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# THE REAL EXCHANGE RATE, EXPORTS, AND MANUFACTURING PROFITS: A THEORETICAL FRAMEWORK WITH SOME EMPIRICAL SUPPORT

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Columbia University, The National Bureau of Economic Research, and The Federal Reserve Bank of New York. This paper emerged after conversations on this subject with Akbar Akhtar and Charles Pigott, and was written during my stay as a Visiting Scholar at the Federal Reserve Bank of New York. I have benefited enormously from the support and surroundings at 33 Liberty St. and would like to thank Richard Davis, Akbar Akhtar, Charles Pigott, Bruce Kasman, Susan Hickock, Juann Hung, Ricardo Caballero, and Dale Henderson for their suggestions. All remaining confusions are my doing. This paper is part of NBER's research program in International Studies. Any opinions expressed are those of the author and not those of the National

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**ABSTRACT**

This paper investigates the relationship between manufacturing profits, exports, and the real exchange rate. Using Marston's (1990) model of pricing-to-market, we derive a co-integrated log-linear profits equation that restricts the long-run relationship among real U.S. manufacturing profits, domestic sales, the real exchange rate, real unit costs, the U.S. relative price of output, and foreign sales. We show that the elasticity of real profits with respect to the real exchange rate is bounded below by the product of (i) 1 minus the long-run pass-through coefficient and (ii) the ratio of export revenues to total profits. Our empirical findings suggest that, even after taking into account output, costs, and relative prices, real exchange rate fluctuations have a sizable and statistically significant influence on real U.S. manufacturing profits. The framework developed in this paper appears to be of some value in directing attention towards a heretofore underappreciated channel through which real exchange rate changes can potentially influence national savings.

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# THE REAL EXCHANGE RATE, EXPORTS, AND MANUFACTURING PROFITS: A THEORETICAL FRAMEWORK WITH SOME EMPIRICAL SUPPORT

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## 1. Introduction

In this paper, we investigate the relationship between manufacturing profits, exports, and the real exchange rate. Traditionally, empirical studies of aggregate profits (Clark (1984)) focus on the relationship between profits and product prices, sales, and the cost of production. In fact, it might be expected that, once such traditional variables are taken into account, there is little left for the real exchange rate to explain, notwithstanding the fact that real exchange rate fluctuations may be correlated with or contribute to fluctuations in product prices, sales, and the cost of production. This conjecture turns out to be wrong, at least in aggregate US manufacturing data during the floating rate period. In fact, interpreting the profits equation to be derived and estimated below as a co-integrating relationship, we estimate that, holding constant the volume of domestic sales, unit costs, and relative domestic prices, a permanent 10 percent real depreciation results in a greater than 6 percent rise in the real profits of US manufacturers. We demonstrate that the elasticity of real profits with respect to the real exchange rate is bounded below by the product of (i) 1 minus the pass-through coefficient and (ii) the ratio of the dollar value of foreign sales to the dollar value of total profits. We note that even if dollar revenues from foreign sales are small relative to total sales, *they are likely to be large relative to total profits.*

If all of a given real depreciation is passed through to foreign currency prices, dollar profits per unit sold abroad are unchanged, but the volume of exports rises in response to the decline in the relative foreign currency price of the US export. If none of a given real depreciation is passed through to foreign currency prices, exports rise only at the rate of foreign income growth multiplied by the foreign income elasticity of demand, but dollar profits per unit sold abroad rise dollar for dollar with the jump in dollar price of foreign exchange. Thus, a real depreciation of the dollar should boost the profits of US manufacturers *regardless of whether pass-through is complete, partial, or non-existent*.

## 2. A Model

We begin with a profits equation for a representative manufacturing firm that must choose, each period, how much to produce, how much to sell domestically, and how much to sell abroad.

