Assessing the Exchange Rate's Impact on U.S. Manufacturing Profits

by Juann Hung

The large and persistent swings of the dollar over the past two decades have generated much discussion about the causes of these movements and their consequences for the U.S. trade balance and U.S. competitiveness. Relatively little effort has been made, however, to assess the effect of exchange rate movements on U.S. manufacturing profits.[1] This article will examine the exchange rate-profits relationship since the introduction of floating rates in 1973, evaluating not only the overall impact of exchange rate changes on aggregate manufacturing profits but also the effects on the profits of exporting and import-competing firms.[2]

Undertaking such a study is important for many reasons. Most obviously, the effects of large and prolonged exchange rate swings on profits will, over time, have significant ramifications for the employment and welfare of manufacturing workers. In addition, fluctuations in manufacturing profits will affect investment and savings, and consequently long-term U.S. economic growth. An increase in profits tends to boost investment by enhancing firms' confidence in potential returns on new investment and by relaxing firms' budget constraints. A rise in corporate profits may increase gross savings through corporate retained earnings, personal savings of dividend income, and government tax revenues.

Of course, exchange rate swings are only one determinant of manufacturing profits at any point in time. Other macroeconomic conditions at home and abroad and factors such as management skills and production efficiency may also affect manufacturing profits, and hence employment and investment. Nevertheless, because exchange rate swings have been so sizable and persistent in the past two decades, their contribution to the evolution of profits in the same period is likely to have been important. Thus, studying the impact of exchange rate swings on profits seems critical to understanding how exchange rates have helped to shape the economy's course.

This article begins by explaining why U.S. manufacturing profits are likely to have a negative correlation with exchange rate movements—that is, why a rise in the dollar is likely to lower profits. The article's second section shows that U.S. manufacturing profits over the past fifteen years do appear to have been negatively correlated with the exchange value of the dollar. The third section introduces an econometric model of manufacturing profits that makes it possible to assess more precisely the quantitative impact of the dollar exchange rate on manufacturing profits. The model focuses on the direct transmission of exchange rate changes to profits through shifts in export and import prices.

Our econometric results show that a sustained appreciation of the dollar does have a significantly negative direct effect on U.S. manufacturing profits in the long

[1]One recent exception is Richard Clarida, "The Real Exchange Rate and U S Manufacturing Profits A Theoretical Framework with Some Empirical Support," Federal Reserve Bank of New York, Research Paper no 9214, 1992

[2]Manufacturing profits here refer to profits of domestic U S manufacturing firms only Exchange rate movements also affect profits of overseas subsidiaries of U S manufacturing firms Consequently, the total impact of exchange rate change on U S. manufacturing profits ought to include the impact on both domestic profits and overseas profits Data problems, however, make it necessary to limit this study to the exchange rate's effect on profits of domestic manufacturing firms

run, affecting exporters' profits more than those of import-competitors. Simulations based on the model further suggest that the rise in the dollar in the first half of the 1980s cut manufacturing profits substantially. Although the return of the dollar in the second half of the decade to its 1980 level reversed the decline in the profit rate due to the earlier rise of the dollar, the cumulative effect of the 1981-86 high dollar still resulted in a substantial manufacturing profit loss of about $230 billion (in 1987 constant dollar terms) for the 1981-90 period as a whole. Even if one assumes away the multiplier effect on the economy, this loss is large; indeed, it is equivalent in size to about 10 percent of total gross manufacturing profits during the 1980s.

To be sure, these quantitative findings capture only the direct impact of exchange rate changes on profits. Because exchange rates may influence other determinants of profits, our estimates are suggestive rather than precise.[3] Nevertheless, the dollar's impact on manufacturing profits in the 1980s is shown to be of such a magnitude that the conclusion appears inevitable: a huge and sustained swing in the dollar exchange rate will have a substantial impact on U.S. manufacturing profits.

The linkage between exchange rates and manufacturing profits

Because manufactured goods dominate both U.S. exports and imports, the profits of U.S. manufacturing firms are more susceptible to exchange rate movements than are other components of U.S. corporate profits.[4] This section briefly describes the mechanism through which changes in the exchange rate are transmitted to profits in the exporting and import-competing sectors. A formal derivation of the linkage between manufacturing profits and the exchange rate—how and to what extent a change in the dollar's value affects exporters' and import competitors' profits—is given in the appendix.

From the perspective of a U.S. exporting firm, an appreciation in the dollar is always bad news, whether or not the dollar appreciation results in an increase in (foreign currency) export prices. To be sure, an exporting firm that has market power abroad can try to minimize its profit loss by choosing the extent to which the (foreign currency) export price of its goods adjusts to a dollar appreciation.[5] Nevertheless, a firm's "pricing to market" strategies can only mitigate, but not eliminate, the negative impact of a dollar appreciation.

The firm may choose a strategy of "complete pass-through" and raise the foreign currency price of its exports to the full extent of the dollar's appreciation. In this case, the firm leaves the unit dollar profit of its exports unchanged by holding its dollar export price fixed.[6] The firm's profits are still likely to fall with this strategy, however, because its goods become less price competitive relative to foreign goods and hence its export volume drops.

Alternatively, the firm may choose a strategy of "zero pass-through" and keep the foreign currency price of its exports unchanged, allowing the dollar price of its exports to fall to the same extent that the dollar has appreciated. With this strategy, the firm seeks to prevent its export volume from declining, thereby preserving its market share. In this case, both the firm's export volumes and its profits measured in foreign currency terms are unchanged; however, these foreign currency profits will translate into fewer dollars. In other words, the firm's profits measured in dollar terms will fall because of a dollar translation effect.

In general, the exchange rate pass-through is likely to be incomplete but more than zero, so that an appreciation of the dollar hurts export profits both by lowering the volume of exports and by translating (foreign currency) profits into fewer dollars. There is, in fact, a trade-off between the price/volume effect and the translation effect: as the exchange rate pass-through to U.S. export prices (that is, the increase in the foreign currency price of U.S. exports in response to a dollar appreciation) becomes larger, a given appreciation of the dollar hurts export profits more through a loss in the volume of sales but less through a dollar translation effect.

An appreciation of the dollar also tends to be bad news for U.S. import-competing firms, but good news for foreign exporters. Let's first discuss the effects on foreign firms by supposing that the yen depreciates against the dollar but the production costs (in yen terms) of Japanese goods are not affected.[7] A Japa-

[3]A change in the exchange rate may indirectly affect profits through its impact on GNP and other variables

[4]For example, manufactured goods constituted 76 percent of total U S exports and 79 percent of total U S imports in 1990

[5]See Richard Marston, "Pricing to Market in Japanese Manufacturing," *Journal of International Economics*, vol 29 (1990), Alberto Giovannini, "Exchange Rates and Traded Goods Prices," *Journal of International Economics*, vol 24 (1985); Paul Krugman, "Pricing to Market When the Exchange Rate Changes," in S W Arndt and J D Richardson, *Real-Financial Linkages Among Open Economies* (Cambridge, Mass MIT Press, 1987)

[6]The production costs of U.S. exports tend not to be affected by changes in the dollar exchange rate because petroleum and other major imported commodity inputs are priced in dollars

[7]Because commodities tend to be priced in dollars, exchange rate pass-through to U S import prices may stem not only from foreign firms' pricing-to-market strategies, but also from changes in their

nese exporting firm is going to benefit no matter what it does, although the extent of its benefit will depend on its pricing strategy. The Japanese firm may choose to keep its price competitiveness by leaving the dollar price of its goods unchanged. In this case, its yen profits would rise as yen sales revenue increases relative to yen production costs, even though its sales volume would not change. That is, with a "zero pass-through" strategy, the Japanese firm would benefit from the dollar's appreciation purely as a result of a yen translation effect. Alternatively, the firm might allow the appreciation of the dollar to pass through fully to the dollar price of its goods (that is, it might maintain the yen price of its goods by allowing the dollar price to fall), thereby increasing the price competitiveness of its goods and expanding its market share in the United States. In this case, the firm benefits through increased sales volume owing to its enhanced price competitiveness.

Of course, Japanese firms' production costs are likely to rise as the yen's depreciation (against the dollar) pushes up the cost of their imported raw material. In this case, Japanese firms are not likely to pass through fully the yen's depreciation to the dollar price of their goods (that is, they are not likely to lower the dollar price of their goods to the full extent of the yen depreciation), since such a strategy would entail a decline in the yen profit margin of their goods sold in the United States. Therefore, the exchange rate pass-through to the U.S. import price is likely to be incomplete in general.

The extent of the loss incurred by U.S. import-competing firms because of the dollar's appreciation depends on the extent to which foreign suppliers pass through their currency's depreciation (against the dollar) to U.S. import prices, as well as the sensitivity of demand for U.S. manufactured goods with respect to the ratio of U.S. prices to import prices. If foreign exporters do not lower the dollar price of their products as the dollar appreciates—the case of zero pass-through—U.S. import-competing firms' profit will not be lowered by the dollar's appreciation, since U.S. goods will not become less price competitive relative to foreign goods. Short of zero pass-through, however, U.S. import-competing firms will tend to suffer from a stronger dollar through the erosion in the price competitiveness of U.S. goods. Indeed, as the appendix shows, the greater the extent to which foreign suppliers pass through their currency's depreciation, the greater the loss incurred by U.S. import-competitors for the same degree of appreciation in the dollar.

In sum, the above partial equilibrium analysis suggests that an appreciation of the dollar would hurt U.S. manufacturing profits regardless of the pricing behavior of U.S. and foreign exporters. By the same token, a depreciation of the dollar would increase manufacturing profits. What accounts for these findings is not only that changes in the dollar exchange rate tend to alter the price competitiveness of U.S. manufactured goods at home and abroad, but also that the dollar profit margin of U.S. exports may change through a dollar translation effect.

U.S. manufacturing profits since the mid-1970s

Our discussion suggests that if other macroeconomic variables remain roughly unchanged, we should observe a negative co-movement between U.S. manufacturing profits and the value of the dollar. When examining the relationship between gross manufacturing profits as a share of GDP and the dollar exchange rate over the past fifteen years, however, we find only some weak evidence of this inverse relationship (Chart 1). The dollar appreciated by about 40 percent from 1980 to its peak in early 1985, and then more or less returned to its 1980 level by 1987. Since then, it has remained in a relatively narrow range. Over that period, the ratio of manufacturing profits to GDP declined considerably during the first half of the 1980s from its 1970s level, as the dollar appreciation would have led one to expect, but then hardly recovered by the late 1980s despite the dollar's fall.

