

# FLUCTUATIONS IN CURRENCY VALUE AND THE AGGREGATE PROFIT OF THE U.S. MANUFACTURING SECTOR

Ki-ho Kim and Charles T. Davidson

This paper reports evidence that the aggregate profit of the U.S. manufacturing industry is affected by fluctuations in the real exchange rate of the dollar. Using quarterly data covering the 1975Q1-1993Q4 period, regression of the manufacturing profit on the exchange rate and other key variables reveals a significant negative relationship between the dependent variable and the exchange rate. The estimated regression coefficient indicates that a 1% change in the dollar value will change the profit in the opposite direction by 0.56%. It was also found that the manufacturing unit labor cost and raw materials price are negatively related to the manufacturing profit and that the manufacturing capacity utilization rate and the aggregate income level are positively related to the profit level. Unit root and cointegration tests ascertained that the variables have long-run equilibrium relationships. A vector autoregressive analysis further confirmed the relationship.

## I. INTRODUCTION

The exchange rate of the dollar is now widely recognized as one of the important determinants of U.S. business profit because fluctuations in the value of the dollar affect all prices in the economy. Interest in the effect of the exchange rate on U.S. corporations has recently been heightened by the extraordinary volatility of the dollar exchange rate during the mid-1980s and the ever-increasing exposure of U.S. firms to foreign competition.

There has been a considerable number of empirical studies analyzing the effect of exchange rate changes on import and export prices and on external balances. However, there has been a relative paucity of empirical investigations into the direct relationship between the value of the dollar and the profitability of American firms.

Many of the previous investigations focused on the relationship between changes in the foreign exchange values and the export or import prices (the so-called pass-through effect) and have implied the profitability of domestic firms. Thus Mann [15], using quarterly data from 1977 to 1985, discovered evidence that about 60% of the dollar exchange rate changes was passed through to the dollar price of non-oil imports over a two-year period. From this, she inferred that as the dollar depreciated (appreciated) foreign profit margins tended to fall below (rise

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above) their normal levels. Evidence of U.S. exports of non-agricultural goods, in contrast, suggested that the profit margin of U.S. exporters was hardly affected by the exchange rate fluctuations: pass-through for U.S. exports was close to 100%; i.e., the foreign currency price of U.S. exports rose almost one-for-one with the dollar appreciation.

Dornbusch [2] relied on various models of industrial organization to explain price adjustments in terms of the degree of market concentration, the extent of product homogeneity and substitutability, and the relative market shares of domestic and foreign firms. His analysis predicted that a dollar appreciation would lead to a decline in the U.S. price of imports but that the extent of the drop depended on the homogeneity of goods, the competition, and the number of home and foreign firms in the market. For U.S. exports, the models showed that the relative (export/import) prices generally remained unchanged as a result of dollar appreciation. Absence of appropriate data, unfortunately, prevented Dornbusch from conducting a rigorous empirical test of the models; but his "informal" quantitative analysis confirmed the analytical findings.

In a similar analytical work, Fisher [5] confirmed the link between exchange rate changes and import prices and concluded that the pass-through depended on the market structure. Ohno [17], studying exchange-rate-caused pricing behaviors of U.S. and Japanese businesses, attributed the differing degree of pass-through to firms' planning horizons and the existence of hysteresis. In particular, he showed that if Japanese exporters are long-term maximizers while U.S. businessmen are short-term maximizers, pass-through to U.S. prices would be lower and Japanese export penetration in the U.S. market higher.

Using an extensive collection of data from the U.S. and nine other industrial nations that accounted for more than 75% of U.S. imports of manufactured goods, Hooper and Mann [8] found a significant and negative relation between the value of the dollar and U.S. import prices of manufactured goods. More specifically, they estimated the impact of pass-through to be about 20%; but over a period of five to seven quarters, the import prices changed by about 60% of the exchange rate fluctuations.