$$(1) \qquad \pi_t = P_{ht}H_t + S_tQ_{ft}F_t - VC_t - K_t;$$

where $\pi_t$ is the dollar value of profits, $P_{ht}$ is the dollar price of output - $H_t$ in quantity - sold domestically, $Q_{ft}$ is the foreign currency price of output - $F_t$ in quantity - sold abroad, $S_t$ is the dollar price of foreign currency, $VC_t$ is total variable costs in dollars, and $K_t$ is total fixed cost in dollars. We shall assume that total variable cost may be expressed as:

$$(2) \qquad VC_t = W_t(H_t + F_t)^{(\lambda)}\epsilon_t/Z_t;$$

where $W_t$ is the dollar wage, $\epsilon_t$ is a stationary shock to costs, and $Z_t$ is a permanent shock to productivity. We shall use (2) along with data on unit labor costs, $U_t$, to infer the behavior of variable manufacturing costs. In particular, we assume that, subject to a stationary measurement error $\nu_t$ we observe:

$$(3) \qquad U_t = (VC_t/(H_t + F_t))\nu_t$$

Since we do not have quarterly data on fixed cost, we shall assume that total fixed cost may be expressed as:

$$(4) \qquad K_t = KP_t(H_t + F_t)\xi_t$$

where $\xi_t$ is a stationary shock to fixed - overhead - costs.

At an optimum, the dollar price charged in each market is a markup over marginal cost. Following Marston (1990):

$$(5a) \qquad P_{ht} = (e_{ht}/(e_{ht} - 1))[\lambda W_t(H_t + F_t)^{(\lambda - 1)}\epsilon_t/Z_t];$$

$$(5b) \qquad Q_{ft} = (e_{ft}/(e_{ft} - 1))[\lambda W_t(H_t + F_t)^{(\lambda - 1)}\epsilon_t/Z_t](1/S_t);$$

where $e_{ht}$ is the elasticity of demand in the home market, $e_{ft}$ is the elasticity of demand in the export market, and the expression in brackets is equal to marginal cost:

$$(6) \qquad MC_t = [\lambda W_t(H_t + F_t)^{(\lambda - 1)}\epsilon_t/Z_t].$$

Using (4) and (5), and postulating demand functions for home and foreign output of the form $D_h(P_{ht}/P_t;Y_{ht})$ and $D_f(Q_{ft}/Q_t;Y_{ft})$, we see that in equilibrium, the production of output sold domestically and the production of output sold abroad solve the following two product market clearing conditions:

$$(7) \qquad H_t = D_h((e_{ht}/(e_{ht} - 1))[\lambda W_t(H_t + F_t)^{(\lambda - 1)}\epsilon_t/Z_t]/P_t;Y_{ht});$$

$$(8) \qquad F_t = D_f((e_{ft}/(e_{ft} - 1))[\lambda W_t(H_t + F_t)^{(\lambda - 1)}\epsilon_t/Z_t](1/S_tQ_t);Y_{ft}).$$

Marston (1990) uses this framework to investigate the phenomena of exchange rate pass-through and pricing-to-market. For example, he demonstrates that if marginal cost and the demand elasticities are constant, a depreciation of the exchange rate must result in a complete pass-through to the foreign currency price, $\partial \log Q_{ft}/\partial \log S_t = -1$, leaving the dollar price of exports, $S_tQ_{ft}$, and the price of domestic sales, $P_{ht}$, unchanged. If marginal cost is increasing, pass-through is incomplete, foreign sales rise, and domestic sales fall, as $P_{ht}$ and $S_tQ_{ft}$ rise in proportion to the increase in marginal cost. If demand elasticities are not constant, and markups decline with a rise in product prices, pass-through is less than complete even with constant marginal cost, and the dollar price of output sold abroad must rise relative to the domestic price, $P_{ht}$.

Our interest is not in pricing behavior, *per se*, but rather, in the relationship between profits and the real exchange rate. As we argued in the introduction, we would expect a real depreciation to boost the dollar profits of US manufacturers regardless of whether or not said depreciation is passed-though fully, partially, or not at all. We now derive an equation that can be used to illustrate this reasoning and that can be investigated empirically.

Totally differentiating (1), using (3), and dividing by $\pi_t$, we obtain:

$$(9) \qquad d\log(\pi_t/P_t) = (\theta-\eta\psi-\phi\psi)d\log H_t + (\theta - \phi)d\log(P_{ht}/P_t) + \gamma d\log(S_t/P_t) - \eta d\log(U_t/P_t) + \gamma d\log Q_{ft} + (\gamma - \eta(1-\psi) - \phi(1-\psi))d\log F_t + \eta d\log v_t - \eta d\log\epsilon_t - \phi d\log\xi_t;$$

where the parameters $\theta$, $\gamma$, $\eta$, $\phi$, and $\psi$ are defined by:

$$\theta = P_{ht}H_t/\pi_t;$$

$$\gamma = S_tQ_{ft}F_t/\pi_t;$$

$$\eta = VC_t/\pi_t; \tag{10}$$

$$\phi = K_t/\pi_t;$$

$$\psi = H_t/(H_t + F_t).$$

Note that from (1), the restriction:

$$\theta + \gamma - \eta - \phi = 1; \tag{11}$$

must hold period by period.

