

**The Real Exchange Rate and U.S. Manufacturing Profits:
A Theoretical Framework with Some Empirical support**

by
Richard H. Clarida, Columbia University

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Richard H. Clarida
Columbia University
The National Bureau of Economic Research
The Federal Reserve Bank of New York

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ABSTRACT

This paper investigates the relationship between manufacturing profits and the real exchange rate. Using Marston's (1990) model of pricing-to-market, we identify two channels, a valuation channel and volume channel, through which changes in the real exchange rate can shift the profits of a price-setting exporter. Employing the econometric approach developed Johansen (1990;1991), we estimate a dynamic vector error correction model on quarterly data for real US manufacturing profits and five variables that theory suggests should be useful in accounting for the behavior of real profits in an open economy: domestically sold output, the real exchange rate, real unit costs, the relative price of domestically sold output, and real foreign income. Finding evidence of cointegration, we estimate via maximum likelihood the single cointegrating relationship that is defined by the conditional probability distribution of real manufacturing profits implied by the VECM. We test, and confirm, that both real profits and the real exchange rate are elements of this cointegrating vector, and interpret this cointegrating relationship as a long-run open economy profits equation. Our estimates imply that, holding constant domestic sales, real unit costs, the relative price of domestic output, and real foreign income, the long-run elasticity of real profits with respect to the real exchange rate exceeds 0.80.

Richard H. Clarida
Department of Economics
Columbia University
Room 1020
International Affairs Bld.
New York NY 10027

(212)-854-2512

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1. Introduction

This paper investigates the relationship between manufacturing profits and the real exchange rate. Using Marston's (1990) model of pricing-to-market, we identify two channels, a valuation channel and volume channel, through which changes in the real exchange rate can shift the profits of a price-setting exporter. We show that, via the valuation channel, the elasticity of real profits with respect to the real exchange rate is given by the product of (i) 1 minus the pass-through coefficient and (ii) the ratio of export revenues to total profits. Via the volume channel, the elasticity of real profits with respect to the real exchange rate is given by the product of (i) the pass-through coefficient; (ii) the price elasticity of demand; and (iii) the ratio of export profits 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 remain unchanged but dollar profits per unit sold abroad rise dollar for dollar with the jump in dollar price of foreign exchange. A real depreciation of the dollar should boost the profits of US manufacturers *regardless of whether pass-through is complete, partial, or non-existent.*

Employing the econometric approach developed by Soren Johansen (1990;1991) and Peter Phillips (1990), we estimate a dynamic vector error correction model on quarterly data for real US manufacturing profits and five variables that theory suggests should be useful in accounting for the behavior of real profits in an open economy: domestically sold output, the real exchange rate, real unit costs, the relative price of domestically sold output, and real foreign income. All variables are found to possess unit roots. We test and reject the hypothesis that there are no "long-run", cointegrating relationships among these variables. We then estimate the single cointegrating relationship that is defined by the conditional probability distribution of real manufacturing profits implied by the VECM. We test, and confirm, that both real profits and the real exchange rate are elements of the cointegrating vector, and interpret this cointegrating relationship as a long-run open economy profits equation. Our estimates imply that, holding constant domestic sales, real unit costs, the relative price of domestic output, and real foreign income, the long-run elasticity of real profits with respect to the real exchange rate exceeds 0.80.

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.

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

where π_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. In anticipation of the empirical work, we assume that variable cost are given by:

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

where W_t is the dollar wage, ϵ_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 v_t we observe:

$$(3) \quad U_t = (VC_t / (H_t + F_t)) v_t$$

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

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

where ξ_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):

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

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

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:

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

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:

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

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

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, $S_t Q_{ft}$, 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 $S_t Q_{ft}$ 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 proceed to derive an equation that can be used to illustrate this reasoning and that can be used to motivate the empirical work to follow.