While many of the studies focused on U.S. experiences, Khosla and Teranishi [12] examined export price behaviors of 23 countries and discovered substantial differences in the degree of pass-through among them. They found that the international differences in pass-through were strongly influenced by the trade composition of individual countries; i.e., the nations with a higher proportion of final goods in their export mix had a higher pass-through of changes in exchange rates to export prices than did the countries where exports of raw materials predominated.

In a related endeavor, Ma and Kao [13] employed monthly data from 1973 to 1983 to investigate the impact of exchange rate fluctuations on the relative stock prices of the seven industrialized countries. Their findings showed that the equilibrium relative stock prices were negatively related to exchange rate changes but positively related to exchange rate levels.

One recent study linked foreign exchange rates directly to the profitability of U.S. manufacturing firms. Hung [9] used a large number of variables in a three-equation, simultaneous system to evaluate the overall impact of exchange rate swings on the aggregate profits of domestic firms since 1973. The author found that a sustained appreciation in the dollar exchange rate had a significant negative effect on the profit level of U.S. firms.<sup>1</sup>

In this paper, we engage in empirical research on factors that influence the profitability of U.S. manufacturing corporations. Among the variables considered as significant determinants of the aggregate profit is the dollar exchange rate because the fluctuations in the dollar value have had a considerable effect on corporate profit. The purpose of this study is to provide empirical evidence of a direct linkage between the dollar exchange rate and the profitability of U.S. manufacturing firms.

Hung [9] tackled the problem by employing more than a dozen variables and using traditional regression analysis. This approach features a theoretical dichotomy in endogenous and exogenous variables. The current study uses a much smaller number of variables and a single-equation model. In addition, we extend the analysis by utilizing a cointegration method, which ascertains whether variables in a model have long-run equilibrium relationships, and a vector autoregressive (VAR) system, which is a popular statistical technique employed in dealing with the problem of categorizing endogenous and exogenous variables on *a priori* basis.

Our findings indicate that all the factors we examine have significant effects on manufacturing profits. In particular, the value of the dollar is negatively related to the aggregate profit of the manufacturing sector.

This paper is organized as follows: analytical framework and data are described in Section II, followed by regression and other statistical tests in Section III. Section IV presents concluding remarks.

## II. ANALYTICAL FRAMEWORK AND DATA

Of many complex factors influencing business profit, we selected six variables to account for manufacturing profit. The model features profit (PF) as a function of the dollar exchange rate (ER), the manufacturing capacity utilization rate (CU), the manufacturing unit labor cost (LC), raw industrial materials price (MP), interest rate (R), and disposable personal income (Y) of the United States; i.e.,

$$PF = a_0 + a_1ER + a_2CU + a_3LC + a_4MP + a_5R + a_6Y + u \quad (1)$$

While the model may be criticized as being too naive and simple to describe the intricate phenomenon of profit determination, we believe it is adequate to capture the essential relationships among the variables. Furthermore, the parsimonious and simple nature of the model is justified in view of the well-known

fact that large and elaborate models do not necessarily fare better than smaller and unsophisticated versions. Besides, the number of variables has to be limited in a VAR analysis in order to save degrees of freedom.

It is hypothesized that PF is negatively related to ER, LC, MP, and R and positively related to CU and Y. The theorized relationship of PF to the independent variables is straightforward. Higher capacity usage rates translate into a lower average cost of production as fixed costs are shared by more units of output, whereas increases in unit labor cost, materials price, and interest rate mean less profit, assuming firms cannot pass on the increased costs to product prices in the short run. Firms experience increased demand for their products and find it easier to raise prices when income is rising.