There are several noteworthy implications embedded in equation (9). First, profits are homogeneous of degree 1 in domestic nominal variables and the nominal exchange rate. Second, profits are homogenous of degree 0 in foreign nominal variables and the nominal exchange rate. Third the elasticity of real profits with respect to a depreciation that is not passed-through is equal to $\gamma$, the ratio of the dollar value of foreign *revenues* to total *profits*:

$$d\log(\pi_t/P_t) = \gamma d\log(S_t/P_t). \tag{12}$$

As shown in Marston (1990) and Feenstra (1987), if marginal cost is constant and the markup declines with a rise in product prices - as will be the case for any demand curve that is less convex than the log linear demand curve -

the domestic price $P_{ht}$ is unchanged in response to a nominal depreciation, and the pass-through to the foreign currency price $Q_{ft}$ goes to zero as the elasticity of the foreign markup, $N_t = e_{ft}/(e_{ft} - 1)$, with respect to $Q_{ft}$ goes to $-\infty$. In this case, pricing-to-market is complete. Export volume remains unchanged, but dollar profits from foreign sales, which represent $\gamma$ times total profits, rise in proportion to the rate of depreciation.

Fourth, the elasticity of real profits with respect to a depreciation that is fully passed-through is given by:

$$(13) \qquad dlog(\pi_t/P_t) = e_f(\gamma - \eta(1-\psi) - \phi(1-\psi))dlog(S_t/P_t).$$

when marginal cost is constant. As summarized above, Marston (1990) shows that pass-through is complete, and the domestic price remains unchanged, in response to a nominal depreciation when marginal cost and the elasticity of foreign demand are constant. It follows that, for this case in which no pricing-to-market takes place, the channel through which real depreciation boosts profits is through greater export volumes. With complete exchange rate pass-through and an equiproportional decline in the foreign currency price of exports, the percent rise in exports is given by $e_f dlog(S_t/P_t)$. From (9) we see that this translates into a rise in profits of $e_f(\gamma - \eta(1-\psi) - \phi(1-\psi))dlog(S_t/P_t)$ percent.

Fifth, the elasticity of real profits with respect to a depreciation that is only partially passed-through is easily obtained from (9) and (13). Letting $\mu$ equal minus the pass-through elasticity, $\mu = -dlogQ_{ft}/dlogS_t$, we have:

$$(14) \qquad dlog(\pi_t/P_t) = [\gamma(1 - \mu) + \mu e_f(\gamma - \eta(1-\psi) - \phi(1-\psi))]dlog(S_t/P_t).$$

When pass-through is incomplete, a real exchange rate depreciation boosts profits through two channels. The rise in the dollar price of exports boosts profits by $\gamma(1 - \mu)\mathrm{dlog}(S_t/P_{ht})$ percent, while the rise in export volumes boosts profits by $\mu e_f(\gamma - \eta(1-\psi) - \phi(1-\psi))\mathrm{dlog}(S_t/P_{ht})$ percent.

As demonstrated in Marston (1990), the pass-through coefficient $\mu$ is related to the elasticity of the markup with respect to the foreign currency price $Q_{ft}$, $-(\partial N/\partial Q_{ft})(Q_{ft}/N) = \tau$. In fact, with constant marginal cost:

$$\mu = 1/(1 + \tau). \tag{15}$$

In general, at a profit maximizing optimum, it must be the case that:

$$S_t Q_{ft} = MC_t N(Q_{ft}/Q_t), \tag{16}$$

where we have imposed the assumption that the foreign demand curve is weakly-separable in foreign income. Taking logs, totally differentiating (16), and substituting into (9) for $\mathrm{dlog}Q_{ft}$, we obtain the following profits equation:

$$\begin{aligned} dlog(\pi_t/P_t) = {} & (\theta - \eta\psi - \phi\psi)dlogH_t + \gamma(1-\mu)dlog(S_tQ_t/P_t) \\ & - (\eta-\mu\gamma)dlog(U_t/P_t) + (\theta - \phi)dlog(P_{ht}/P_t) \\ & + (\gamma - \eta(1-\psi) - \phi(1-\psi))dlogF_t \\ & + (\eta-\mu\gamma)dlog\upsilon_t - (\eta-\mu\gamma)dlog\epsilon_t - \phi dlog\xi_t; \end{aligned} \tag{17}$$

It is easily verified that (12), (13), and (14) follow from (17) when $\mu = 0$, $\mu = 1$, and $0 < \mu < 1$ respectively.