When we recall that manufacturing profits are also subject to other influences, however, the weak inverse mapping between profits and the dollar exchange rate displayed in Chart 1 appears less surprising. To obtain a clearer picture of the correspondence between exchange rate changes and manufacturing profits—in aggregate and across industries—over the past fifteen years, let us now turn to a more detailed, although still impressionistic, analysis. Table 1 traces the evolution not only of the gross profit share in GNP, but also of profit margins, export shares of total sales, and import penetration of major manufacturing industries since the mid-1970s.[8] It presents period averages for each of the above indicators during three subperiods marked by huge shifts in the dollar. The value of the dollar against major foreign currencies in the second period (1981-86)

Footnote 7 continued
production costs induced by changes in the dollar exchange rate As a result, the total exchange rate pass-through elasticity for import prices tends to derive from the impact of exchange rate changes both on foreign production costs and on firms' pricing-to-market considerations

[8]Gross profits in Table 1, as in Table 2, refer to profits before depreciation and taxes but after net interest payments The definition of gross profits in these two tables differs from that in Chart 1 and other parts of this article because data for net interest payments are not available at a disaggregate industry level

was on average about 22 percent higher than in the first period (1975-80), and subsequently fell back about 24 percent, on average, between the second and the third (1987-91) periods [9]

The table shows that although the correspondence between the ratio of profits to GNP and the value of the dollar was not clear by the late 1980s, profit margins appeared to be significantly and inversely correlated with the dollar over the past fifteen years [10] The profit margin of the nonpetroleum manufacturing sector as a whole declined by 0.5 percentage point from the first period to the second, and then increased by 1 full percentage point in the third low-dollar period

To identify the factors underlying the seemingly insufficient revival in the ratio of profits to GNP in the late 1980s, it is useful to examine the manufacturing performance on both the exporting and import-competing fronts For the exporting sector, Table 1 shows that the average ratio of exports to sales hardly increased from the first to the second period despite growing world trade, but then increased sharply from the second to the third period Chart 2 gives a clearer picture of this inverse relationship between the value of the dollar and manufacturing export performance. export sales as a share of total sales increased about 0 4 percentage point each year in the first period, declined about 0.5 percentage point annually in the second period, but then increased rapidly—1.1 percentage points each year—in the third period.

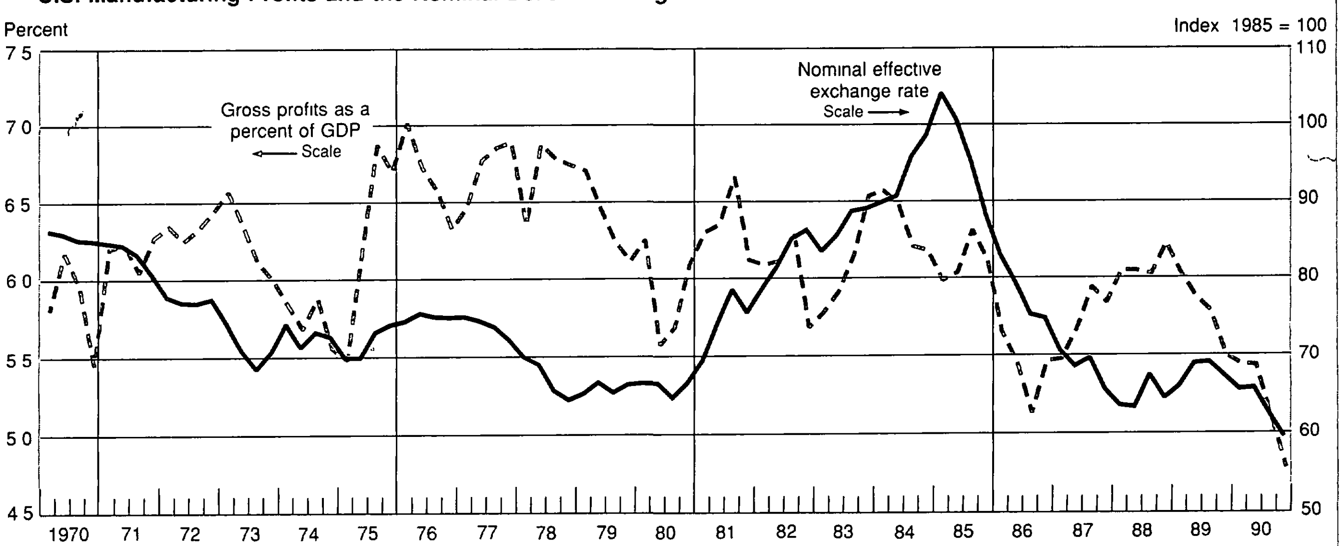
On the domestic market side, the import penetration ratio rose markedly in the period of the sustained dollar appreciation but hardly declined when the dollar depreciated (Table 1) In particular, the import penetration ratio rose from about 9 percent in 1981 to 13 percent in 1986, increasing about 0 8 percentage point annually in the second period. The high ratio of import penetration continued up to 1990, only to decline sharply in 1991 (Chart 2) The persistence of foreigners' inroads into the U S market as the dollar receded from its appreciated level may have been caused by lingering effects from earlier dollar appreciation. But it could also have stemmed from other developments, such as growing competition from newly industrialized and developing countries in the 1980s and an increase in world trade effected by other factors

[9]The occurrence of a recession in each subperiod helps to average out cyclical influences on the ratio of profits to GNP across the three subperiods

[10]As noted earlier, for a given volume of export sales, a dollar appreciation would lower the profit margin of U S exports in dollar terms (that is, the dollar profit per unit of exports) as a result of a dollar translation effect

Chart 1

U.S. Manufacturing Profits and the Nominal Dollar Exchange Rate



Notes Gross profits refer to profits before depreciation, interest payments, and taxes The nominal exchange rate is a trade-weighted average of the dollar relative to the currencies of thirteen industrial countries

The evidence in Table 1 and Chart 2 suggests that the exporting sector has been adversely influenced by exchange rate movements: both the profit margin and the volume of exports appear to have been inversely related to exchange rate changes. The relationship between the import penetration ratio and the exchange rate is not clear, however. The import-competing sector does not seem to have benefited greatly from the sharp depreciation of the dollar in the late 1980s. Indeed, these import developments may be one major factor underlying the apparently weak response of the manufacturing profits–GNP ratio to the dollar's fall during this period.

Table 2 provides further evidence of the adverse effects of the dollar appreciation on manufacturing profits in the first half of the 1980s. It traces changes in the rate of return for major manufacturing industries from the low-dollar 1978-89 period to the high-dollar 1985-86 period. (The years 1978-79 are chosen as the beginning period for this exercise to control for uneven impacts of the 1980 recession on different industries. The dollar exchange rate in 1978-79 was about the same as the 1980 rate.) The question at issue in Table 2 is whether industries that were more vulnerable to international competition showed a greater decline in the rate of return between these two periods.

The data indicate that the appreciation of the dollar between the 1978-79 and 1985-86 periods was accompanied by a decline in the real rate of return in most manufacturing industries. Moreover, the index of "loss in market share," calculated as the average of the increase in import penetration and the decrease in the ratio of exports to sales, shows that all U.S. manufacturing industries' market shares declined during this period of dollar appreciation. Aside from the primary metals industry, all listed industries experienced a distinct deterioration in their ratios of export sales to total sales while facing greater foreign competition in their respective domestic markets in 1985-86 relative to 1978-79. Overall, the table suggests that the decline in an industry's profit rate was positively, albeit roughly, correlated with the erosion of that industry's international competitiveness as measured by the loss in market share index. Industries that incurred higher market share loss tended

Table 1

Performance of Major U.S. Manufacturing Industries since the Mid-1970s

Percent, Subperiod Average

	Subperiods	Primary Metals	Fabricated Metals	Machinery & Equipment	Electric Equipment	Motor Vehicles	Food Products	Chemical Products	Other (Nonpetroleum)	Total Nonpetroleum Manufacturing
Ratio of gross profit to GNP†										
	75-80	0.3	0.3	0.6	0.4	0.4	0.5	0.6	1.5	4.7
	81-86	0.1	0.2	0.4	0.4	0.4	0.5	0.5	1.4	3.9
	87-91	0.2	0.2	0.4	0.4	0.4	0.5	0.6	1.4	4.0
Profit margin‡										
	75-80	6.3	6.9	9.3	10.2	8.4	5.3	10.1	7.1	7.6
	81-86	3.8	6.8	7.2	8.8	8.7	5.6	9.2	7.0	7.1
	87-91	5.9	7.6	7.8	11.1	9.0	6.9	11.6	7.3	8.1
Ratio of exports to sales										
	75-80	5.0	5.4	18.9	12.8	10.6	4.0	10.3	6.7	8.3
	81-86	5.2	5.5	18.7	11.9	9.5	3.7	11.1	6.8	8.4
	87-91	8.5	6.0	22.6	17.0	11.9	4.1	12.8	9.0	10.6
Import penetration§										
	75-80	10.2	3.5	7.5	12.7	16.4	3.7	4.1	6.6	7.3
	81-86	15.3	4.9	12.8	18.4	23.5	3.8	5.6	8.6	10.4
	87-91	15.2	6.9	21.9	25.5	28.5	4.1	7.8	10.7	13.5

Memo

	1975-80	1981-86	1987-91
The nominal dollar effective exchange rate (Index 1985=100)	72.06	88.08	67.42

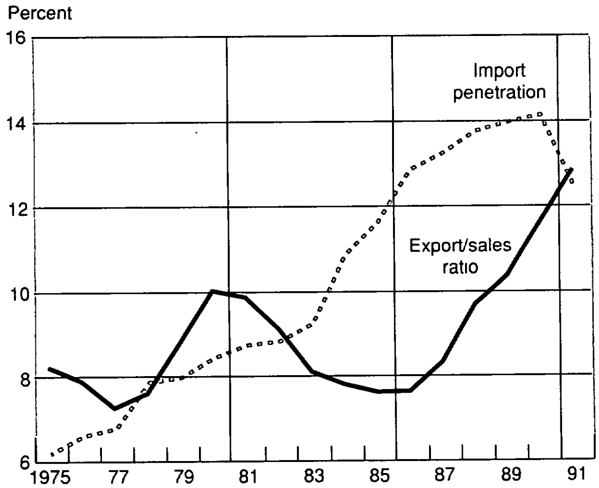
†Gross profits in this table are profits before taxes and depreciation, but after interest payments
‡The profit margin is calculated as the ratio of gross profits to total sales
§Import penetration is calculated as imports/[total sales + imports − exports]

to show greater erosion in their rates of return.[11]

[11]The notable anomalies are the auto and food industries The surprisingly good performance of the auto industry is largely due to the choice of the 1978-79 period as the base period for our comparison The auto industry's profit in 1979 was substantially lower than its normal profit because of the 1978-89 oil crisis

Chart 2

U.S. Manufacturing Sector's International Competitiveness



Note: Manufacturing sector excludes the petroleum industry.