Totally differentiating (1), using (3), and dividing by π_t , we obtain:

$$\begin{aligned}
 (9) \quad d\pi_t/\pi - dP_t/P = & [\theta - (\eta + \phi)\psi]_t dH_t/H + [\theta - \phi]_t (dP_{ht}/P_h - dP_t/P) \\
 & + \gamma_t (dS_t/S - dP_t/P) - \eta_t (dU_t/U - dP_t/P) + \gamma_t dQ_{ft}/Q_f \\
 & + [\gamma - (\eta + \phi)(1 - \psi)]_t dF_t/F \\
 & + \eta_t dv_t/v - \phi_t d\xi_t/\xi;
 \end{aligned}$$

where θ_t , γ_t , η_t , ϕ_t , and ψ_t are given by:

$$\begin{aligned}
 (10) \quad \theta_t &= P_{ht} H_t / \pi_t; \\
 \gamma_t &= S_t Q_{ft} F_t / \pi_t; \\
 \eta_t &= VC_t / \pi_t; \\
 \phi_t &= K_t / \pi_t; \\
 \psi_t &= H_t / (H_t + F_t).
 \end{aligned}$$

From (1), the restriction $\theta_t + \gamma_t - \eta_t - \phi_t = 1$ must hold period by period.

As demonstrated in Marston (1990), the pass-through coefficient μ_t is related to the elasticity of the markup $N_t = e_{ft}/(e_{ft} - 1)$ with respect to the foreign currency price Q_{ft} , $-(\partial N_t / \partial Q_{ft})(Q_{ft}/N) = r_t$. In fact, with constant marginal cost:

$$(11) \quad \mu_t = 1/(1 + r_t).$$

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

$$(12) \quad S_t Q_{ft} = MC_t N(Q_{ft}/Q_t).$$

where we have imposed the assumption that the foreign demand curve is weakly-separable in foreign income. Totally differentiating (12), dividing by Q_{ft} , substituting into (9), and using the fact that

$$(13) \quad dF_t/F_t = e_{ft} d\log(Q_{ft}/Q_t) + e_{yft} d\log(Y_{ft});$$

where e_{yft} is the foreign activity elasticity of demand, we obtain the following relationship between profits, domestic sales, costs, the real exchange rate, and domestic prices:

$$\begin{aligned}
(14) \quad d\pi_t/\pi - dP_t/P &= [\theta - \eta\psi - \phi\psi]_t dH_t/H + [\theta - \phi]_t (dP_{ht}/P_h - dP_t/P) \\
&+ [\gamma(1-\mu) + \mu e_f(\gamma - \eta(1-\psi) - \phi(1-\psi))]_t (dS_t/S + dQ_t/Q - dP_t/P) \\
&- [\eta - \mu\gamma + \mu e_f(\gamma - \eta(1-\psi) - \phi(1-\psi))]_t (dU_t/U - dP_t/P) \\
&+ [\gamma - \eta(1-\psi) - \phi(1-\psi)]_t e_{yft} dY_{ft}/Y_{ft} \\
&+ [\eta - \mu Q]_t dv_t/v - \phi_t d\xi_t/\xi.
\end{aligned}$$

There are two channels through which a real exchange rate depreciation can boost the real profits of a US exporter, a *valuation* channel and a *volume* channel. Via the *valuation* channel, any exchange rate depreciation that is not fully passed through to the foreign currency price will result in an increase in the dollar value of export sales for any given volume of exports. Via the *volume* channel, any exchange rate depreciation that is at least partially passed through will lower the foreign currency price of the export, boosting export volumes and profits for any given dollar value per unit exported. From equation (14), the elasticity of real profits with respect to a real depreciation is given by:

$$(15) \quad d\log(\pi_t/P_t)/d\log(S_t Q_t/P_t) = [\gamma_t(1 - \mu_t)] + [\mu_t e_{ft}(\gamma - \eta(1-\psi) - \phi(1-\psi))]_t.$$

The first bracketed term reflects the influence of the valuation effect on exporter profits, while the second term reflects the the volume effect.