Given the money wage $W_t$ and constant marginal cost, the optimal response of a price setting exporter to a depreciation of the dollar is to let the foreign price alone absorb the impact of the depreciation. Of course, the same factors - such as monetary policy - that contribute to the dollar depreciation may ultimately result in a rise in money wages. If this rise occurs, and there is no subsequent "correction" in the value of the dollar, both domestic and foreign currency prices of exportables will rise in tandem with the increase in domestic wages. Indeed, if wages rise ultimately by the initial fall in the dollar's value the initial decline in foreign currency prices is completely reversed, and it is easy to show that the long run elasticity of real profits with respect to a real depreciation is unity. Of course, if the domestic price level rises in proportion to the nominal depreciation, the long run real depreciation is zero as is the ultimate change in real profits.

This being said, a depreciation of the dollar that does not ultimately result in an equal jump in wages will in general boost the real profits of US exporters. We now turn to an investigation of the empirical relationship between the real exchange rate and the real profits of US manufacturers in the floating rate period.

## *3. An Empirical Specification*

Letting lower case letters denote logs, an empirically tractable specification that is consistent with (17) is given by:

$$(18) \qquad \begin{aligned} \pi_t - p_t = {} & (\theta - \eta\psi - \phi\psi)h_t + \gamma(1-\mu)(s_t + q_t - p_t) \\ & - (\eta-\mu\gamma)(u_t - p_t) + (\theta - \phi)(p_{ht} - p_t) \\ & + (\gamma - \eta(1-\psi) - \phi(1-\psi))f_t \\ & + (\eta-\mu\gamma)v_t - (\eta-\mu\gamma)\epsilon_t - \phi\epsilon_t. \end{aligned}$$

Our empirical strategy is as follows. Suspecting that many, if not all of the variables under study are non-stationary in levels, we first perform Dickey-Fuller (1981) tests of the null hypothesis that each variable included in (15) is in fact I(1). Under the identifying assumption that $\epsilon_t$ and $\varepsilon_t$, the unobservable shocks to variable and fixed costs, and $\upsilon_t$, the error in measuring variable cost, are stationary, a finding that all of the variables under study are in fact I(1) would imply that the profits equation (18) represents a co-integrating equation, an equation that defines the "long run" equilibrium relationship among profits, sales, exports, product prices, and the real exchange rate. The null hypothesis that (18) does not represent a co-integrating equation is tested using the approach suggested by Granger and Engle (1987). If this null hypothesis of no-cointegration is rejected, OLS can be used to provide a consistent estimate of the co-integrating vector, while Phillips-Loretan Non-Linear Least Squares (1991) can be used to provide an unbiased estimate with asymptotically correct standard errors.

Given an estimate of the co-integrating vector, the product of the parameters $\gamma$ and $(1 - \mu)$ is identified. However, the co-integrating vector corresponding to the profits equation (18) does not identify the pass-through coefficient $\mu$. Note that when pass-through is complete, $\mu = 1$, the theory predicts that the coefficient on the log real exchange rate $s_t + q_t - p_t$ is zero. In this case, a real depreciation can only boost profits by increasing exports, since the dollar price of exports remains unchanged. Thus, although $\mu$ is in general not identified from the profits equation, it is possible to test the null hypothesis that pass-through is complete.