The relationship between PF and ER is more tangled and difficult to extricate. First, we have to distinguish between exporters and importers/producers of importables. Variations in the exchange rate cause the prices of importables and exportables, and, consequently, the profit, to change in the opposite direction. For example, depreciation of the dollar brings about higher import prices and leads to price increases for domestic goods, while domestic exporters have incentives to raise the dollar prices as their products become cheaper in foreign currencies. Appreciation of the dollar has the opposite effect: Imports and importables become cheaper so that the domestic prices decrease, and domestic exporters are pressured to lower the dollar prices to offset the increasing foreign currency prices of their products.<sup>2</sup>

The fluctuating value of the dollar has another effect on profit that is contrary to the above explanation. When the dollar appreciates (depreciates), the profit level tends to expand (contract) as costs of imported materials decrease (increase). This positive impact, however, is more than offset by the negative influence as explained above for the following reasons. The profit of the domestic manufacturers cannot improve noticeably when the dollar is stronger because the falling domestic prices will neutralize the effect on the profit of cheaper materials costs. Similarly, the profit level cannot deteriorate substantially when the dollar is weaker because rising domestic prices tend to lessen the impact of increasing materials costs on corporate profit. Second, since the costs of imported materials constitute only a fraction of the total production cost, any change in their prices will have a less proportionate effect on total cost. Therefore, the influence of the costs of imported materials on the profitability is much less important than that of product pricing.

Another consideration is the two-faceted impact of exchange rate changes on the profit level, i.e., the volume effect on both the importers and the exporters of manufactured goods and the translation effect on exports of manufactured goods. In order to analyze these effects, we have to know the degree of exchange rate pass-through for imports and exports. For instance, a complete (100%) pass-through means that the foreign currency prices of exports change one-for-one with exchange rate changes, while the domestic currency prices of exports remain the same, so that only the volume effect occurs. In the other extreme case of a zero percent pass-through, foreign currency prices of exports remain the same but the

domestic currency prices of exports change one-for-one with exchange rate changes, so that only the translation effect arises.

The prior empirical studies (e.g., [8,15]) confirmed a near complete pass-through for U.S. exporters and an approximate 60% pass-through for foreign suppliers to U.S. markets. This means that appreciation of the dollar, for example, will cause a reduction in the U.S. export volume and a fall in domestic prices as imports and importables cost less, thus tending to lower aggregate profit. Depreciation of the dollar will bring about the opposite result as the foreign currency prices of U.S. exports decrease (so that the U.S. export volume increases) and the dollar prices of imports and importables increase, causing profit to increase. Notice that the (partial) translation effect is experienced only by foreign suppliers since a 100% pass-through is assumed for U.S. exporters.

The data set employed for the statistical analysis covers the period from the first quarter of 1975 to the last quarter of 1993. These variables are included in the data set: PF is the manufacturing corporate profit (before deduction of capital consumption allowances, with inventory valuation adjustment)<sup>3</sup> divided by the producer price index; ER is the real multilateral trade-weighted value of the dollar (units of foreign currency per dollar so that an increase means dollar appreciation); CU is the manufacturing capacity utilization rate; LC is the index of manufacturing unit labor costs (labor compensation costs expended in the production of a unit output); MP is the index of raw materials price; R is a real interest rate derived as the yield on new issues of high-grade corporate bonds minus an inflation rate measured by the consumer price index; and Y is the disposable personal income in 1982 dollars.

Values of PF, ER, Y, and the producer price index are obtained from various issues of the *Economic Report of the President*. Values of CU, LC, the consumer price index, MP, and the yield on new issues of high grade corporate bonds are obtained, respectively, from pages C-33, December 1994; C-41, October 1995; C-43, November 1994; C-30, November 1994; and C-40, November 1994; in issues of *Survey of Current Business* published by the U.S. Department of Commerce. All the variables except the interest rate are in natural logarithm.

### III. STATISTICAL ANALYSIS

As is usual with time-series data, the OLS regression of Equation (1) resulted in serious serial correlation; and the Cochrane-Orcutt procedure was used to remove autocorrelation. On the other hand, application of a homoscedasticity test of Pagan and Hall [18] indicated constancy in the error term. The regression estimate is presented below,<sup>4</sup> with t-statistics in parentheses.

$$PF = 3.61 - 0.50ER + 1.40CU - 0.65LC - 0.40MP - 0.008R + 0.29Y \quad (2)$$

$$(-1.09) \quad (-2.27) \quad (2.84) \quad (-1.98) \quad (-1.35) \quad (-0.40) \quad (1.02)$$

$$\text{Adjusted } R^2 = 0.842 \quad DW = 1.98 \quad F(10, 61) = 21.2$$

All the variables have the correct signs; the F and Durbin-Watson statistic are satisfactory; but the t-statistics of MP, R, and Y are not significant at the 95% level of confidence interval. There appears to be a serious multicollinearity problem, especially for the interest rate variable. Use of other measures of interest rate such as nominal rates or real rates based on the yield on AAA corporate bonds or long-term U.S. Treasury bonds did not fare any better.