The impressionistic evidence presented in Tables 1 and 2 and Charts 1 and 2 appears to support the theoretical claim that U.S. manufacturing profits are inversely correlated with the exchange value of the dollar. Nonetheless, because factors such as business cycles here and abroad may have simultaneous but different influences on exchange rates and profits, the correspondence between manufacturing profits and the exchange rate is not strong. The analysis in the next section will provide a more complete and quantitative understanding of the relationship between manufacturing profits and the exchange rate in a framework that controls for the impact of other factors.

The long-run impact of the exchange rate on U.S. manufacturing profits—an econometric analysis

This section uses an empirical model to assess the long-run impact of the dollar exchange rate on U.S. gross manufacturing profits.[12] The formal derivation of the model and estimation methodologies are described in the appendix. Here an intuitive explanation of the model is given, and the estimation results are analyzed.

A brief description of the model

The behavior of manufacturing profits in an open economy is best understood by regarding total profits as the sum of two components: profits on domestic sales and

[12]Gross profits refer to profits before depreciation, interest payments, and taxes

Table 2

Profitability Changes of Major U.S. Manufacturing Industries between 1978-79 and 1985-86

Percentage Changes

Industry	Change in Real Rate of Return†	Index of Loss in Market Share‡	Increase in Import Penetration	Decrease in Ratio of Exports to Sales
Nonpetroleum manufacturing	−2.1	2.4	4.3	0 6
Electric	−10.6	5.5	8.0	3.0
Motor vehicles	2 2	5.3	9 9	0.7
Machinery	−17 0	4.3	8.1	0 5
Primary metals	−6.3	3 3	6.1	0.4
Fabricated metals	−2.0	1 1	1.8	0.5
Chemicals	−0 7	1.0	2.1	−0.1
Food	3.1	0.6	0.1	1.1
Other	1.3	1.5	2.8	0.3

†Real rate of return is calculated as the ratio of gross profit to capital stock. Change in rate of return is the difference between the average rate of return in 1978-79 and that in 1985-86. Gross profits in this table are profits before taxes and depreciation, but after interest payments.

‡Index of loss in market share is calculated as 1/2 [increase in import penetration + decrease in exports/sales ratio]. Import penetration is calculated as imports/[total sales + imports − exports].

profits on export sales. Domestic profits are affected by the exchange rate through a price/volume effect on the import-competing sector's profits: the greater the extent to which exchange rate changes are passed through to import prices, the greater the effect of exchange rate changes on the volume of, and profits from, import-competing sales. Export profits are affected by the exchange rate through some combination of a price/volume effect and a dollar translation effect, depending on the degree to which exchange rate changes are passed through to export prices.

Our model is built to capture the two channels through which exchange rate changes affect profits: the price/volume effect (on both the import-competing and the exporting sectors), and the dollar translation effect (on the exporting sector).[13] Correspondingly, the key equation in this model relates changes in manufacturing profits to changes in three exchange-rate-related prices: the ratio of (foreign currency) U.S. export prices to foreign prices (to capture the price/volume effect in the exporting sector), the ratio of import prices to U.S. domestic prices (to capture the price/volume effect in the import-competing sector), and the dollar price of exports (to capture the dollar translation effect in the exporting sector). Other factors affecting profits such as U.S. and foreign activities and unit variable costs are also included in this profit equation.

In addition, the model has two subsidiary equations that estimate the exchange rate pass-through to U.S. export and import prices. The exchange rate pass-through coefficients estimated by these two equations are necessary inputs into our key profit equation, allowing us to trace the long-run effect of a change in the dollar exchange rate through changes in export and import prices and ultimately to changes in manufacturing profits.

Our model of long-run U.S. manufacturing profits thus comprises three long-run equilibrium equations. Details of the three equations and their estimations are reported in Box 1. Here a brief discussion is provided of the estimation results for the main variables and the overall effects of exchange rate changes on manufacturing profits.

Estimation results

Estimation results for the export price equation show that when production costs and foreign prices are held constant, a 1 percent appreciation of the dollar would result in a 0.19 percent decline in dollar export prices.[14] In other words, as the dollar appreciates by 1 percent, unit export price measured in foreign currency terms would increase by about 0.81 percent, thereby resulting in a mere 0.19 percent decrease in dollar export prices.[15]

Estimation results for the import price equation show that when foreign production costs and U.S. goods prices are held constant, a 1 percent appreciation of the dollar would result in a 0.47 percent decrease in U.S. import prices. This finding indicates that foreign suppliers, compared with U.S. exporters, tend to absorb more of the exchange rate shocks by adjusting their profit margins than by passing through exchange rate changes to the dollar price of their goods. Overall, the results on exchange rate pass-through to both export prices and import prices are consistent with other researchers' findings.[16]

Turning to the manufacturing profits equation, let's first note that the coefficients on U.S. and foreign activities are reassuringly reasonable. The coefficient on foreign activity weighted by the share of exports in total sales is estimated to be 3. (This weighting is necessary because foreign activity only affects the export component of total U.S. profits.) This finding means that a 1 percent increase in foreign activity would raise real *total* manufacturing profits by 3 percent times the share of exports in total sales. The share of exports in total sales averaged about 0.09 during the floating rate period (Chart 3). The coefficient on the foreign activity variable thus suggests that a permanent 1 percent increase in growth abroad is estimated to increase U.S. manufacturing profits by about 0.27 percent (that is, 3 percent times 0.09).

By the same token, a sustained 1 percent growth in the U.S. economy is estimated to increase manufacturing profits by 1 percent. That is, it would raise total

[13]Corporate hedging strategies for dealing with exchange rate movements—strategies such as entering into forward contracts or swap arrangements to offset the short-run effect of dollar fluctuations—are not considered in our model, since these strategies have the effect of smoothing cash flows as opposed to shaping long-run corporate performances

[14]A coefficient estimate in regression analysis using data in log terms can be interpreted as a percent change in a dependent variable in response to a 1 percent change in the independent variable associated with that coefficient

[15]The data indicate a very slight break in this relationship after the mid-1980s The export price pass-through coefficient has declined from 0 81 percent to 0 80 percent since the third quarter of 1985

[16]See Catherine Mann, "Prices, Profit Margins and Exchange Rates," *Federal Reserve Bulletin*, 1986, Peter Hooper and Catherine Mann, "Exchange Rate Pass-Through in the 1980s. The Case of U S Imports of Manufactures," *Brookings Papers on Economic Activity*, 1989 1, Ohino Kenichi, "Export Pricing Behavior of Manufacturing A U S -Japan Comparison," *International Monetary Fund Staff Papers*, vol 36 (September 1989), and Michael Knetter, "Price Discrimination by U S and German Exporters," *American Economic Review*, vol 79 (March 1989)

Box 1: An Open-Economy Model of U.S. Manufacturing Profits in the Long Run

Our model of long-run U.S. manufacturing profits comprises three long-run equilibrium, or so-called cointegrating, regression equations (Exhibit 1).† In all three equations, variables are entered in natural log terms. The nominal exchange rate (S) is defined as the dollar price of foreign currency, so that an increase in the exchange rate means a depreciation in the dollar. Because the derivation of the profit equation is more involved than that of the export and import price equations, let's briefly consider the two price equations before we turn to the profit equation.

The export price equation (equation 2) shows that in the long run, U.S. export prices measured in dollar terms (SP^x) are positively related to unit labor costs in the United States (U), the price level abroad (P^*), and the nominal dollar exchange rate (S). This equation is derived from the notion that dollar export prices are determined by a markup over unit variable costs (here measured as unit labor costs). As noted in the text, export markups (or profit margins) are affected by the dollar exchange rate to the extent that changes in the rate are not passed through to export prices. In addition, export markups adjust to prices of competing goods in the foreign market (P^*). One final term in the export price equation, DVS, is a slope dummy variable that tests whether the relationship between export prices and the exchange rate has changed significantly as a result of the sharp appreciation of the dollar in the early 1980s.

By the same token, the import price equation (equation 3) shows that in the long run, U.S. import prices measured in dollar terms (P^m) are positively related to unit variable costs abroad (U^*), prices of U.S. manufactured goods (P^h), and the dollar exchange rate (S). This equation is derived from the notion that dollar import prices are equal to the product of the dollar exchange rate and foreign currency import prices and that foreign currency import prices are in turn determined by a markup over unit variable costs of imports. Import markups are affected by the dollar exchange rate to the extent that changes in the exchange rate are not passed through. In addition, import markups respond to prices of U.S. goods that compete with foreign goods in the U.S. market.‡

Equations 2 and 3 together allow us to estimate the response of export prices and import prices to a change in the dollar exchange rate. To complete the assessment of the impact of a change in the dollar exchange rate on profits, we still need to estimate the impact of a change in export prices or import prices on manufacturing profits. To that end, let us now turn to the principal equation—the equilibrium profit equation.

The profit equation (equation 1) is built on the idea that profits are the difference between revenue and costs. Revenue increases either when sales volume increases at a given profit margin or when profit margins increase for a given sales volume. Our regression variables are devised to capture these effects. On the export volume side, an increase in foreign activity (Y^*) or a decrease in the ratio of (foreign currency) export price to foreign price (P^x/P^*) would increase export revenue by increasing the volume of export sales. Exporting revenues are also positively related to the (real) dollar export price (SP^x/P): an increase in the dollar price of exports would increase export profit margins in dollar terms for a given export volume, thereby raising export revenues purely through a dollar translation effect.§

On the import-competing side, an increase in U.S. activity (Y) or in the ratio of import prices to U.S. prices (P^m/P^h) would increase domestic revenue by raising the volume of domestic sales. Finally, as to costs, an increase in real unit variable costs (U/P) would reduce the total profits by increasing total variable cost for any given volume of sales. This cost variable is the last term of the regression.

Because the profit equation explains total manufacturing profits rather than export profits and domestic sales profits separately, however, scaling adjustments must be made to the above variables in the regression. Thus, the variables affecting export volume are scaled by the export share in total sales, and the variables affecting domestic sales volumes are scaled by the share of domestic sales in total sales. More specifically, the factors affecting export volume—the foreign activity variable

†In a cointegrating regression equation, the nonstationary dependent variable and nonstationary independent variables drift together over time, so that the unexplained "residuals" of the regression equation are stationary over time. The projected value of the equation's dependent variable represents its long-run equilibrium value given the underlying values of independent variables. The residuals of the regression represent the deviation of the actual value from the long-run equilibrium value of the dependent variable

‡A slope dummy term was initially included in the import price equation to test whether the relationship between import prices and the exchange rate changed in the second half of the 1980s This slope dummy term turned out to be insignificant and was dropped from the equation.