## *4. Empirical Results*

We suspect that many, if not all, of the variables included in the profits equation implied by the theory are non-stationary in levels. We investigate this possibility with the augmented Dickey-Fuller (1981) t-test. Under the null hypothesis that a variable $x_t$ is difference - but not level - stationary, the regression:

$$(19) \qquad \Delta x_t = \alpha_0 + \alpha_1 t + \beta x_{t-1} + \rho \Delta x_{t-1} + e_{xt};$$

is run, and a t-test of the significance of $\beta$ is performed. Under the null, $\beta = 0$ and the t-ratio has a skewed distribution that has been investigated and tabulated by Dickey and Fuller (1981). The results of this test are reported in Table 1. There is no decisive evidence against the null hypothesis that each variable under study is non-stationary in levels, although in the case of real profits, production sold domestically, and the relative domestic price the t-ratios are sufficiently large so as to indicate at least some evidence against the null. We proceed under the assumption that all of the variables are I(1).

We next test for co-integration using the approach suggested by Granger and Engle (1987). To test the null hypothesis that $x_t$, $y_t$, and $z_t$ are not co-integrated, we first run the regression:

$$(20) \qquad x_t = \alpha + \alpha_1 t + \beta_1 y_t + \beta_2 z_t + e_{xt}.$$

Under the null, $e_{xt}$ is non-stationary. We perform an augmented Dickey-Fuller test on the estimated residuals in (20) by regressing the change in the estimated residual, $\Delta e_{xt}$ on one lagged level of the residual and lagged changes:

$$(21) \qquad \Delta e_{xt} = \delta \epsilon_{xt-1} + \rho_1 \Delta e_{xt-1} + \ldots + \rho_4 \Delta e_{xt-4} + v_{ext}.$$

The test is just a t-test on the coefficient $\delta$; the appropriate critical values are those reported in Phillips and Ouliaris (1989). The results for equation (18), the specification that imposes the first-order condition (16), are presented in Table 2.

As can be seen in the Table, the null hypothesis of no co-integration among real profits, domestic sales, the real exchange rate, real unit costs, the relative price of output, and exports can be rejected at the 5.0 percent level. This finding is important, because it means that it is possible to recover the "long run" relationship among these variables without the necessity of specifying correctly - or at all - the short-run dynamics. Note that according to our specification, these dynamics arise from stationary shocks to costs. Another interpretation that is consistent with the finding of co-integration is that the profit dynamics arise from sluggish adjustment of prices to real exchange rate changes, domestic demand, or costs. According to this "error correction" interpretation, a finding of co-integration implies that sluggish price adjustment induces a dynamic adjustment of real profits that is stationary about a long run equilibrium described by equation (18).

The finding of co-integration also implies that an OLS regression of real manufacturing profits on domestic sales, the real exchange rate, real unit costs, the relative price of output, and manufacturing exports is not a spurious regression in the sense of Granger and Newbold (1974). In fact, Stock proves that OLS is consistent, so that $\beta_{1ols}$ represents a consistent estimate of $(\theta-\eta\psi-\phi\psi)$, $\beta_{2ols}$ is a consistent estimate of $\gamma(1-\mu)$, $\beta_{3ols}$ is a consistent estimate of $-(\eta-\mu\gamma)$, $\beta_{4ols}$ is a consistent estimate of $(\theta - \phi)$, and $\beta_{5ols}$ represents a consistent estimate of $(\gamma-\eta(1-\psi)-\phi(1-\psi))$.

While OLS is consistent, it is not unbiased, and OLS standard errors cannot in general be used for statistical inference (Campbell and Perron (1991), p. 48). To estimate the parameters of the co-integrating vector, and to perform hypotheses tests, we employ the non-linear least squares approach of Phillips and Loretan (1991).

Phillips and Loretan (1991) propose a parametric procedure for estimating the co-integrating vector in an equation in which the variables are in fact known to be co-integrated. The Phillips and Loretan approach tackles the simultaneity problem by including lagged and lead values of the change in the regressors. The approach deals with the autocorrelation in the residuals by including lagged values of the stationary deviation from the co-integrating relationship. Phillips and Loretan prove that the estimates of the co-integrating vector obtained from this approach are asymptotically FIML. They also show that the Wald test can be used to test hypotheses about the parameters of the co-integrating vector.