It was decided to omit the interest rate in view of its lowest t-value and the insignificant coefficient.<sup>5</sup> The revised regression produced much improved estimates as shown in the equation below.

$$PF = 3.56 - 0.56ER + 1.45CU - 0.79LC - 0.40MP + 0.38Y \quad (3)$$

$$(1.10) (-3.30) \quad (2.97) \quad (-2.09) \quad (-1.79) \quad (1.99)$$

$$\text{Adjusted } R^2 = 0.846 \quad DW = 1.97 \quad F(9,62) = 23.9$$

The t-statistics of the explanatory variables are significant at the 95% or higher level of confidence, except that of MP, which is significant at the 90% level. The adjusted  $R^2$  is hardly affected by the omission of the interest rate variable.

As hypothesized, the exchange rate is negatively related to profit and plays a significant role. Since the variables are in logarithm, their coefficients are regarded as elasticities. Thus, for example, a 1% change in the exchange rate will bring about a 0.56% change, in the opposite direction, in manufacturing profit. Even though the magnitude of the exchange rate coefficient is not the largest, the importance of the exchange rate in the determination of the profit derives from the fact that it fluctuates more frequently and widely than any other variables.

Hung [9:54] reports "...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." This translates to an elasticity of -0.60, as compared with our estimate of -0.56.

It is desirable to separate the impact of currency fluctuations on corporate profit between importers and exporters, but data problems prevent such an undertaking. However, some insight can be gathered via a simple technique employed by Ma and Kao [13].<sup>6</sup> This method boils down to modifying the exchange rate variable so that the net impact of exchange rate changes on profit is determined by the relative importance of exporting firms versus importing firms in the manufacturing sector. The modified exchange rate is constructed as

$$ER_t' = \ln(s/c)_t (\ln ER_t - \ln ER_{t-1})$$

where  $\ln$  is natural logarithm and  $c$  and  $s$  are, respectively, the cost and sales elasticity with respect to changes in the exchange rate.

The sign of  $\ln(s/c)$  depends on the U.S. trade imbalance,<sup>7</sup> i.e.,

(a) If the U.S. manufacturing sector is import dominated; then  $c > s$  and  $\ln(s/c) < 0$ .

(b) If the U.S. manufacturing sector is export dominated, then  $c < s$  and  $\ln(s/c) > 0$ .

Since  $\ln(s/c)$  is not observable, we use a proxy variable constructed as

$$\ln(s/c)_t = \ln(\text{merchandise exports}_t / \text{merchandise imports}_t).^8$$

The OLS regression analysis employing the new exchange rate and the other variables in the first-differenced form is presented below.<sup>9</sup>

$$\text{PF} = -0.61\text{ER}' + 1.97\text{CU} - 0.52\text{LC} - 0.94\text{MP} + 0.48\text{Y} \quad (4)$$

(-1.64)    (2.01)    (-2.40)    (-3.47)    (2.51)

$$\text{Adjusted } R^2 = 0.29 \quad \text{DW} = 1.91 \quad \text{F}(4, 71) = 8.78$$

Since the variables are first differenced, their coefficients reflect rates of change in the aggregate profit level due to rates of change in the explanatory variables. However, we note that the t-statistic of the exchange rate is significant at about only the 90% confidence interval. We further note that while DW and F statistics are satisfactory, the explanatory power of the model is somewhat low even for a first-differenced regression.

### Stationarity Test and Cointegration

The validity of regression analysis rests on the assumption that the variables are stationary over time and that the relationship is constant. An investigation by Nelson and Plosser [16] and a series of studies spawned by it found that many macroeconomic time series behaved like random walks.