§In the zero pass-through case, a 1 percent dollar depreciation (1 percent increase in S) would leave P^x and export volume unchanged while raising the dollar export price (SP^x/P) by 1 percent. Consequently, if other variables are held constant, the percent change in manufacturing profits due to a 1 percent increase in the dollar export price—the coefficient on $\ln(P^x_t S_t/P_t)$ in the regression—would be equal to the pure translation effect

Box 1: An Open-Economy Model of U.S. Manufacturing Profits in the Long Run *(Continued)*

and the ratio of (foreign currency) export price to foreign price—are scaled by the share of exports in total manufacturing sales (X) The factors affecting domestic sales volume—U.S activity and the ratio of import price to U S goods price—are scaled by the share of domestic sales in total manufacturing sales (1-X)

The (real) dollar export price (SP^x/P) is not scaled by export share in total sales, however, since it affects total profits through a translation effect rather than a price/volume effect The dollar export price is instead scaled by the ratio of export revenue to total manufacturing profits (SP^xX/Π). For a given export volume, a 1 percent increase in the (real) dollar export price would increase real export revenues by exactly 1 percent Therefore, if the unit variable cost of production is unchanged, this 1 percent rise in the dollar export price would increase total manufacturing profits by 1 percent times the contribution that export revenues make to total profits (that is, by [SP^xX/Π] percent) According to this theoretical relationship, a 1 percent increase in the dollar export price (SP^x/P) for a given export volume would increase total profits by (SP^xX/Π) percent exactly To test whether the data support this theoretical correlation, the coefficient on (SP^xX/Π)ln(SP^x/P) is restricted to be one in the regression.

Overall, our model appears to fit the data quite well The high R^2's for all three equations suggest that most of the variations in the dependent variables are explained by the independent variables included in each equation The augmented Dickey-Fuller statistics for the three equations further suggest that each equation is reasonably cointegrated The coefficient estimates and their implications are discussed in the text

Exhibit 1: Long-Run Equations for an Open-Economy Model of U.S. Manufacturing Profits
(Sample period 1973-III to 1990-IV, t-statistics in parentheses)

(1) The long-run manufacturing profits equation

$$\ln(\Pi/P)_t = \underset{(-5\ 32)}{-8\ 41} + \underset{(\dagger)}{1}\,(SP^xX/\Pi)_t \ln(SP^x/P)_t + \underset{(3.67)}{3\ 0}\,X_t \ln(Y^*)_t$$
$$\quad \underset{(-2.11)}{-2\ 22}\,X_t \ln(P^x/P^*)_t + \underset{(6\ 06)}{1\ 14}\,(1-X)_t \ln(Y)_t$$
$$\quad + \underset{(2\ 46)}{0\ 57}\,(1-X)_t \ln(P^m/P^h)_t - \underset{(-3\ 53)}{1\ 42}\,\ln(U/P)_t$$
$$\quad + \mu^1_t$$

Adjusted R^2 = 0 93 ADF statistic = −4 57

† the null hypothesis that this coefficient equals one cannot be rejected (t-statistic = 0 2)

(2) The long-run export price equation

$$\ln(SP^x)_t = \underset{(11\ 39)}{1\ 90} + \underset{(4\ 97)}{0\ 19}\,\ln(S) + \underset{(2\ 27)}{0\ 01}\,DVS_t + \underset{(2.61)}{0\ 22}\,\ln(U)_t$$
$$\quad + \underset{(6\ 91)}{0\ 57}\,\ln(P^*)_t + \mu^2_t$$

Adjusted R^2 = 0.99 ADF statistic = −3 93

(3) The long-run import price equation

$$\ln(P^m)_t = \underset{(14\ 91)}{1\ 90} + \underset{(14\ 76)}{0\ 47}\,\ln(S)_t + \underset{(9\ 99)}{0\ 39}\,\ln(U^*)_t$$
$$\quad + \underset{(12\ 08)}{0\ 48}\,\ln(P^h)_t + \mu^3_t$$

Adjusted R^2 = 0 99 ADF statistic = −4 25

Variables

- Π = gross nominal profits of domestic U S manufacturing firms in dollar terms
- P = U S wholesale price level, 1987=100
- P^h = U S manufactured goods price, excluding food and energy
- P^* = foreign price level
- P^m = U S import price in dollar terms
- P^x = U S export price in foreign currency terms
- Y = real U S. domestic demand
- Y^* = real foreign domestic demand
- U = unit labor cost in the U S manufacturing sector
- U^* = unit variable cost of foreign goods (in foreign currency) a weighted average of unit labor cost, world commodity price, and oil price
- S = the nominal exchange rate (dollar/foreign currency)
- DVS = slope dummy for ln(S_t) for 1985-III to 1990-IV
- X = the share of exports in total sales
- $1-X$ = the share of domestic sales in total sales
- μ^i = residual for equation i

manufacturing profits by the estimated coefficient (1 14) times the share of domestic sales in total sales, which averaged about 0 91 during the floating rate period [17]

Coefficient estimates on the three price variables of concern also appear plausible. The coefficient on the ratio of (foreign currency) export price to foreign price weighted by the export share in total sales is -2 22 This finding suggests that, on average, a 1 percent increase in the ratio of export prices to foreign prices would lower manufacturing profits about 0 21 percent (-2.22 times 0.09, the average share of exports in total sales during the floating rate period) through the price/volume effect in the exporting sector

Similarly, the coefficient on the ratio of import price to U S price weighted by the share of domestic sales in total sales is 0 57 This estimation suggests that a 1 percent increase in the ratio of import price to U S goods price on average would increase manufacturing profits about 0 53 percent (0 57 times 0 91, the average share of domestic sales in total sales during the floating rate period) through the price/volume effect in the import-competing sector

The coefficient on the (real) dollar export price weighted by the ratio of export revenue to total profit is 1, suggesting that a 1 percent increase in real dollar export prices would raise total real manufacturing profits by 1 percent times the ratio of export revenue to total profits [18] Because the ratio of export revenue to total profit averaged about 0 84 during the floating rate period (Chart 4), this finding suggests that a 1 percent increase in the real dollar export price would raise manufacturing profits by about 0 84 percent through the dollar translation effect All these coefficient estimates appear plausible

We can now combine these three equations to understand the magnitude and distribution of the long-run effect of a dollar appreciation on manufacturing profits Let's start by gauging the effect of a 10 percent dollar appreciation on total profits through the exporting sector The export price equation suggests that a 10 percent appreciation of the dollar would result in about an 8 percent increase in foreign currency export prices and hence an 8 percent increase in the ratio of foreign currency export price to foreign price (for a given foreign price level) The profit equation tells us that an 8

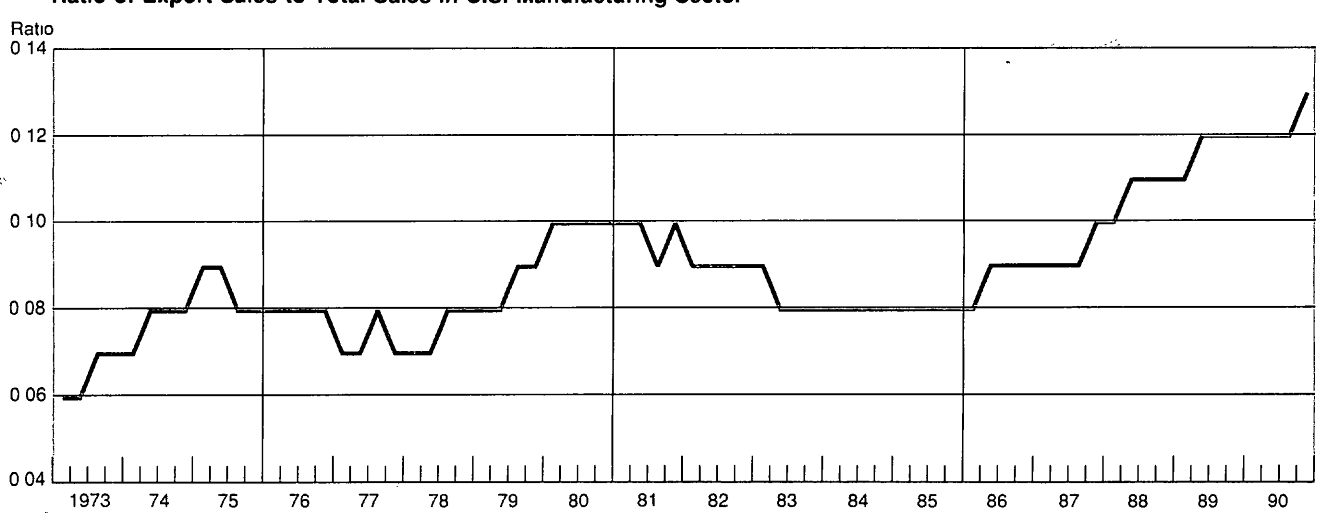
[17]It is interesting to note that the influence of foreign economies on manufacturing profits appears to be growing gradually more important export sales as a share of total sales have been increasing slightly over the past two decades as the U S economy has become increasingly open

[18]For a given export volume, a 1 percent increase in the (real) dollar export price would increase real export revenues by exactly 1 percent Therefore, a 1 percent increase in the dollar export price (SP^x/P) for a given export volume would increase total profits exactly 1 percent times the ratio of export revenues to total profits To test whether or not this theoretical relationship is consistent with the data the coefficient on the dollar export price weighted by the ratio of export revenue to total profits, $(SP^xX/\Pi)\ln(SP^x/P)$ was restricted to be one (see Box 1 for details)

The t-statistic, estimated on the basis of the null hypothesis that the coefficient is one, is extremely low (0 2) suggesting that the null hypothesis cannot be rejected

Chart 3

Ratio of Export Sales to Total Sales in U.S. Manufacturing Sector



percent increase in the ratio of foreign currency export price to foreign price would lower profits by about 1 7 percent (that is, 0 21 times 8 percent) through its price/volume effect on export sales Similarly, the export price equation suggests that a 10 percent appreciation of the dollar results in about a 2 percent decline in dollar export prices From the profit equation, we also know that a 2 percent decline in dollar export prices would lower manufacturing profits by about 1 7 percent (that is, 2 times 0 84 percent) through a dollar translation effect Overall, a 10 percent dollar appreciation would lower manufacturing profits about 3 4 percent through the exporting sector, half through a price/volume effect and half through a dollar translation effect

With coefficient estimates for the profit equation and the import price equation, we can also calculate the impact of a dollar appreciation on manufacturing profits through a price/volume effect on the import-competing sector The import price equation indicates that a 10 percent dollar appreciation would result in a 4 7 percent decline in U.S import price, and hence a 4 7 percent decrease in the ratio of import price to U S price for a given U.S price level From the profit equation, we also know that a 4 7 percent decline in the ratio of import price to U S. price would tend to lower manufacturing profits by about 2 5 percent (that is, 0 53 percent times 4 7) through a price/volume effect on the import-competing sector An appreciation of the dollar thus appears to have hurt the import-competing sector substantially, although not quite as much as it hurt the exporting sector[19]