As shown in Marston (1990) and Feenstra (1987), if marginal cost is constant, the price charged on domestic sales P_{ht} is unchanged in response to an exchange rate depreciation. If, in addition to marginal cost, the markup is constant, the exporter finds it optimal to pass-through fully any depreciation of

the exchange rate. If the foreign markup is not constant but declines with a rise in the product price Q_{ft} - as will be the case for any demand curve that is less convex than the log linear demand curve - pass-through is incomplete.

It is easily verified that profits are homogenous of degree one and that sales volumes and real profits are homogenous of degree zero in domestic nominal disturbances that are fully reflected in the nominal exchange rate. An equiproportional increase in dollar production costs and the US price level, when accompanied by an equiproportional depreciation of the dollar, will induce the price setting exporter to raise its domestic price by a like amount - since $P_{ht} = MC_t M(P_{ht}/P_t)$ - and to leave its foreign currency price unchanged. With no shift in relative home and foreign prices, sales volume and real profits remain unchanged. We also note that an increase in the foreign price level, when accompanied by an equiproportional appreciation of the dollar, will induce the price setting exporter to raise its foreign currency price by a like amount, leaving exports export revenues, and nominal and real profits unchanged.

This being said, a depreciation of the dollar in excess of any rise in domestic prices and dollar production costs 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. The Data and Empirical Preliminaries

The data used in this paper are quarterly, seasonally adjusted series obtained from the National Income and Product Accounts, the Bureau of Labor Statistics, and the Council of Economic Advisers. The sample begins in 1973:2 and ends in 1990:4. Throughout, logs will be denoted by lower case letters, so that, for example, $s_t + q_t - p_t = \log(S_t Q_t / P_t)$. The series are as follows:

π_t : Domestic manufacturing profits with inventory valuation and capital consumption adjustments, Table 6.18b NIPA. 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.

P_{ht} : Implicit price deflator for Goods Output, Table 7.8. 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.

$S_t Q_t / P_t$: 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 production costs in manufacturing. Source: Bureau of Labor Statistics, Monthly Labor Review, various issues.

Y_{ft} : Trade-weighted geometric average of G6 real GDP expressed in 1980 dollars. Source: OECD Main Economic Indicators.

We suspect that many, if not all, of the variables under study are non-stationary in levels but stationary in first-differences. We investigate this hypothesis with the augmented Dickey-Fuller (1981) t-test. Under the null hypothesis that a variable x_t is difference not level stationary, the regression:

$$(16) \quad \Delta x_t = \alpha_0 + \alpha_1 t + \beta x_{t-1} + \rho_1 \Delta x_{t-1} + \dots + \rho_p \Delta x_{t-p} + e_{xt};$$

is run, and a t-test of the significance of β 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 applied to quarterly data in log levels for the floating rate period, 1973:4-1990:4, are reported in Table 1. There is no decisive evidence against the null hypothesis that each variable under study is non-stationary in log levels, although in the case of real profits, production sold domestically, the relative domestic price, and even the real exchange rate, the t-ratios are sufficiently large so as to indicate at least some evidence against the null. We proceed under the working hypothesis that all of the variables are I(1).

4. An Empirical Specification

Based upon the theoretical relationship derived in equation (14) and our finding that the variables under study are I(1), we investigate a dynamic vector error correction model (Hendry (1986), Engle and Granger (1987), Johansen (1988)) for real manufacturing profits, domestically sold production, the real exchange rate, real unit costs, the relative price of domestically sold output, and foreign income. Letting $y_t = [(\pi_t - p_t), h_t, (s_t + q_t - p_t), (u_t - p_t), (p_{ht} - p_t), y_{ft}]'$ denote the $n = 6$ by 1 vector of the system's variables, the vector error correction model can be written:

$$(17) \quad \Delta y_t = \mu + \Gamma_1 \Delta y_{t-1} + \dots + \Gamma_{k-1} \Delta y_{t-k+1} + \Pi y_{t-k} + \zeta_t.$$