The variables in Equation (3) were subjected to the Dickey and Fuller [1] and the augmented Dickey-Fuller (ADF) tests for unit root to determine stationarity. For variable  $x_t$ , the  $p$ th order ADF test statistic is given by the t-ratio of  $a_2$  in the OLS regression of

$$\Delta x_t = a_0 + a_1 T + a_2 x_{t-1} + \sum_{i=1}^p b_i \Delta x_{t-1} + e_t \quad (5)$$

where  $T$  is a trend and  $e_t$  are assumed to be identically and independently distributed random variables.

**Table 1**  
**ADF Test for Unit Root**

Variable	Test of I (0)	Test of I (1)
Number of observations = 76 (1975Q1 - 1993Q4)		

PF	-2.58	-5.06
ER	-2.17	-3.89
CU	-3.17	-4.08
LC	-1.98	-3.73
MP	-3.08	-4.94
Y	-2.05	-4.59

Note:

- The 95% critical value for testing the significance of ADF statistic is -2.90 for variables without trend and -3.47 for variables with trend. Only LC and Y had trend.
- Variables are PF=real manufacturing corporate profit, ER=multilateral trade-weighted real exchange rate of the dollar, CU=manufacturing capacity utilization rate, LC=index of manufacturing unit labor cost, MP=index of industrial materials price, and Y=U.S. disposable personal income in 1982 dollars.

The ADF test result is reported in Table 1. A time series  $x_t$  is said to be integrated of order one or  $I(1)$  if its first difference is stationary, whereas a stationary time series is referred to as integrated of order zero or  $I(0)$ . A random walk is a special case of an  $I(1)$  series. As can be seen from the table, only the capacity utilization rate (CU) and the materials price (MP) are stationary while the remaining variables are  $I(1)$ ; i.e., they attain stationarity after the first differencing. Since the majority of the variables in Equation (3) are nonstationary, it is possible that the relationship exhibited there is spurious and that it will change over time.

We next perform a cointegration analysis to see whether such problems exist. Even though most of the variables are random walks, they may still possess a long-run equilibrium or cointegrating relation. The concept of cointegration was first introduced by Granger [7] and expanded upon by Engle and Granger [3]. According to this idea, when two variables  $x_t$  and  $y_t$  follow random walks but a linear combination  $z_t = x_t - ay_t$  is stationary, then the two variables are said to be cointegrated, meaning that they tend to move together over the long run.

In order to test for cointegration, we employ a method devised by Johansen [10] and expanded by Johansen and Juselius [11]. This method features the well-accepted principle of the maximum likelihood procedure and facilitates treatment of multivariate cases, as opposed to the Engle-Granger method, which was designed for bivariate problems. Furthermore, in a recent Monte Carlo study, Gonzalo [6] tested several alternative cointegration techniques and found that Johansen's method performed best in estimating and testing cointegration relationship.

The maximum likelihood estimation method is based on the error correction representation of the VAR model with Gaussian errors

$$\Delta x_t = a_0 + \Gamma_1 \Delta x_{t-1} + \Gamma_2 \Delta x_{t-2} + \dots + \Gamma_{p-1} \Delta x_{t-p+1} + \Pi x_{t-p} + Bz_t + e_t \quad (6)$$

where  $x_t$  is an  $m \times 1$  vector of  $I(1)$  variables,  $\Gamma_1, \Gamma_2, \dots, \Gamma_{p-1}, \Pi$  are  $m \times m$  matrices of unknown parameters,  $z_t$  is an  $s \times 1$  vector of  $I(0)$  variables,  $B$  is an  $m \times s$  matrix, and  $e_t$  are normally distributed with zero mean and constant variance. The



Johansen procedure estimates Equation (6) subject to the hypothesis that  $\Pi$  has a reduced rank,  $r < m$ . This hypothesis can be written as:

$$H(r) = \alpha\beta' \quad (7)$$

where  $\alpha$  and  $\beta$  are  $m \times r$  matrices. Johansen and Juselius [11] show that, under certain conditions, the reduced rank condition implies that the process  $\Delta x_t$  is stationary,  $x_t$  is nonstationary, and  $\beta'x_t$  is stationary. The stationary relations  $\beta'x_t$  are referred to as the cointegrating relations.