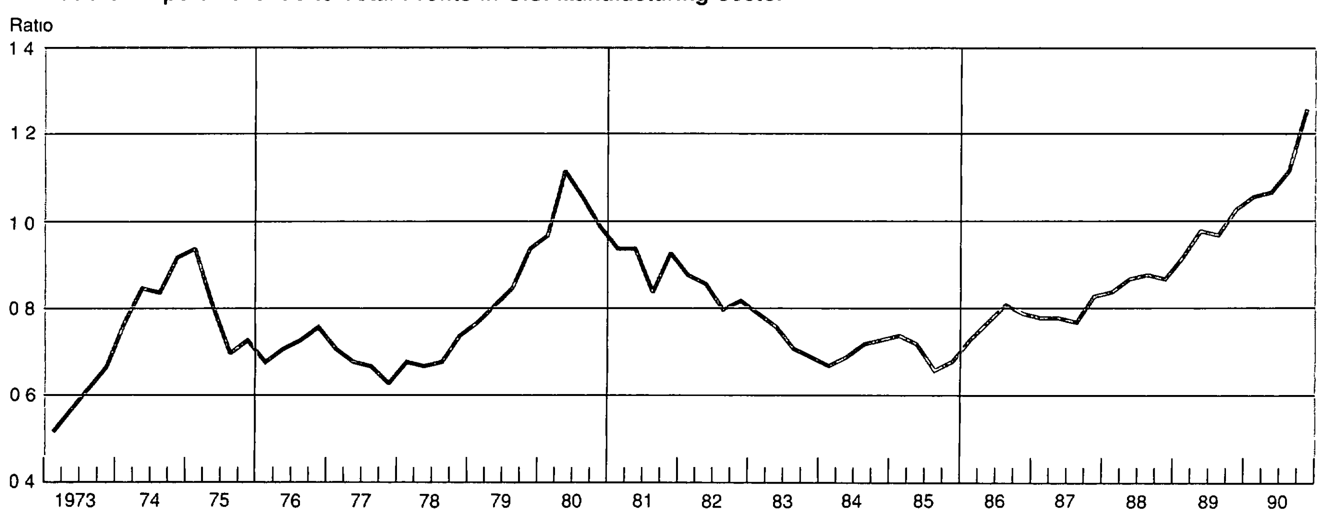
In aggregate, we find that a 10 percent sustained appreciation in the dollar would eventually result in about a 6 percent decline in gross U S manufacturing profits Applying this estimate to the actual amount of real gross manufacturing profits during the 1981-90 period, which averaged about $245 billion (in constant 1987 dollars) per year, we see that a sustained 10 percent dollar appreciation would lower manufacturing profits by roughly $14 5 billion per year On the basis of this estimate, we can roughly assess the long-run impact of the dollar's swings in the 1980s on manufacturing profits If we use 1980 as the base year, as many analysts do, then the average real dollar in the 1981-90 period was about 13 2 percent higher than the real dollar's base-year level. Our model suggests that the manufacturing profit loss caused by a 13.2 percent real dollar appreciation sustained over a ten-year period amounts to about $190 billion (that is, $1 45 billion times 13 2 percent times 10) in the long run

Two qualifications should be added to this summary of our findings. First, the estimated long-run impact of a

[19]Exchange rate changes have a substantial impact on domestic manufacturing profits mainly because the U S manufacturing sector relies more heavily on the domestic market than on the foreign market Domestic sales constitute about 88 percent, while exports constitute about 12 percent, of total U S manufacturing shipments during the floating exchange rate period

Chart 4

Ratio of Export Revenue to Total Profits in U.S. Manufacturing Sector



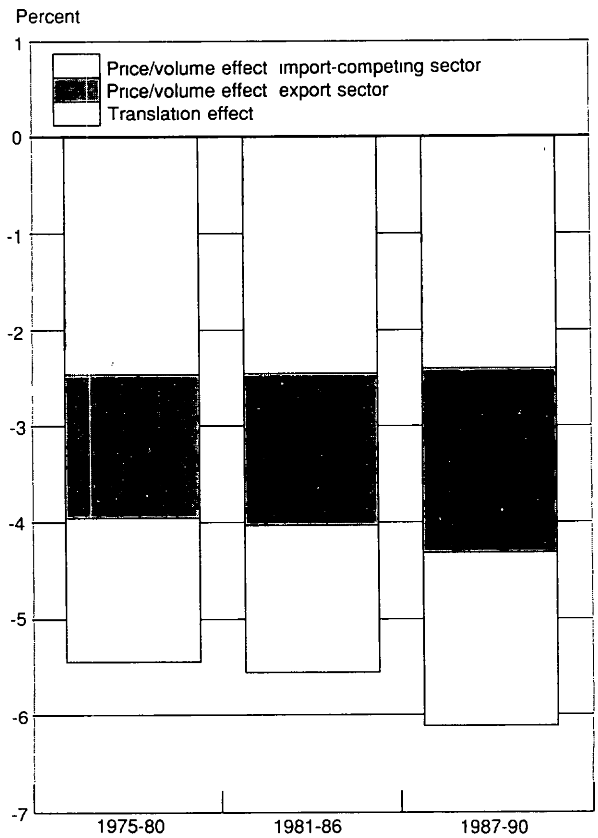
dollar appreciation on profits would depend on the size of the two changing ratios—the ratio of export sales to total sales and the ratio of export revenue to total profits—in any given period Chart 5 shows that as the export sector became more important in the 1980s, the impact of exchange rate changes on manufacturing profits through the exporting sector gradually increased

Second, the above estimates alone do not tell us the length of time it takes for the long-run effect of exchange rate changes on profits to be fully realized To obtain a more precise estimate of the evolution of the high dollar's impact on manufacturing profits in the 1980s, we need to extend the above model to include short-run dynamic relations between the exchange rate and profits

Chart 5

Estimated Percent Change in Gross U.S. Manufacturing Profits Due to Ten Percent Dollar Appreciation

Period Averages



The impact of the dollar's swings in the 1980s on manufacturing profits in the short run and the long run

This section conducts simulations to assess how profit losses of U S manufacturing firms have evolved in response to the sharp swings of the dollar in the 1980s The analysis requires two steps In the first step, our model is expanded to include both the short-run effect of exchange rate changes on profits and the long-run impact of exchange rate changes on the two adjustment ratios—the ratio of export sales to total sales and the ratio of export revenue to total profits The estimations and results of these five equations are discussed in Box 2 The second step entails using the expanded model to project the path that manufacturing profits would have taken if the real dollar exchange rate had stayed at its 1980 level throughout the 1980s These hypothetical "equilibrium" profits are compared with our baseline profits to project the path of manufacturing profit losses attributable to the dollar's movements in the 1980s

The base year chosen is 1980, in part because many analysts believe that the dollar was roughly at its equilibrium purchasing power parity level that year Purchasing power parity holds when a dollar can buy roughly the same amount of goods abroad as it can in the United States That is, the prices of goods at home and abroad, if translated into a common currency, are about the same

Of course, the dollar moved sharply during the 1980s From 1980, the real dollar rose about 40 percent to reach its peak in the first half of 1985, then started to fall sharply until it was more or less restored to its 1980 level in 1987 On average, the real dollar was 25 percent above its 1980 level during the 1981-86 period and was slightly below its 1980 level (by about 1 percent) during the 1987-90 period (Chart 6)

Hypothetical nominal exchange rates, computed on the assumption that the real exchange rate had stayed at its 1980 level, are plugged into our expanded model to project the hypothetical profits that would have resulted from a stable real dollar during the 1980s Baseline profits are obtained by fitting actual exchange rates in the 1980s to our model Finally, the hypothetical profits are compared with the baseline profits to assess the impact of exchange rate developments on manufacturing profits over the past decade

Simulation results are summarized in Table 3 and Chart 6 Chart 6 shows that the dollar's rise in the first half of the 1980s did result in a large and lingering profit loss in the manufacturing sector. Because of the complicated dynamics involved, however, the time profile of the profit loss did not exactly mirror the evolution of the dollar's rise and fall Although the dollar translation effect was felt almost immediately, the price/volume

Box 2: Expanding the Open-Economy Model of U.S. Manufacturing Profits

This box expands our model by estimating the short-run dynamic counterpart of the three long-run equilibrium equations, as well as two auxiliary regressions The short-run equations are necessary since the three long-run equations alone will not allow us to estimate the time profile of the impact of exchange rate changes on manufacturing profits The two auxiliary regressions are included to ensure that the simulation results incorporate the effect of exchange rate changes on profits through their effect on the two adjustment factors

Exhibit 2 presents the estimation results of these five new equations Equation 4 shows the error correction model of manufacturing profits † Equations 5 and 6 show the error correction model of U S export prices and import prices, respectively Overall, the three equations fit the data reasonably well the R^2's are reasonably high for these types of regression Together, these three equations provide insights into the short-run dynamic effect of the exchange rate on manufacturing profits

Equation 4 suggests that the rate of change in real manufacturing profits, $\Delta \ln(\Pi/P)_t$, is driven not only by the deviation of actual from long-run equilibrium real profits in the past period ($\mu^1_t - 1$), but also by lagged U S economic growth and lagged changes in the ratio of import price to U S goods price, the ratio of export price to foreign price, the domestic real interest rate, and manufacturing capital stock ‡ The coefficient estimate on μ^1_{t-1} implies that on average about 22 percent of the deviation of profits from their long-run equilibrium level is eliminated each quarter Lagged changes in the dollar export price—$\Delta \ln(SP^x)_{t-1}$—do not appear significant in the regression, suggesting that changes in the exchange rate affect manufacturing profits faster through the translation effect than through the price/volume effect. Equation 4 also indicates that the price/volume effect of exchange rate movements on import competitors' profits takes longer to be fully realized than that on exporters' profits: changes in the ratio of import price to U S price have a lagged effect on profits that lasts at least five quarters, while most lagged effects of changes in the ratio of export price to foreign price are realized after three quarters

Equation 5 is based on the idea that the rate of change in dollar export prices—$\Delta \ln(SP^x)_t$—is driven not only by the deviation of the actual from the long-run equilibrium dollar export price in the past period (μ^2_{t-1}), but also by changes in lagged dollar export prices and in lagged domestic and foreign prices The coefficient estimate on μ^2_{t-1} suggests that on average only about 16 percent of the deviation of the dollar export price from its long-run equilibrium level is eliminated each quarter Most of the lengthy adjustment time, however, is required for export prices to respond to factors other than the exchange rate The high coefficient estimate on lagged dollar export prices—$\Delta \ln(SP^x)_{t-1}$—implies that the bulk of exchange rate pass-through is actually achieved rapidly following changes in the exchange rate

Similarly, equation 6 tells us that the rate of change in import prices—$\Delta \ln(P^m)_t$—is driven not only by the deviation of the actual from the long-run equilibrium import price in the past period (μ^3_t-1), but also by lagged changes in the exchange rate, import prices, U.S manufacturing goods prices and unit variable costs abroad About 44 percent of the dollar import price's deviation from its long-run equilibrium level is eliminated each quarter Changes in the exchange rate—$\Delta \ln(S)$—have an impact on import price even after four-quarter lags, suggesting that it takes at least five quarters to achieve the bulk of the long-run exchange rate pass-through to import prices

This discussion points to two conclusions First, the exchange rate's long-run translation effect on profits is achieved more quickly than its long-run price/volume effect. Second, the long-run price/volume effect on exporters' profits is realized more rapidly than that on import competitors' profits

Now let's briefly discuss the two auxiliary long-run equations linking the exchange rate and the two adjustment factors in the profit equation. Equation 7 shows that the ratio of export revenue to total profits is positively, but only slightly, affected by a dollar depreciation Equation 8 indicates that the ratio of export sales to total sales is not significantly affected by changes in the dollar exchange rate in the long run This finding is plausible because a 1 percent appreciation of the dollar would eventually lower domestic sales almost as much as export sales The regression results of the two auxiliary equations suggest that exchange rate changes in the long run have only a trivial effect on the two adjustment factors For the sake of completeness, however, these two equations are included in the model simulation.