Let $y_t$ denote the vector $[h_t,\ (s_t+q_t-p_t),\ (u_t-p_t),\ (p_{ht}-p_t),\ f_t]'$ and let $\beta$ denote the vector $[\beta_1,\ \beta_2,\ \beta_3,\ \beta_4,\ \beta_5]'$. The Phillips-Loretan equation is given by:

$$(22) \qquad \pi_t - p_t = \beta' y_t + \rho(\pi_{t-1} - p_{t-1} - \beta' y_{t-1}) + \sum_{i=1}^{5} \sum_{j=-\tau}^{\tau} \varphi_{ij}\, \Delta y_{it-j} + \epsilon_{\pi t}.$$

The $\beta$ vector is estimated by non-linear least squares. The implied estimates of $\beta$ along with standard errors and the results of Wald tests for the significance of each coefficient are reported in Table 3.

As can be seen from the Table, the estimated value of $\beta_2 = \gamma(1-\mu)$ is 0.57 which is statistically significant from 0 at the 5 percent level. This implies that the long run elasticity of real profits with respect to a real depreciation of the dollar is bounded below by 0.57. This estimate represents a lower bound because it ignores the pass-through of the real depreciation to foreign currency prices and the resulting rise in export volumes. According to the theoretical model, it is possible to test the hypothesis that, in the long run, pass-through is complete, $\mu = 1$. This is just a test that $\beta_2 = 0$. As noted above, this null hypothesis can be rejected at the 5 percent level.

The estimated value of $\beta_1$, the elasticity of real profits with respect to domestic sales is 2.21, significant at the 5 percent level, while the estimated value of $\beta_5$, the elasticity of real profits with respect to export volumes, is 0.52 and not statistically significant. According the theory, $\beta_1 = (\theta-\eta\psi-\phi\psi)$, the share of total profits that is earned from domestic sales. Thus, a long run elasticity of real profits with respect to domestic sales in excess of 1 seems large. A point estimate of $\beta_5 = (\gamma-\eta(1-\psi)-\phi(1-\psi))$, the share of total profits earned from export sales, equal to 0.52 also appears large, although as mentioned above this parameter is not estimated precisely.

The estimated value of $\beta_3 = -(\eta - \mu\gamma)$, the elasticity of real profits with respect to real unit costs, is -2.86, significantly less than zero at the 1 percent level. The estimated value of $\beta_4$, the elasticity of real profits with respect to the relative domestic price of output is 15.51, significant at the 1 percent level. According to the theory, $\beta_3 = (\theta - \phi)$, the difference between domestic revenues and fixed costs divided by total profits, so that an estimate of $\beta_3 = 15.51$ does appear to be a bit large.

The theory places two testable restrictions on the estimated coefficients. From (11) we know that $\theta + \gamma - \eta - \phi = 1$. It follows from (17) that the elasticities of real profits with respect to domestic output and exports sum to unity, and that the elasticities of real profits with respect to the real exchange rate, real unit costs, and the relative price of output sum to unity. Thus, a test of underlying model used to motivate the co-integrating regression:

$$(23) \qquad \pi_t - p_t = \beta_1 h_t + \beta_2(s_t+q_t-p_t) + \beta_3(u_t-p_t) + \beta_4(p_{ht}-p_t) + \beta_5 f_t + e_{\pi t};$$

is just the test that $\beta_1 + \beta_5 = 1$ and that $\beta_2 + \beta_3 + \beta_4 = 1$. Using a Wald test, the former restriction cannot be rejected at the 15 percent level, but the latter restriction can be rejected at the 1 percent level, even though each of $\beta_2$, $\beta_3$, and $\beta_4$ is significant and of the expected sign.

## *5. Assessments and Conclusions*

What are we to make of these results? Our findings suggest that, even after taking into account output, costs, and relative prices, real exchange rate fluctuations have a sizable and statistically significant influence on US manufacturing profits, a finding that is consistent with the version of Marston's (1990) model of pricing to market derived in this paper. Theoretically, the elasticity of real profits with respect to the real exchange rate is bounded below by the product of (i) 1 minus the pass-through coefficient and (ii) the ratio of export revenues to total profits. By contrast, we find that, after taking into account domestically sold output, costs, relative prices, and the real exchange rate, fluctuations in export volumes have a statistically insignificant influence on US manufacturing profits. Taken together, these finding are not inconsistent with our version of Marston's model of pricing to market if pass-through is incomplete.