The Johansen method has two test statistics for the number of cointegrating vectors: the maximum eigenvalue and trace. Under the maximum eigenvalue, the number of cointegrating vectors ( $r$ ) is determined sequentially, starting with the null hypothesis that there is no cointegrating relation; that is,  $r = 0$ , against the alternative that  $r = 1$ . If the null is rejected, then the null hypothesis that there is at most one cointegrating vector ( $r \leq 1$ ) is tested against the alternative that  $r = 2$ , and so on. The procedure for the trace test is the same as for the eigenvalue test, and either may be used to check the conclusion of the other.

As we report in Table 2, there are three cointegrating vectors or long-run equilibrium relationships among the variables.<sup>10</sup> This means that the regression estimates shown in Equation (3) are expected to be stable over time.

### Vector Autoregressive System

One problem with the traditional regression analysis is the *a priori* classification of endogenous and exogenous variables and the assumption that changes in the dependent variable are caused by changes in the right-hand-side variables. In reality, one is not so sure about such causation. It could be that the direction of causation is the opposite or that two variables influence each other or even that everything is caused by everything else in the system. In the context of our regression Equation (3),

high profit levels may lead to wage increases, which, in turn, cause inflation and lower value of the dollar, which increase net exports, income, and capacity utilization.

Given the absence of a clear-cut classification of exogenous and endogenous variables, a useful way to capture links among the variables is to employ a vector autoregressive system in which all variables potentially cause each other. A system of VAR is an econometric model requiring a minimum of *a priori* theory to restrict the relationship among variables of interest. Under this methodology--which is sometimes called the atheoretic approach--model builders do not have to depend on

**Table 2**  
**Johansen Maximum Likelihood Cointegration Test**

**(non-trended case)**

Number of observations=76 (1975Q1 - 1993Q4)					
Lag in vector autoregression = 4					
Variables in cointegrating vector			Based on maximal eigenvalue	Critical	Value
	Null	Alternative		95%	90%
PF,ER,CU, LC,MP,Y	r = 0	r = 1	50.84	34.40	31.66
	r ≤ 1	r = 2	30.36	28.14	25.56
	r ≤ 2	r = 3	24.19	22.00	19.77
	r ≤ 3	r = 4	13.40	15.67	13.75
	r ≤ 4	r = 5	4.10	9.24	7.53
			Based on trace		
PF,ER,CU, LC,MP,Y	r = 0	r = 1	122.87	76.07	71.86
	r ≤ 1	r = 2	72.04	53.12	49.65
	r ≤ 2	r = 3	41.68	34.91	32.00
	r ≤ 3	r = 4	17.49	19.96	17.85
	r ≤ 4	r = 5	4.10	9.24	7.53

Note:

- Test statistics and critical values are generated by *Microfit 3.0* by Pesaran and Pesaran [19].
- r is the number of cointegrating vectors.
- Introducing a linear trend in the cointegrating vector yielded essentially the same results. Only LC and Y had trend.
- Variables are PF=real manufacturing corporate profit, ER=multilateral trade-weighted real exchange rate of the dollar, CU=manufacturing capacity utilization rate, LC=index of manufacturing unit labor cost, MP=index of industrial materials price, and Y=U.S. disposable personal income in 1982 dollars.

particular economic theories because all the variables are treated as endogenous. First introduced by Sims [20], the VAR analysis has been widely applied to diverse areas of empirical investigations despite its limitations.<sup>11</sup>

VAR estimates are obtained by OLS regression of

$$Z_t = \sum_{i=1}^p A_i Z_{t-i} + E_t \quad (8)$$

where  $Z_t$  is a column vector of observations on the current values of all the variables in the model and  $E_t$  is a column vector of random errors assumed to be contemporaneously correlated but not autocorrelated. When applying the VAR technique to our model, each of the six variables in Equation (3) is regressed against the lagged values of itself and all of the other variables and a constant to extract any information existing in the movements of these variables.<sup>12</sup> The

estimated VAR equations are difficult to interpret and are not presented here, but the characteristics of the system are best understood by studying the contemporaneous correlations among the residuals or innovations in the different equations.