If the matrix Π is of full rank $r = n$, the VECM reduces to the usual VAR in the levels of stationary variables. If Π is the null matrix so that $r = 0$, the VECM represents a VAR in first-differences. The VECM differs from the usual VAR in that it allows for the existence of long-run "equilibrium" relationships among a system's variables. If the matrix Π is of reduced rank $r < n$, it can be factored into the product of two n by r matrices α and β such that:

$$(18) \quad \phi = \alpha\beta'.$$

where β' is the r by n matrix of the system's r *cointegrating vectors*, and α is the n by r matrix of r *adjustment coefficients* for each of the system's n equations. Each cointegrating relationship defines a *long run equilibrium* to which the system ultimately returns after a shock. The r parameters in each of the n rows of the α matrix determine the rates at which each of the system's n variables adjust in response to lagged deviations:

$$(19) \quad z_{t-k} = \beta'y_{t-k};$$

from the r cointegrating relationships.

The presence of cointegration - a linear combination of $I(1)$ variables that is itself stationary and thus $I(0)$ - among a system's variables has a important implications for both the modeling and estimation of the short and long-run relationships among the variables. By the Granger Representation Theorem (1987), the existence of a cointegrating relationship among the elements of y_t implies that a vector autoregression (VAR) in first-differences Δy_t will not exist, but that a VECM of the form (17) must exist. In the typical case in which Δy_t is stationary about a vector of drifts δ , these drifts or growth rates must satisfy the cointegrating restrictions $\beta'\delta = 0$.

5. Empirical Results

Table 2 presents the results of two tests developed by Johansen to investigate the hypothesis that the number of cointegrating vectors in a system of n variables is less than or equal to r . According to both the trace and the λ -max statistic, we cannot reject the hypothesis that $r \leq 2$, but, using the trace statistic, we can reject at the 5% level the hypothesis that the number of cointegrating vectors is less than or equal to 1. However, using the λ -max statistic, we cannot reject the hypothesis that $r \leq 1$ against the alternative that $r \leq 2$. We draw from this evidence the tentative conclusion that there are most likely two cointegrating vectors that restrict the long-run behavior of this system of 6 variables, but we recognize that, as pointed out by Campbell and Perron (1991), in finite samples a system of 2 cointegrating vectors can be arbitrarily well approximated by a system containing 1 cointegrating vector.

Following the lead of Phillips (1990) and Johansen (1990), we investigate a transformation of the VECM that represents a projection of one variable, the growth in real US manufacturing profits $\Delta(\pi_t - p_t)$, on the current values of the other variables in the system Δy_{2t} and on the relevant history of the system $\Delta y_{t-1}, \dots, \Delta y_{t-k+1}, y_{t-k}$:

$$(20) \quad \Delta(\pi_t - p_t) = E[\Delta(\pi_t - p_t) | \Delta y_{2t}, \Delta y_{t-1}, \dots, \Delta y_{t-k+1}, y_{t-k}] + u_t$$

where $y_{2t} = [h_t, (s_t + q_t - p_t), (u_t - p_t), (p_{ht} - p_t), y_{ft}]'$. This of course is nothing more than a traditional error-correction equation for $\Delta(\pi_t - p_t)$. Johansen shows that, given the time path of Δy_{2t} and the relevant history of the system as summarized by the VECM, the conditional distribution for $\Delta(\pi_t - p_t)$ defines a single cointegrating vector that restricts the long-run relationship between

profits, domestic sales, the real exchange rate, unit costs, the US relative price of manufactures, and real foreign income. This single cointegrating vector that is defined by the VECM and the conditional distribution for $\Delta(\pi_t - p_t)$, call it $\beta^{(1)}$, is just a weighted average of the system's r cointegrating vectors, where the weights are a function of the adjustment coefficients α_{ij} in the system's n equations as well as the variance-covariance matrix Ω of the system's innovations. In particular, letting β_{ij} denote the coefficient on the j th element of y_{t-k} in cointegrating vector $i = 1, 2$ Johansen(1990) proves that, after normalizing so that $\beta^{(1)}_1 = 1$, $\beta^{(1)}_j$ is given by:

