ Jewelry 3914{Silverware and stainless steel 3931{Musical instruments 3944{Games and toys 3949{ Sporting and athletic goods 3951{Pens, mechanical pencils

Table 1

The signi¯cance of the Exposure; Model of Constant Exposure.

This table presents summary statistics on the signi¯cance (at the 10% level) of the exchange-rate exposure using the model shown below. Frequencies are presented for the constant exposure $\pm_{1i}$.

$$R_{it} = \bar{}_{0i} + \bar{}_{1i} R_{mt} + \pm_{1i} FXI_t + {}^{2}{}_{it};\ t = 1; :::; T \quad (6)$$

Period	# Industries	$\pm_{1i}$	% Industries
1978-86	137	13	9%
1987-90	124	14	11%

Table 2a

The significance of the Exposure; Model does not include constant exposure.

This table presents summary statistics on the significance (at the 10% level) of the exchange-rate exposure using the model shown below (time-varying only). Frequencies are presented for the exposure through the share of imports, γ_{2i}, and the exposure through the share of exports, γ_{3i}. Estimation is done through seemingly unrelated regressions (SUR).

$$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \gamma_{2i}(IMP_{it}/V_{it}) \times FXI_t + \gamma_{3i}(EXP_{it}/V_{it}) \times FXI_t + \epsilon_{it}; \quad t = 1, \ldots, T \quad i = 1, \ldots, n \quad (7)$$

Period	# Ind.	γ_{2i}	γ_{3i}	Total	% Ind.
1978-86	137	22	24	30	22%
1987-90	124	36	32	39	32%

Table 2b

The significance of the Exposure; Model includes constant exposure.

This table presents summary statistics on the significance (at the 10% level) of the exchange-rate exposure using the model shown below (augmented model). Frequencies are presented for the constant exposure δ_{1i} as well as the exposure through the share of imports, γ_{2i}, and the exposure through the share of exports, γ_{3i}. Estimation is done through seemingly unrelated regressions (SUR).

$$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \delta_{1i} FXI_t + \gamma_{2i}(IMP_{it}/V_{it}) \times FXI_t + \gamma_{3i}(EXP_{it}/V_{it}) \times FXI_t + \epsilon_{it}; \quad t = 1, \ldots, T \quad i = 1, \ldots, n \quad (8)$$

Period	# Ind.	δ_{1i}	γ_{2i}	γ_{3i}	Total	% Ind.
1978-86	137	24	26	27	43	31%
1987-90	124	27	30	32	46	37%

Table 3

Likelihood Ratio test; Choosing between the Model with and without constant exposure.

This table presents likelihood ratio tests for the two models presented below. The first model (augmented) is the unrestricted model and the second model (time-varying) is the restricted model nested in the first model. The table presents the number of industries for which, the restriction of zero constant exposure, ($\delta_{1i} = 0$), is rejected in each of the two periods we examine, (1978-86) and (1987-90).

$$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \delta_{1i} FXI_t + \delta_{2i}(IMP_{it}/V_{it}) \times FXI_t + \delta_{3i}(EXP_{it}/V_{it}) \times FXI_t + \epsilon_{it}; \quad t = 1, \ldots, T \tag{9}$$

$$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \delta_{2i}(IMP_{it}/V_{it}) \times FXI_t + \delta_{3i}(EXP_{it}/V_{it}) \times FXI_t + \epsilon_{it}; \quad t = 1, \ldots, T \tag{10}$$

Period	# Industries	# Rejections	% Industries
1978-86	137	18	13.2%
1987-90	124	18	14.5%

Table 4a

The economic significance of the exposure;

This table presents results on the economic significance of the exchange-rate exposure using exposure coefficients estimated by the model shown below for the period 1978-86. Industries are selected based on the statistical significance of their exposures. The exposure through imports (exports), EXP I (EXP E) is calculated by multiplying the import(export)-exposure coefficient γ_{2i} (γ_{3i}) by the industry import(export)-share average IMP_i/V_i (EXP_i/V_i). The total exposure is the sum of the exposure through imports and the exposure through exports.

$$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \gamma_{2i}(IMP_{it}/V_{it}) \times FXI_t + \gamma_{3i}(EXP_{it}/V_{it}) \times FXI_t + \epsilon_{it};\quad t = 1, \ldots, T \quad i = 1, \ldots, n \qquad (11)$$