Empirically, real manufacturing profits, domestic sales, unit costs, the real exchange rate, the US relative price of manufacturing output, and exports are found to be integrated variables. This fact, along with the profits equation derived in Section 2, is shown to imply that these variables are co-integrated. We rejected the hypothesis of no co-integration, and used this result to justify our estimation and testing of the model with the non-linear least squares approach suggested by Phillips and Loretan. The model places two testable restrictions across the coefficients of the profits equation. We were unable to reject at the 15 percent level the restriction that the elasticities of real profits with respect to domestic output and exports sum to unity. We were able to reject at the 1 percent level the restriction that the elasticities of real profits with respect to the real exchange rate, real unit costs, and the relative price of output sum to unity.

Thus, while the framework developed in this paper has been useful in obtaining an intuitive, co-integrated profits equation that reveals the significant long-run influence of real exchange rate fluctuations on real US manufacturing profits, the model underlying the profits equation is sufficiently well specified so as to be rejected by the data. The source of the rejection is not the sign or significance of the coefficients, but rather that three significant coefficients of the predicted sign fail to sum to unity. From this, it would not be unjustified to conclude that this framework is of some value in directing attention towards a heretofore neglected channel through which real exchange rate changes can potentially influence national savings.

## REFERENCES


Campbell, J. and P. Perron, "What Macroeconomists Should Know About Unit Roots," NBER Macroeconomics Annual, forthcoming, 1991.

Clarida, R., "Aggregate Stochastic Implications of the Life-Cycle Hypothesis," Quarterly Journal of Economics, forthcoming, 1991.

Clarida, R., "Co-integration, Aggregate Consumption, and the Demand for Imports: A Structural Econometric Investigation," Federal Reserve Bank of New York Working Paper, June 1991.

Clark, P., "Productivity and Profits in 1980's: Are They Improving?" Brookings Papers on Economic Activity, (1) 1984.

Dickey, D. and W. Fuller, "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root," Econometrica, (49), 1981.

Engle, R. and C. Granger, "Co-integration and Error Correction," Econometrica, (55) 1987.

Feenstra, R., "Symmetric Pass-Through of Tariffs and Exchange Rates Under Imperfect Competition," NBER Working Paper No. 2453, 1987.

Fuller, W., Introduction to Statistical Time Series, New York: John Wiley, 1976.

Goldstein, M. and M. Kahn, "Income and Price Effect in Foreign Trade," Chapter 20 in the Handbook of International Economics, Amsterdam: North Holland, 1985.

Giovannini, A., " Exchange Rates and Traded Goods Prices," Journal of Internation Economics, (24) 1985.

Granger, C., and P. Newbold, "Spurious Regression in Econometrics", Journal of Econometrics, (2) 1974.

Hickok, S., J. Hung, and K. Wulfekuhler, "An Expanded, Co-Integrated Model of US Trade," mimeo, Federal Reserve Bank of New York, June 1991.

Krugman, P., "Pricing to Market When the Exchange Rate Changes," in S. W. Arndt and J. D. Richardson, Real-Financial Linkages Among Open Economies, MIT Press: Cambridge MA, 1987.

Marston, R., "Pricing to Market in Japanese Manufacturing," Journal of International Economics, (29) 1990, 217-236.

Marquez, J., "The Econometrics of Elasticities or the Elasticities of Econometrics: An Empirical Analysis of the Behavior of US Imports," Discussion Paper, 396, Federal Reserve Board, 1991.

Phillips. P. and M. Loretan, "Estimating Long-Run Economic Equilibria," Review of Economic Studies, forthcoming, 1991.

Shiells, C., R. Stern, A. Deardorff, "Estimates of the Elasticity of Substitution Between Imports and Home Goods for the United States," Weltwirtschaftliches Archiv, (122) 1986.

Stock, J. and M. Watson, "Testing for Common Trends," Journal of the American Statistical Association, (83) 1988.

Stock, J. and M. Watson, "A Simple MLE of Cointegrating Vectors in Higher Order Integrated Systems," NBER Tech. Working Paper, no. 83, 1990.

## Appendix

The data used in this paper are obtained from the National Income and Product Accounts, the Bureau of Labor Statistics, and the Council of Economic Advisers. Tables refer to the NIPA accounts unless otherwise noted. The sample begins in 1973:2 with the collapse of the Smithsonian Agreement, the advent of floating rates, and the availability of a real exchange rate series with some variation. The sample ends in 1989:4 to allow for sufficient leads in the Phillips-Loretan estimation procedure.