$$(21) \quad \beta^{(1)}_j = \beta_{1j} + [(\sum_{m=1, p} \Lambda_m \alpha_{2m}) / (\sum_{m=1, p} \Lambda_m \alpha_{1m})] \beta_{2j};$$

where the weights Λ_m , $m = 1, \dots, n$, are functions of the elements of Ω , explicit expressions for which are given in Johansen (1990). The adjustment coefficient $\alpha^{(1)}$ that is defined by the conditional distribution of $\Delta(\pi_t - p_t)$ is simply:

$$(22) \quad \alpha^{(1)} = \sum_{m=1, p} \Lambda_m \alpha_{1m};$$

so long as $\beta_{11} = 1$ and $\beta_{21} = 0$, conditions that can always be satisfied after normalization (Phillips (1990)) of the r cointegrating vectors in the full system.

Table 3 reports maximum likelihood estimates of $\beta^{(1)}$ and $\alpha^{(1)}$, two key parameters of the conditional distribution for $\Delta(\pi_t - p_t)$ defined by (20). The estimated cointegrating vector $\beta^{(1)}$ for the profits equation

$$(23) \quad \begin{aligned} \pi_t - p_t = & 1.70h_t + 0.83(s_t + q_t - p_t) - 2.89(u_t - p_t) \\ & + 13.23(p_{ht} - p_t) + 1.31y_{ft}; \end{aligned}$$

indicates that the long-run elasticity of real profits with respect to the real exchange rate is 0.83. All other elasticities are of the expected sign and appear to be of plausible magnitudes. We note that the estimated value of the adjustment coefficient:

$$\alpha^{(1)} = -0.63$$

indicates that real manufacturing profits tend to adjust rapidly in response to a shock that pushes profits away from the long-run equilibrium relationship defined by (23).

We now present estimates of and test restrictions on the two cointegrating vectors β_1 and β_2 that, according to the Johansen trace statistic, are present in the full system. From the results obtained in Phillips (1990), we know that in an n variable system with r cointegrating vectors, it must be possible to select r variables, $y^{(1)}_t \dots y^{(r)}_t$, such that the r cointegrating relations can be written as:

$$(24) \quad \begin{aligned} y^{(1)}_t &= \sum_{j=r+1, n} \beta_1 j y^{(j)}_t + \epsilon^{(1)}_t; \\ y^{(2)}_t &= \sum_{j=r+1, n} \beta_2 j y^{(j)}_t + \epsilon^{(2)}_t; \\ y^{(r)}_t &= \sum_{j=r+1, n} \beta_r j y^{(j)}_t + \epsilon^{(r)}_t. \end{aligned}$$

These r cointegrating vectors form a basis for the space of all possible such vectors. We test to see if there exists a cointegrating vector that includes $(\pi_t - p_t)$ and that excludes real foreign income y_{ft} . As shown in Table 4, both the trace and λ -max statistics indicate that among the variables $(\pi_t - p_t)$, h_t , $(s_t + q_t - p_t)$, $(u_t - p_t)$, and $(p_{ht} - p_t)$ there is 1 cointegrating relation. Table 4 also reports the result of a χ^2 test of the hypothesis that $(\pi_t - p_t)$ is not an

element of this cointegrating relation. This hypothesis can be rejected at the 1% level. A χ^2 test of the hypothesis that $(s_t+q_t-p_t)$ is not an element of this cointegrating relation can be rejected at the 2% level. We conclude that one of the two vectors that form the basis for the cointegrating space of this system can be expressed as:

$$(25) \quad \pi_t - p_t = 2.24h_t + 0.90(s_t+q_t-p_t) - 2.17(u_t - p_t) + 9.75(p_{ht} - p_t);$$

the single cointegrating relation among (π_t-p_t) , h_t , $(s_t+q_t-p_t)$, (u_t-p_t) , and $(p_{ht}-p_t)$ that is estimated by the Johansen procedure.