Industry	IMP_i/V_i	EXP I	TOTAL
2819	17.06	-2.388	0.438
2865	16.31	-2.120	-0.042
3292	19.2	-6.144	0.608
3452	15.46	-2.319	0.047
3537	12.97	-1.688	-0.565
3621	11.89	-1.071	-0.020
3635	3.86	-0.849	-0.310
3661	7.33	-1.282	-0.437
3674	34.53	-3.453	0.160
3679	15.6	-1.092	0.040
3711	31.35	-2.508	0.252
3724	5.96	-3.814	-0.190

Table 4b

The economic significance of the exposure;

This table presents results on the economic significance of the exchange-rate exposure using exposure coefficients estimated by the model shown below for the period 1978-86. Industries are selected based on the statistical significance of their exposures. The exposure through imports (exports), EXP I (EXP E) is calculated by multiplying the import(export)-exposure coefficient γ_{2i} (γ_{3i}) by the industry import(export)-share average IMP_i/V_i (EXP_i/V_i). The total exposure is the sum of the exposure through imports and the exposure through exports.

$$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \gamma_{2i}(IMP_{it}/V_{it}) \times FXI_t + \gamma_{3i}(EXP_{it}/V_{it}) \times FXI_t + \epsilon_{it}; \;\; t = 1; \ldots; T \;\; i = 1; \ldots; n \qquad (12)$$

Industry	EMP_i/V_i	EXP E	TOTAL
2033	3.11	1.08	0.089
2819	20.19	2.82	0.438
2865	23.09	2.07	-0.042
2869	13.15	1.31	0.095
2893	2.03	2.41	0.767
3144	1.59	1.49	-0.156
3199	7.34	4.33	1.940
3292	19.86	6.75	0.608
3351	3.82	1.29	0.903
3452	4.55	2.36	0.047
3537	14.04	1.12	-0.565
3621	15.85	1.04	-0.024
3679	14.26	1.14	0.048
3711	7.26	2.76	0.252
3724	16.44	3.61	-0.198
3743	12.03	2.28	0.212
3951	12.13	1.09	-0.370

Table 4c

The economic significance of the exposure;

This table presents summary statistics (means (top rows), standard deviations (bottom rows)) on the economic significance of the exchange-rate exposure using exposure coefficients estimated by the model shown below. The exposure through imports (exports), EXP I (EXP E) is calculated by multiplying the import(export)-exposure coefficient γ_{2i} (γ_{3i}) by the industry import(export)-share average IMP_i/V_i (EXP_i/V_i). The total exposure (TOTAL) is the sum of the exposure through imports and the exposure through exports.

$$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \gamma_{2i}(IMP_{it}/V_{it}) \times FXI_t + \gamma_{3i}(EXP_{it}/V_{it}) \times FXI_t + \epsilon_{it}; \quad t = 1;\ldots;T \quad i = 1;\ldots;n \tag{13}$$

Period	EXP E	EXP I	TOTAL
1978-86	0.469	-0.376	0.093
	1.164	1.272	0.550
1987-90	-0.056	0.154	0.097
	4.190	3.840	1.340

Table 5a

The signs of the Exposure; Model does not include constant exposure.

This table provides results for the signs of the exposure through the import share (γ_{2i}) and through the export share (γ_{3i}) estimated from the model below (time-varying model) for the two periods we consider (1978-86) and (1987-90). Results include the frequency of negative (positive) exposure through import share (export share) and the p-values of the sign test for the hypothesis of equal number of positive and negative exposures. Results are presented for both the statistically significant coefficients (top row) and for all coefficients (bottom row).

$$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \gamma_{2i}(IMP_{it}/V_{it}) * FXI_t + \gamma_{3i}(EXP_{it}/V_{it}) * FXI_t + \epsilon_{it}; \; t = 1;\ldots;T \; i = 1;\ldots;n \quad (14)$$

Period	Ind.	γ_{2i} (-)	% Ind.	p-value (I)	γ_{3i} (+)	% Ind.	p-value (E)
1978-86	Signif.	17/22	77%	0.008	20/24	83%	0.007
	Total	90/137	66%	0.001	92/137	67%	0.00003
1987-90	Signif.	16/36	44%	0.79	15/32	47%	0.70
	Total	57/124	46%	0.83	48/124	39%	0.99

Table 5b

The signs of the Exposure; Model includes constant exposure.