†An error correction model of a stochastic variable X characterizes the short-run dynamic adjustment process of X around its long-run equilibrium level Typically, the first difference of X, ΔX_t, is regressed on the equilibrium error (that is, the deviation between the actual X and the long-run equilibrium X) in the past period, and on lagged changes in ΔX and in independent variables A parsimonious representation is usually achieved by eliminating most insignificant lag terms The coefficient estimate on the equilibrium error in an error correction model reflects the average speed of adjusting to the equilibrium level See the appendix for details

‡Variables affecting the short-run movements of profits but not included in the long-run profit equation should also be included in the error correction model The model thus includes capital expenditure, inflation, and changes in the real interest rate

Box 2: Expanding the Open-Economy Model of U.S. Manufacturing Profits *(Continued)*

Exhibit 2: Short-Run Adjustments and Auxiliary Equations for an Open-Economy Model of U.S. Manufacturing Profits (Sample period: 1973-III to 1990-IV)

(4) The short-run dynamics of manufacturing profits

$$\begin{aligned}\Delta\ln(\Pi/P)_t = {} & -0.22\ \mu^1_{t-1} - 0.03\ \Delta R_{t-2} \\ & + 0.62\ (1\text{-}\chi)\ \Delta\ln(Y)_{t-1} \\ & - 1.16\ (1\text{-}\chi)\ \Delta\ln(P^m/P^h)_{t-2 \text{ to } -5} \\ & - 1.46\chi\ \Delta\ln(P^x/P^*)_{t-2 \text{ to } -3} \\ & + 2.94\ \Delta\ln(P^h)_{t-3} - 5.40\ \Delta\ln(K)_{t-1} + \mu^4_t\end{aligned}$$

Adjusted $R^2 = 0.38$

(5) The short-run dynamics of U.S. export prices

$$\begin{aligned}\Delta\ln(SP^x)_t = {} & -0.16\ \mu^2_{t-1} + 0.52\ \Delta\ln(SP^x)_{t-1} \\ & + 0.34\ \Delta\ln(P^h)_{t-1} - 0.05\ \Delta\ln(P^*)_{t-2 \text{ to } -6} \\ & + \mu^5_t\end{aligned}$$

Adjusted $R^2 = 0.70$

(6) The short-run dynamics of U.S. import prices

$$\begin{aligned}\Delta\ln(P^m)_t = {} & -0.44\ \mu^3_{t-1} + 0.42\ \Delta\ln(P^m)_{t-1} \\ & + 0.13\ \Delta\ln(S)_{t-1 \text{ to } -4} + 0.36\ \Delta\ln(P^h)_{t-4} \\ & + 0.25\ \Delta\ln(U^*)_{t-2 \text{ to } -4} + \mu^6_t\end{aligned}$$

Adjusted $R^2 = 0.63$

Two auxiliary long-run equations:

$$\begin{aligned}(7)\ (SP^xX/\Pi)_t = {} & 7.96 + 0.18\ \ln(S)_t + 2.20\ \ln(Y^*)_t \\ & - 2.06\ \ln(Y)_t + 0.18\ \ln(P^h)_t + \mu^7_t\end{aligned}$$

Adjusted $R^2 = 0.87$ ADF statistic $= 4.14$

$$\begin{aligned}(8)\ \chi_t = {} & 0.79 + 0.001^*\ \ln(S)_t + 0.37\ \ln(Y^*)_t - 0.28\ \ln(Y)_t \\ & + \mu^8_t\end{aligned}$$

Adjusted $R^2 = 0.93$ ADF statistic $= 4.44$

Variables:

K = U.S. manufacturing capital stock
Π = gross nominal profits of domestic U.S. manufacturing firms in dollar terms
P = U.S. wholesale price level, 1987 = 100
P^h = U.S. manufactured goods price, excluding food and energy
P^* = foreign price level
P^m = U.S. import price in dollar terms
P^x = U.S. export price in foreign currency terms
R = the real interest rate in the United States
Y = real U.S. domestic demand
U^* = unit variable cost of foreign goods (in foreign currency)
S = the nominal exchange rate (dollar/foreign currency)
χ = the share of exports in total sales
$1-\chi$ = the share of domestic sales in total sales
μ^i = residual for equation i.

Note: All coefficients shown are statistically different from zero, except the one noted by *.

effects on both exporters' and import competitors' profits, which accounted for about three-quarters of the total long-run impact of dollar appreciation on profits, took about three years to be fully realized. Consequently, the real manufacturing profit loss due to the dollar appreciation in the early 1980s was not significant until the beginning of 1983. It then climbed steadily as the dollar continued to rise, reaching $55 billion (measured in 1987 dollars) in 1984. The profit loss then lingered at about $50 billion during 1985-86 because of continuing price/volume effects, even though the dollar started to plunge in the second half of 1985. In 1987, two years after the plunge of the dollar, the profit loss began to fall sharply.

The latter half of the 1980s highlights the complex timing dynamics more dramatically. The rapid positive translation effect on profits of the dollar's 1985-87 fall resulted in a slight profit gain for the manufacturing sector by 1988. The persistent negative lagged price/volume effect of the earlier high dollar, together with the negative translation effect of the rise in the dollar from its low 1987 level, then caused the profit loss to resurface in late 1988 and early 1989. During the second half of 1989 and the first half of the 1990, however, the lagged price/volume effects of the dollar's mid-1980s fall again led to a profit gain.

Table 3 shows that the average annual profit loss reached $51 billion (in 1987 constant dollars) in the highest dollar period (1984-86), remained around $17 billion in 1987-88 when the dollar was already back to its base year level, and was reversed by 1989-90 as the dollar remained low and lagged price/volume effects of the earlier high dollar tapered off On average, manufacturing profit losses amounted to about $23 billion per year over the past decade Our calculations suggest that this profit loss was distributed somewhat more heavily on exporters than on import competitors The exporting sector's profit loss, stemming more or less equally from the price/volume effect and the translation effect of the dollar's appreciation, was about $13 billion per year. Import competitors' profit loss, deriving entirely from the price/volume effect of the dollar's rise on profits, was about $10 billion per year. Overall, the cumulative dollar profit loss for the entire 1981-90 period was about $230 billion, or 10 percent of total manufacturing profits.

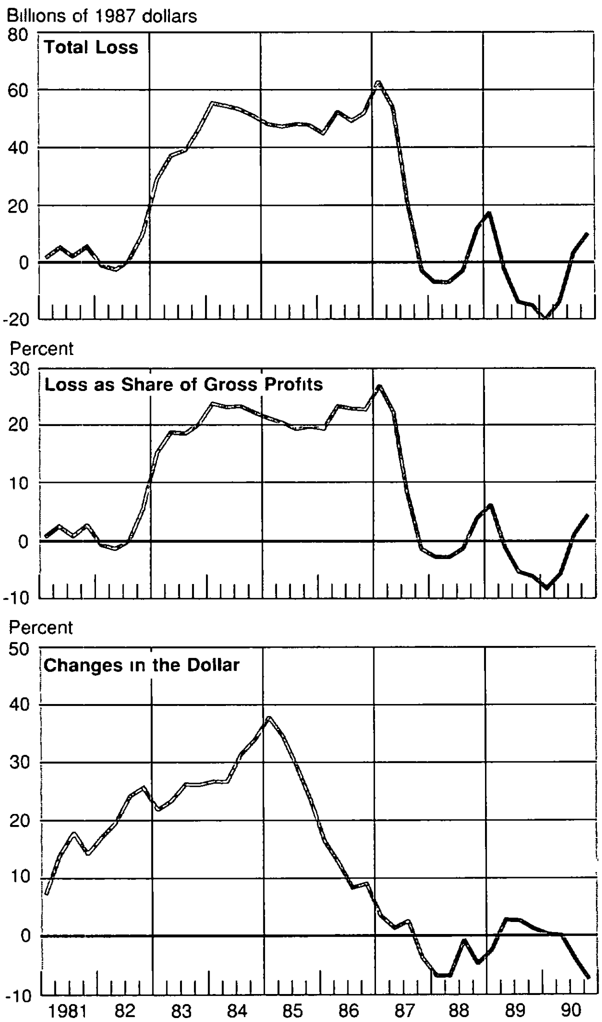
These estimates appear reasonable, given that the price/volume effects of the dollar's appreciation take time to be fully realized and that the average value of the real dollar over the 1981-90 period was still about 13 2 percent higher than the value of the real dollar in 1980 The long-run effect of the high dollar in the 1980s on manufacturing profits drops noticeably, however, once the lagged price/volume effects of the 1987-90 dollar's return to its 1980 level are completed Our previous estimate, based on the three long-run equilibrium equations alone, indicates that the cumulative manufacturing profit loss amounts to about $190 billion when all the lagged effects are realized (roughly by 1993)[20]

In sum, the simulation results imply that the manufacturing profit loss caused by the high dollar during the 1981-85 period has been sizable, enduring, and widespread In view of the substantial degree of the dollar's rise during the first half of the 1980s relative to 1980, these results are not surprising If the degree of the dollar's appreciation during the 1980s had been trivial, its cumulative impact on manufacturing profits would have been negligible in the long run[21]