We next test to see if there exists a cointegrating vector that includes y_{ft} and that excludes $(\pi_t - p_t)$. As shown in Table 5, both the trace and λ -max statistics indicate that among the variables y_{ft} , h_t , $(s_t+q_t-p_t)$, (u_t-p_t) , and $(p_{ht}-p_t)$ there is 1 cointegrating relation. The cointegrating vector that includes all 5 of these variables does not yield to an obvious interpretation. Table 5 reports the result of a hypothesis test that (u_t-p_t) and $(p_{ht}-p_t)$ are not elements of this cointegrating relation β_2 . This hypothesis cannot be rejected as is seen from the 0.35 p-value of the $\chi^2(2)$ statistic. A χ^2 test of the hypothesis that y_{ft} can also be excluded from this cointegrating relation β_2 can be rejected at the 1% level. We conclude that the second of the two vectors that form the basis for the cointegrating space of this system can be expressed as:

$$(26) \quad y_{ft} = h_t + 0.16(s_t+q_t-p_t);$$

the single cointegrating relation, suitably normalized and restricted, among y_{ft} , h_t , $(s_t+q_t-p_t)$, (u_t-p_t) , and $(p_{ht}-p_t)$ that is estimated by the Johansen procedure. According to the cointegrating relation (26), a permanent 1 percent jump in the ratio of foreign national product to domestically sold manufactured output is accompanied over the long run by a 6 percent real depreciation of the dollar.

6. Assessments and Conclusions

What are we to make of these results? Our findings suggest that, even after taking into account output, costs, relative prices, and foreign income, shifts in the real exchange rate have, over the floating rate period, had a sizable and statistically significant influence on real US manufacturing profits, a finding that is consistent with the version of Marston's (1990) model of pricing to market derived in this paper.

Empirically, real manufacturing profits, domestic sales, unit costs, the real exchange rate, relative price of manufactures in the US, and foreign income are found to be integrated variables. We have presented evidence that these variables are in fact cointegrated, and used this finding to justify our estimation of the long-run relationship among these variables that is implied the conditional probability distribution of real manufacturing profits.

The framework developed in this paper has been useful in obtaining an intuitive, empirically tractable open economy profits equation that reveals the significant long-run influence of real exchange rate fluctuations on real US manufacturing profits. In light of the results reported in this paper, we 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.

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TABLE 1

Testing for Unit Roots

Dickey-Fuller Regression

$$\Delta x_t = \mu_0 + \mu_1 t + \beta x_{t-1} + \rho_1 \Delta x_{t-1} + \dots + \rho_4 \Delta x_{t-4} + e_{xt}$$

| Variable | Estimated β | t-ratio |
|----------|-------------------|---------|
| ----- | ----- | ----- |
| $\pi-p$ | -0.191 | 2.800 |
| h | -0.169 | 2.725 |
| y_f | -0.063 | 0.877 |
| $u-p$ | -0.059 | 2.210 |
| p_h-p | -0.097 | 2.610 |
| $s+q-p$ | -0.041 | 2.706 |

The Fuller (1976) critical values from Table 8.5.2 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 1973:4 through 1990:4. Variables are as defined in the text. The Dickey-Fuller regression was run with up to $p=4$ lags of Δx_{t-j} , and the lag length used to calculate the t statistic for β was chosen as recommended by Campbell and Perron (1991).