$\pi_t$: Domestic manufacturing profits with inventory valuation and capital consumption adjustments, Table 6.18b. Billions of current dollars. Source: Department of Commerce, National Income and Product Accounts.

$P_t$: Implicit price deflator for the Gross National Product, Table 7.7. Source: Department of Commerce, National Income and Product Accounts.

$F_t$: Real merchandise exports, Table 4.4. Billions of 1982 dollars. Source: Department of Commerce, National Income and Product Accounts.

$H_t$: Real domestically sold production, billions of 1982 dollars. Calculated as the difference between the real output of goods, measured in billions of 1982 dollars and reported in Table 1.4, and real merchandise exports.

$S_tQ_t/P_t$: Multilateral trade-weighted value of the dollar, adjusted for differences in consumer prices. Sources: The Federal Reserve Board of Governors and the Council of Economic Advisers, Economic Report of the President, Table B-109, various issues.

$U_t$: Unit labor costs in manufacturing. Source: Bureau of Labor Statistics, Income and Productivity, various releases.

TABLE 1

**Testing for Unit Roots**

The Dickey-Fuller Regression: $\Delta x_t = \mu_0 + \mu_1 t + \beta x_{t-1} + \rho \Delta x_{t-1} + e_{xt}$.

| Variable | Estimated $\beta$ | t-ratio |
|---|---|---|
| $\pi - p$ | -0.185 | 2.720 |
| $h$ | -0.162 | 2.683 |
| $f$ | -0.270 | 0.720 |
| $u - p$ | -0.049 | 1.756 |
| $p_h - p$ | -0.099 | 2.797 |
| $s + q - p$ | -0.055 | 1.529 |

The Fuller (1976) critical values from Table 8.5.2 for a sample size of 100 are:

-3.15 at the 10 percent level;
-3.45 at the 5 percent level;
-4.04 at the 1 percent level.

The sample is 1973:2 through 1989:4. Variables are as defined in the text.

TABLE 2

**Testing for Co-Integration**

The Co-integrating Regression - Equation (18):

$$\pi_t - p_t = \alpha_0 + \alpha_1 t + \beta_1 h_t + \beta_2(s_t+q_t-p_t) + \beta_3(u_t-p_t) + \beta_4(p_{ht}-p_t) + \beta_5 f_t + e_{\pi t}.$$

The Dickey-Fuller Regression: $\Delta e_{\pi t} = \delta \epsilon_{\pi t-1} + \rho \Delta e_{\pi t-1} + v_{e\pi t}$

| Estimated $\delta$ | t-ratio |
|---|---|
| -0.568 | 5.094** |

The Phillips-Ouliaris(1989) critical values from Table IIa are:

-4.73 at the 10.0 percent level***;
-5.02 at the 5.0 percent level**;
-5.58 at the 1.0 percent level*.

The Dickey-Fuller residual regression was run with up to 4 lags of $\Delta e_{\pi t-j}$, and the lag length used to calculate the t statistic for $\delta$ was chosen as recomended by Campbell and Perron (1991).

TABLE 3

**Estimation of the Parameters**

**Phillips and Loretan(1991) Non-Linear Least Squares**

$$y_t = [h_t,\ (s_t+q_t-p_t),\ (u_t-p_t),\ (p_{ht} - p_t),\ f_t]'.$$

Phillips-Loretan equation:

$$\pi_t - p_t = \theta' y_t + \rho(\pi_{t-1} - p_{t-1} - \theta' y_{t-1}) + \sum_{i=1}^{i=5} \sum_{j=-\tau}^{j=\tau} \varphi_{ij} \Delta y_{it-j} + \epsilon_{\pi t}.$$

The non-linear least squares estimates of $\theta$ are:

| Coefficient | Estimated Value |
|---|---|
| $\beta_1$ | 2.214** (1.074) |
| $\beta_2$ | 0.575** (0.290) |
| $\beta_3$ | -2.867* (1.045) |
| $\beta_4$ | 15.508* (4.083) |
| $\beta_5$ | 0.526 (0.510) |

The Wald statistic for a test of the hypothesis that $\beta_i = 0$, is distributed as chi-square with 1 degree of freedom:

* significant at the 1 percent level;
** significant at the 5 percent level;
*** significant at the 10 percent level.

The sample is 1973:2 to 1989:4. A constant and a trend were also included in the equation. Variables are defined in text.