This table provides results for the signs of the exposure through the import share (γ_{2i}) and the exposure through the export share (γ_{3i}) estimated from the model below (augmented model) for the periods (1978-86) and (1987-90). Results include the frequency of negative (positive) exposure through import share (export share) and the p-values of the sign test for the hypothesis of equal number of positive and negative exposures. Results are presented both for the statistically significant coefficients (top row) and for all coefficients (bottom row).

$$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \delta_{1i} FXI_t + \gamma_{2i}(IMP_{it}/V_{it}) \times FXI_t + \gamma_{3i}(EXP_{it}/V_{it}) \times FXI_t + \epsilon_{it}; \quad t = 1, \ldots, T \quad i = 1, \ldots, n \qquad (15)$$

Period	Ind.	γ_{2i} (-)	% Ind.	p-value (I)	γ_{3i} (+)	% Ind.	p-value (E)
1978-86	Signif.	13/22	59%	0.26	18/24	75%	0.01
	Total	84/137	61%	0.005	83/137	61%	0.008
1987-90	Signif.	12/36	33%	0.98	14/32	44%	0.81
	Total	53/124	43%	0.95	54/124	44%	0.93

Table 6

Exchange-rate exposure and the volatility of imports and exports;

This table presents results on the significance (at the 10% level) of the exchange-rate exposure and the signs of the exposure through the import share (γ_{2i}) and through the export share (γ_{3i}) estimated from the model below (time-varying model) for the period 1978-86 for both the high and low trade-share-volatility industries (top and bottom panels respectively). Results include the frequency of negative (positive) import share (export share) exposure and the p-values of the sign test for the hypothesis of equal number of positive and negative exposures.

$$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \gamma_{2i}(IMP_{it}/V_{it}) \times FXI_t + \gamma_{3i}(EXP_{it}/V_{it}) \times FXI_t + \epsilon_{it}; \quad t = 1,\ldots,T \quad i = 1,\ldots,n \tag{16}$$

High trade-share volatility industries

Exposures	% Signif.	Sign Prediction	Sign	Sign-Test p-value
γ_{2i}	15/69 (21.7%)	-	47/69	0.002
γ_{3i}	14/69 (20.3%)	+	48/69	0.001
γ_{2i} or γ_{3i}	19/69 (27.5%)			

Low trade-share volatility industries

Exposures	% Signif.	Sign Prediction	Sign	Sign-Test p-value
γ_{2i}	6/68 (8.8%)	-	39/68	0.14
γ_{3i}	10/68 (14.7%)	+	44/68	0.01
γ_{2i} or γ_{3i}	11/68 (16.17%)			

Table 7

Use of Net Export shares: The statistical significance of the Exposure;

This panel presents summary statistics on the significance (at the 10% level) of the exchange-rate exposure using the model shown below. Frequencies are presented for the net-export share exposure δ_{2i}.

$$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \delta_{1i} FXI_t + \delta_{2i} (NE_{it}/V_{it}) \times FXI_t + \epsilon_{it}; \quad t = 1, \ldots, T \tag{17}$$

Period	# Industries	δ_{2i}	% Industries
1978-86	137	15	11%
1987-90	124	19	15%

Use of Net-Export shares: The signs of the Exposure;

This panel provides results for the signs of the net-export share (δ_{2i}) exposure estimated from the model below for the periods (1978-86) and (1987-90). Results include the frequency of positive net-export share exposure and the p-values of the sign test for the hypothesis of equal number of positive and negative exposures. Results are presented separately for the statistically significant coefficients (top row) and for all coefficients (bottom row).

$$R_{it} = \beta_{0i} + \beta_{1i} R_{mt} + \delta_{1i} FXI_t + \delta_{2i} (NE_{it}/V_{it}) \times FXI_t + \epsilon_{it}; \quad t = 1, \ldots, T \tag{18}$$

Period	Ind.	δ_{2i} (+)	% Ind.	p-value (NE/V)
1978-86	Signif.	13/15	87%	0.003
	Total	80/137	58%	0.029
1987-90	Signif.	4/19	21%	0.99
	Total	55/124	44%	0.91