TABLE 2

Testing for the Number of Cointegrating Vectors
among
 $(\pi_t - p_t)$, h_t , $(s_t + q_t - p_t)$, $(u_t - p_t)$, $(p_{ht} - p_t)$, y_{ft}

| <i>Hypothesis</i> | <i>trace</i> | <i>trace</i> <i>(0.95)</i> | <i>λ-max</i> | <i>λ-max</i> <i>(0.95)</i> |
|-------------------|--------------|-------------------------------|--------------|-------------------------------|
| $r \leq 2$ | 43.03 | 47.21 | 22.93 | 27.07 |
| $r \leq 1$ | 73.42 | 68.52 | 30.38 | 33.46 |
| $r = 0$ | 114.06 | 94.16 | 40.63 | 39.37 |

Critical values are from Osterwald-Lenum (1991) Table II. VECM contains a constant μ and $k-1 = 2$ lags of Δy . The sample is 1973:4 through 1989:4.

TABLE 3

MLE Estimates of $\alpha^{(1)}, \beta^{(1)}$

$$\begin{aligned}\pi_t - p_t &= 1.70h_t + 0.83(s_t + q_t - p_t) - 2.89(u_t - p_t) \\ &\quad + 13.23(p_{ht} - p_t) + 1.31y_{ft} \\ \alpha^{(1)} &= -0.63\end{aligned}$$

The estimate $\beta^{(1)}$ is obtained from the linear projection $E[\Delta(\pi_t - p_t) | \Delta y_{2t}, \Delta y_{t-1}, \dots, \Delta y_{t-k+1}, y_{t-k}]$, the MLE for a single equation in a VECM with normal errors.

TABLE 4

Testing for the Number of Cointegrating Vectors
among
($\pi_t - p_t$), h_t , ($s_t + q_t - p_t$), ($u_t - p_t$), ($p_{ht} - p_t$)

| <i>Hypothesis</i> | <i>trace</i> | <i>trace</i> (0.95) | λ -max | λ -max (0.95) |
|-------------------|--------------|------------------------|----------------|--------------------------|
| $r \leq 1$ | 43.12 | 47.21 | 23.54 | 27.07 |
| $r = 0$ | 72.92 | 68.52 | 29.79 | 33.46 |

Critical values are from Osterwald-Lenum (1991) Table II. VECM contains a constant μ and $k-1 = 2$ lags of Δy . The sample is 1973:4 through 1989:4.

The Estimated Cointegrating Vector β_1

$$\pi_t - p_t = 2.24h_t + 0.90(s_t + q_t - p_t) - 2.17(u_t - p_t) + 9.75(p_{ht} - p_t)$$

Testing Exclusion from the Cointegrating Vector β_1

| <i>Hypothesis</i> | $\chi^2(1)$ | <i>p-value</i> |
|-------------------|-------------|----------------|
| $\beta_{11} = 0$ | 6.20 | 0.01 |
| $\beta_{12} = 0$ | 5.07 | 0.02 |

TABLE 5

Testing for the Number of Cointegrating Vectors
among
 $y_{ft}, h_t, (s_t+q_t-p_t), (u_t-p_t), (p_{ht}-p_t)$

| Hypothesis | trace | trace (0.95) | λ -max | λ -max (0.95) |
|------------|-------|-----------------|----------------|--------------------------|
| $r \leq 1$ | 44.93 | 47.21 | 26.25 | 27.07 |
| $r = 0$ | 84.08 | 68.52 | 39.15 | 33.46 |

Critical values are from Osterwald-Lenum (1991) Table II. VECM contains a constant μ and $k-1 = 2$ lags of Δy . The sample is 1973:4 through 1989:4.

The Estimated Cointegrating Vector β_2

$$y_{ft} = h_t + 0.16(s_t+q_t-p_t)$$

Testing Exclusion from the Cointegrating Vector β_2

| Hypothesis | χ^2 | p-value | d.f. |
|---|----------|---------|------|
| $\beta_{24}=\beta_{25}=0$ | 2.08 | 0.35 | 2 |
| $\beta_{21}=\beta_{24}=\beta_{25}=0$ | 22.89 | 0.01 | 3 |
| $\beta_{24}=\beta_{25}=0$ $-\beta_{21}=\beta_{22}$ | 2.24 | 0.52 | 3 |