Our results also indicate that the complex and prolonged adjustment of profits to exchange rate movements may have contributed significantly to the evolution of profits over the last ten years. Admittedly, developments in the dollar exchange rate do not fully explain the low level of manufacturing profits in the late 1980s Nevertheless, the prolonged adjustment of profits to the 1981-85 dollar appreciation, together with the still incomplete adjustment of profits to the subsequent dollar depreciation, appears to have been a major factor underlying the weakness in U.S manufacturing profits

Chart 6

Estimated Manufacturing Loss Due to Changes in the Dollar in the 1980s



Note Changes in the dollar are measured relative to a benchmark dollar level that would hold the real exchange rate at its 1980 level

[20]Of course, if the average value of the dollar during the entire 1980s had not differed from the value of the dollar in 1980—that is, if the dollar had depreciated substantially from its 1980 level in the late 1980s to compensate for its earlier appreciation from its 1980 level—the dollar's swings in the 1980s would not have resulted in a cumulative profit loss over the long run

[21]For example, if we choose 1981 rather than 1980 as the base year for comparison, then the average value of the 1982-90 real dollar was about 1 percent higher than the base-year real dollar Consequently, if we use 1981 as the base period, the real manufacturing profit loss eventually amounts to a mere $70 billion for the 1982-90 period as a whole, and only about $15 billion in the long run when all lagged adjustments are completed

Table 3

The Estimated Impact of Exchange Rate Development on U.S. Manufacturing Profits

Yearly Average

	1981-83	1984-86	1987-88	1989-90	1981-90
Total loss due to dollar's swings in the 1980s (billions of 1987 dollars)	15 1	51 2	17 2	−3 4	22 6
Loss as share of total manufacturing profits (percent)	7 4	22 2	7 2	−1 3	10 1
Degree of real dollar appreciation relative to 1980 real dollar (percent)	20 3	24 8	−1 3	−0 2	13 2

throughout much of the 1980s

Conclusion

This article investigates the effect of exchange rate changes on U S manufacturing profits since the advent of the floating exchange rate system It first demonstrates that an appreciation of the dollar is likely to lower U S manufacturing profits, regardless of the ways in which U S or foreign exporters adjust their pricing strategies to changes in the dollar exchange rate Changes in the exchange rate are transmitted to manufacturing profits through a combination of two channels a price/volume effect (on both import-competing and exporting profits) and a dollar translation effect (on exporting profits).

Next, an econometric model is built and estimated to assess the direct impact of exchange rate changes on manufacturing profits Estimation results from this model show that over the long run, a 10 percent nominal appreciation of the dollar directly reduces U S. manufacturing profits by about 6 percent about 3 4 percent through losses in the exporting sector and about 2.5 percent through losses in the import-competing sector Expressed in constant (1987) dollar terms and based on profit levels in the 1980s, these estimates imply that a sustained 10 percent dollar appreciation would lower manufacturing profits on average by more than $14 billion per year.

The results indicate that even though the bulk of the decline in the profit rate caused by the high dollar in the first half of the 1980s was restored by the late 1980s, the cumulative profit loss caused by the dollar's swings in the 1980s remained substantial for the 1980s as a whole. If we use 1980 as the base year, the average profit loss due to the high dollar in the 1980s was about $23 billion per year in that decade, or 10 percent of total manufacturing profits At its peak during 1984-86, the manufacturing sector's loss reached about $50 billion per year, or about 22 percent of actual profits. In sum, the cumulative profit loss from the dollar's swings in the 1980s totaled about $230 billion for the entire 1981-90 period. The cumulative loss is expected to decline to about $190 billion over the long term (roughly 1981-93), when all the lagged price/volume effects of the dollar's depreciation in the second half of the 1980s will have been completed

Appendix: The Relationship of the Exchange Rate to Pricing Behavior and Manufacturing Profits

The exchange rate and exporters' profits

The relationship between exporters' profits, the export price pass-through elasticity, and the exchange rate can be represented by the following profit identity

$$
\begin{aligned}
\text{(A1)}\quad \Pi^X &= S\,P^x X - U X \\
X &= X(P^x/P^*) \\
P^x &= P^x(S),
\end{aligned}
$$

where

Π^X = exporting firms' gross nominal profits from sales to the foreign market, in dollar terms
X = export volume
U = the unit variable cost of U S manufactured output
S = the exchange rate (dollar/foreign currency)
P^x = the (foreign currency) unit price of U S exports
P^* = the foreign price level

We can obtain the following equation by taking the derivative of Π^x with respect to the exchange rate (S)

$$
\begin{aligned}
\text{(A2)}\quad \partial\Pi^x/\partial S = {} & P^x X + S X (\partial P^x/\partial S) \\
& + S P^x (\partial X/\partial(P^x/P^*))(\partial(P^x/P^*)/\partial S) \\
& - U (\partial X/\partial(P^x/P^*))(\partial(P^x/\partial P^*)/S)
\end{aligned}
$$

Let θ^x be the elasticity of the U S. export price (in foreign currency terms) with respect to the exchange rate, and λ^x be the elasticity of demand for U S exports with respect to the ratio of (foreign currency) U S. export price to foreign price If we assume that $\partial P^*/\partial S = 0$, then after some algebraic manipulation, equation A2 becomes

$$
\text{(A3)}\quad (\Delta\Pi^X/\Pi^X)/(\Delta S/S) = SP^xX/\Pi^X\,(1 + \theta^x) + \theta^x\,\lambda^x,
$$

where

$$
\begin{aligned}
\theta^x &\equiv (\Delta P^x/\Delta S)/(P^x/S),\ -1 \leq \theta^x \leq 0, \\
\lambda^x &\equiv (\Delta X/\Delta(P^x/P^*))/((P^x/P^*)/X),\ \lambda^x < 0
\end{aligned}
$$

Equation A3 indicates that a 1 percent depreciation in the dollar will always increase U S. exporters' profits by $SP^xX/\Pi^X\,(1 + \theta^x)$ percent through the translation effect and by $\theta^x\,\lambda^x$ percent through a price/volume effect

In the case of zero exchange rate pass-through ($\theta^x = 0$), when U S firms fully prevent the depreciation of the dollar from passing through to P^x, export volume will remain unchanged as the dollar depreciates As a result, a depreciation of the dollar will boost exporters' dollar profit purely through a translation effect. a 1 percent dollar depreciation will raise the dollar export price (SP^x) by 1 percent, and a translation effect of 1 percent dollar depreciation will be equal to the ratio of export revenue to total profits

In the case of complete pass-through ($\theta^x \equiv -1$), when U S firms allow P^x to fall to the full extent of the dollar's depreciation (or to rise by the full extent of the dollar's appreciation), the dollar translation effect will be zero In other words, dollar receipts for each unit exported will not be affected by the change in the dollar exchange rate However, in this case, export profits will increase by λ^x percent through a price/volume effect That is, the elasticity of export profits with respect to the exchange rate will be equal to the price elasticity of foreign demand for U S exports (λ^x)

The exchange rate and import competitors' profits

The relationship between import competitors' profits, the import price pass-through elasticity, and the exchange rate can be expressed by the following profit identity

$$
\begin{aligned}
\text{(A4)}\quad \Pi^H &= P^h H - U H \\
H &= H(P^m/P^h) \\
P^m &= P^m(S),
\end{aligned}
$$

where

Π^H = the gross nominal profits of U S. manufacturing firms in the import-competing sector
H = import-competing firms' output sold domestically
P^h = the (dollar) unit price of U S output sold domestically
P^m = the (dollar) unit price of U S imports

If we assume that P^h remains unchanged when the dollar exchange rate changes (that is, $\partial P^h/\partial S = 0$), then we can obtain equation A5 by taking the derivative of Π^H with respect to the exchange rate (S)

$$
\begin{aligned}
\text{(A5)}\quad \partial\Pi^H/\partial S = {} & P^h (\partial H/\partial(P^m/P^h))(\partial(P^m/P^h)/\partial S) \\
& + U (\partial H/\partial(P^m/P^h))(\partial(P^m/P^h)/\partial S)
\end{aligned}
$$

Let θ^m be the pass-through elasticity of U.S import prices (in dollar terms) with respect to the exchange rate, and λ^h the elasticity of U S domestic demand for manufactured goods with respect to the (P^m/P^h) relative price Then it is easy to understand how the gain in Π^H relates to the pass-through elasticity of P^m by deriving the following equation from equation A5

$$
\text{(A6)}\quad (\Delta\Pi^H/\Pi^H)/(\Delta S/S) = \theta^m\,\lambda^h,
$$

where

$$
\theta^m = (\Delta P^m/\Delta S)/(S/(P^m)),\ 0 \leq \theta^m \leq 1
$$

Appendix: The Relationship of the Exchange Rate to Pricing Behavior and Manufacturing Profits *(Continued)*

$\lambda^h = (\Delta H/\Delta(P^m/P^h))/((P^m/P^h)/H);\ \lambda^h > 0.$

From equation A6, it is clear that a dollar depreciation would raise the profits of U.S. import-competing firms purely through a price/volume effect. Indeed, a 1 percent dollar depreciation would increase U.S. import-competitors' profits by $\theta^m \lambda^h$ percent. If foreign exporters passed through the full extent of the dollar's depreciation to the price of their goods in the United States, so that $\theta^m = 1$, the elasticity of import competitors' profits with respect to the exchange rate would simply equal the price elasticity of domestic demand for manufacturing goods (λ^h). If foreign exporters kept P^m unchanged when the dollar depreciated against their currencies (that is, $\theta^m = 0$), the profits of U.S. import-competing firms would not rise, because the depreciation of the dollar would not make their goods more price competitive. Indeed, it is clear from equation A6 that $(\Delta\Pi^H/\Pi^H)/(\Delta S/S)$ is equal to zero in this case.

An Open-Economy Model of U.S. Manufacturing Profits

To examine the effect of the exchange rate on gross U.S. manufacturing profits, let's divide gross manufacturing profits into two components: profits accrued from export sales and profits accrued from domestic sales. Domestic sales includes sales in the import-competing sector as well as sales not in competition with imports. We can then analyze the impact of the exchange rate by making the following assumptions:

(A7) $\Pi_t = \Pi^X_t + \Pi^D_t$

(A8) $\Pi^X_t = S_t P^x_t X_t - U_t X_t$

(A9) $\Pi^D_t = P^h_t Q_t - U_t Q_t$

(A10) $Q_t = Q(Y_t, P^m_t/P^h_t)$

(A11) $X_t = X(Y^*_t, P^x_t/P^*_t)$

(A12) $P^m_t = S_t \phi^m U^*_t$

(A13) $P^x_t = (1/S_t)\ \phi^x U_t$,

where all profits are in dollar terms, and

Π = gross nominal profits of the manufacturing industry
Π^X = gross nominal profits accrued from export sales
Π^D = gross nominal profits accrued from domestic sales, including sales in both the import-competing sector and the nontrading sector
X = export volume
Q = total volume of U.S. manufactured goods sold domestically
U = the unit variable cost (in dollar terms) of U.S. manufactured output
U^* = the unit variable cost (in foreign currency terms) of U.S. imports
S = the exchange rate (dollar/foreign currency)
P^h = the (dollar) unit price of U.S. output sold domestically
P^m = the (dollar) unit price of U.S. imports
P^* = the (foreign currency) unit price of foreign output sold in the foreign market
P^x = the (foreign currency) unit price of U.S. exports
P = the general U.S. price level
Y = real U.S. national income
Y^* = real foreign income
ϕ^m = the markup that foreign suppliers impose on goods sold in the U.S. market
ϕ^x = the markup that U.S. exporters impose on U.S. exports.

Equations A7 through A9 are identities. Equation A10 assumes that domestic demand for U.S. manufactured goods (Q_t) is a function of U.S. activity (Y_t) and the price competitiveness of U.S. manufactured goods relative to imported goods (P^m/P^h). Similarly, equation A11 assumes that demand for U.S. exports (X_t) is a function of foreign activity (Y^*) and the price competitiveness of U.S. goods abroad (P^x/P^*). Equation A12, the U.S. import price equation, specifies that foreign firms set the price of their goods in their own currency (P^m/S) at a markup (ϕ^m) over their marginal cost of production (U^*), so that $(P^m/S) = \phi^m U^*$, or $P^m = S\,\phi^m U^*$. Finally, equation A13, the U.S. export price equation, maintains that U.S. firms set the price of their goods in dollar terms (SP^x) at a markup (ϕ^x) over their marginal cost of production (U), so that $(SP^x) = \phi^x U$, or $P^x = (1/S)\ \phi^x U$.

If we substitute equations A8 through A11 into equation A7, take total differentiation, and assume that the unit profit margin of export sales equals the unit profit margin of domestic sales (that is, $SP^x - U = P^h - U$), then after some algebraic manipulation we can obtain the following real long-run profit equation expressed in log terms:

$$\text{(A14)}\ \ln(\Pi/P)_t = \text{constant} + \beta_1 (SXP^x/\Pi)_t \ln(P^xS/P)_t + \beta_2 \chi_t \ln(P^x/P^*)_t + \beta_3 \chi_t \ln(Y^*)_t + \beta_4 (1-\chi)_t \ln(Y)_t + \beta_5 (1-\chi)_t \ln(P^m/P^h)_t + \beta_6 \ln(U/P)_t + \mu_t,$$

where $\chi = X/(X+Q)$, or the share of exports in total sales; and μ is the residual. And if we define $\lambda(Z_1,Z_2)$ as the elasticity of Z_1 with respect to Z_2—that is, let $\lambda(Z_1,Z_2) = (\partial Z_1/\partial Z_2)/(Z_1/Z_2)$—then the coefficients in equation A15 can be expressed as follows:

Appendix: The Relationship of the Exchange Rate to Pricing Behavior and Manufacturing Profits *(Continued)*

$\beta_1 = 1$
$\beta_2 = \lambda(X, P^x/P^*)$
$\beta_3 = \lambda(X, Y^*)$
$\beta_4 = \lambda(Q, Y)$
$\beta_5 = \lambda(Q, P^m/P^h)$
$\beta_6 = -(X+Q)U/\Pi$

Equation A14, the profit equation, shows the long-run relationship between real gross U.S. manufacturing profits and a host of variables: the ratio of (foreign currency) export price to foreign price (P^x/P^*), the (real) dollar export price (SP^x/P), U.S. activity (Y), foreign activity (Y^*), the ratio of import price to U.S. goods price (P^m/P^h), and the real unit variable cost (U/P).

Because foreign activity (Y^*) and the ratio of (foreign currency) export price to foreign price (P^x/P^*) affect manufacturing profits through their impact on export sales volume, the effect of a change in either of these two factors on aggregate profits is greater when export sales constitute a larger share of total manufacturing sales.[†] Consequently, in the regression, $\ln(Y^*)$ and $\ln(P^x/P^*)$ are scaled by the share of export sales to total manufactured goods sales (X). By the same token, $\ln(P^h/P^m)$ and $\ln(Y)$ are scaled by the share of domestic sales to total sales $(1-X)$, since the impact of a given change in these factors on profits is bigger when domestic sales constitute a greater share of total sales.

The (real) dollar export price, $\ln(SP^x/P)$, is scaled differently in equation A14 because it affects total manufacturing profits through a translation effect but not a price/volume effect. For a given export volume, a 1 percent increase in the (real) dollar export price (SP^x/P) would increase real export revenues by 1 percent without raising total costs, so that the amount of increase in total real manufacturing profits would be exactly equal to the amount of increase in real export revenue. In other words, the percent increase in total real manufacturing profits (Π/P) due to a 1 percent increase in (SP^x/P) would be equal to (SP^xX/Π) percent. Consequently, in the regression, $\ln(SP^x/P)$ is scaled by (SP^xX/Π), and the coefficient on (SP^xX/Π) $\ln(SP^x/P)$ is restricted to be one.

The last factor included is real unit variable costs (U/P), which is assumed to be the same whether the output is for exports or for domestic sales. If we assume that dollar profit margins on exports and domestic sales are roughly the same, the impact of a 1 percent change in unit variable costs on total profits would depend only on the size of the profit margin, not on the relative size of export sales to domestic sales.[‡] Consequently, we do not scale this variable in the regression.

To estimate the impact of the exchange rate on total manufacturing profits, we still need to estimate the relationship between export prices and the exchange rate, and that between import prices and the exchange rate. In the case of the export price equation, if we assume that the markup (ϕ^x) is a function of competitive pressures in the foreign market and use foreign prices (P^*) as a proxy for the competitive pressure faced by U.S. exporters, then U.S. export prices become a function of the nominal exchange rate, the foreign price level, and the U.S. cost of production (U). We can then derive the following long-run export price equation:

$$\text{(A15)}\quad \ln(SP^x) = \text{constant} + \gamma_1 \ln(S)_t + \gamma_2 \ln(U)_t + \gamma_3 \ln(P^*)_t + \mu^x_t,$$

where we expect $1 > \gamma_1 > 0$, and $(\gamma_1 - 1)$ is the (pass-through) elasticity of P^x with respect to the exchange rate (S).

Similarly, in the case of the import price equation, if we assume that the markup (ϕ^m) is a function of competitive pressures in the U.S. market and use the price level of U.S. manufactured goods (P^h) as a proxy for competitive pressure faced by foreign suppliers, then U.S. import prices become a function of the nominal exchange rate, the price of U.S. goods, and the foreign unit cost of production (U^*). We then can derive the following long-run import price equation.

$$\text{(A16)}\quad \ln(P^m)_t = \text{constant} + \alpha_1 \ln(S)_t + \alpha_2 \ln(U^*)_t + \alpha_3 \ln(P^h)_t + \mu^m_t,$$

where we expect $1 > \alpha_1 > 0$, and α_1 is the (pass-through) elasticity of P^m with respect to the exchange rate.

Together, equations A14, A15, and A16 constitute an empirical model that enables us to determine the long-

†Both Y^* and P^x/P^* affect export profits through the volume effect. For a given dollar export price (SP^x) and unit variable cost (U), a 1 percent increase in export volume (X) would increase both export revenue (SP^xX) and total export cost (UX) by 1 percent, thereby increasing total manufacturing profits by $((SP^x - U)X/\Pi)$ percent, or the percent share of export profits in total manufacturing profits. Under the assumption that profit margins are the same for exports as

Footnote † continued
for domestic sales, the $((SP^x - U)X/\Pi)$ ratio equals the ratio of export sales to total sales.

‡A 1 percent increase in the unit variable cost would increase total variable cost by $(X+Q)U$ percent, and lower total manufacturing profits by $((X+Q)U/\Pi)$ percent. If we assume that the profit margins for export sales and domestic sales are the same, then $(X+Q)U/\Pi$ would be equal to $1/((P/U) - 1)$, where P is the price of the good.

Appendix: The Relationship of the Exchange Rate to Pricing Behavior and Manufacturing Profits *(Continued)*

run impact of a sustained change in the nominal exchange rate on real gross U S manufacturing profits All three equations, with coefficients assumed to be time-invariant, are estimated in two stages using data over the floating exchange rate period from 1973-III to 1990-IV

In the first stage, the parametric correction suggested by Saikkonen (1990) and Stock and Watson (1989) is used to obtain consistent estimates of the three long-run equations [§] Then GLS is used to correct for serial correlation among residuals that may still be present With these corrections, we can use standard t-statistics as a basis for hypothesis testing The estimation results are reported in Exhibit 1 (Box 1)

The second stage involves estimating the short-run dynamic counterparts of the three equations For example, we can estimate the short-run adjustment processes of real U S. manufacturing profits around the long-run equilibrium profit path by estimating the error correction model (ECM) of real U S manufacturing profits More specifically, the first difference of real profits, $\Delta \ln(\Pi/P)_t$, is regressed on the equilibrium error (that is, the deviation of actual profits from long-run equilibrium profits, or the residual from the cointegrating long-run profit equation) in the past period, along with lagged changes in the dependent variable and all independent variables in equation A14 Variables not included in the long-run equation should be included in the error correction model if they affect the short-run movements of manufacturing profits, thus, capital expenditure, inflation, and changes in the real interest rate are also included in the model A parsimonious representation is achieved by eliminating most insignificant lag terms The same method is used to estimate the error correction model of export prices and that of import prices The estimation results of these three error correction models are reported in Exhibit 2 (Box 2)

Equation A14 shows that a proper assessment of the dollar exchange rate's effect on manufacturing profits should take into account the impact of the dollar on both the ratio of export sales to total sales and the ratio of export revenue to total profits. Consequently, we include the following two supplemental equations in the model

$$\text{(A17)}\ (SP^xX/\Pi)_t = \text{constant} + a1\ \ln(S)_t + a2\ \ln(Y)_t + a3\ \ln(y^*)_t + a4\ \ln(P^h)_t,$$

$$\text{(A18)}\ \chi_t = \text{constant} + b1\ \ln(S)_t + b2\ \ln(Y)_t + b3\ \ln(y^*)_t$$

The estimation results of A17 and A18 are reported in Exhibit 2 (Box 2)

§That is, leads and lags of the first differences of the regressors are added to the right-hand side of each of the three equations to correct for the simultaneity bias that may be caused by the endogeneity of the regressors See Pentti Saikkonen, "Asymptotically Efficient Estimation of Cointegration Regression," *Econometric Theory*, vol 7 (March 1991), and James H Stock and Mark W Watson, "A Simple MLE of Cointegrating Vectors in Higher Order Integrated Systems," National Bureau of Economic Research, Technical Working Paper no 83 (1989)