**Table 3**  
**Correlation Matrix of Contemporaneous Innovations**  
**VAR model covering 1975Q1 - 1993Q4**

Variables	PF	ER	CU	LC	MP	Y
PF	1.00					
ER	-0.27	1.00				
CU	0.68	-0.14	1.00			
LC	-0.40	-0.15	-0.68	1.00		
MP	-0.44	-0.05	-0.51	-0.44	1.00	
Y	0.22	-0.03	0.16	0.07	-0.002	1.00

Note:

- a. A 4-quarter lag for each variable in VAR.
- b. Variables are PF=real manufacturing corporate profit, ER=multilateral trade-weighted real exchange rate of the dollar, CU=manufacturing capacity utilization rate, LC=index of manufacturing unit labor cost, MP=index of industrial materials price, and Y=U.S. disposable personal income in 1982 dollars.

The first column of Table 3 shows the correlations of the profit innovations. The negative signs for the exchange rate, the labor cost, and the materials price, and the positive signs for the capacity utilization and the income are consistent with the way these variables are expected to influence the profitability, as shown in Equation (3). We also notice that the innovations in the exchange rate are negatively correlated with the innovations of the remaining four variables, which is consistent with the fact that a higher production rate, labor cost, materials price, and income tend to be associated with a lower exchange value of the dollar. The positive correlation of the capacity utilization disturbances with those of the income is as expected, and the negative correlations with the labor cost and materials price imply that higher input costs lead to lower production and capacity utilization rates. The labor cost is positively correlated with the income, as it should be; and the negative correlation between the labor cost and the materials price means that increases in the cost of either factor result in a lower level of output, which tends to depress the price of the other. Finally, the negative correlation between the materials price and income, although very weak, can be interpreted to mean that higher prices of materials cause lower production and income.

#### IV. CONCLUDING REMARKS

The general floating of major currencies since 1973 spawned numerous empirical studies estimating the impact of exchange rate changes on import/export prices and on external balances, but the empirical investigation into the relationship between the exchange rate changes and the aggregate profit of U.S. manufacturing firms is all but nonexistent. In this paper, we conducted regression analysis to identify several factors, including the dollar exchange rate, that have significant effects on the profitability of the U.S. manufacturing industry. The regression outcome revealed that the exchange rate, the manufacturing unit labor cost, and the industrial materials price were negatively related to aggregate manufacturing profit and the manufacturing capacity utilization rate and the real disposable personal income were positively related.

Performing a stationarity test, we discovered that four of the six variables were random walks; but a cointegration test ensured that the variables have long-run equilibrium relationships and that the regression estimates would be time-invariant. A VAR method was also applied to the data in view of the doubtful nature of categorizing, on *a priori* basis, endogenous and exogenous variables in regression analysis. The VAR technique generally supported the results of the regression analysis.

#### NOTES

1. An earlier study by Finkel and Tuttle [4] found a significant inverse relationship between the U.S. trade balance and the aggregate profit margin of the American corporation.
2. The degree of price adjustments for importables and exports depends on whether the goods are homogeneous or differentiated. The more substitutable the goods are, the more producers will adjust prices to changes in the exchange rate.
3. This is EBIT plus depreciation allowances.
4. ER, MP, and R were lagged two quarters and CU, LC, and Y were lagged one quarter to allow for the time lapse between changes in these variables and sales and profit accounting.
5. There are several solutions to the multicollinearity problem, including dropping variables, which are all ad hoc measures. See Maddala [14:280-295] for a detailed discussion.
6. Ma and Kao [13] used this method to gauge the impact of changes in foreign exchange rate on stock prices, but it is also applicable to corporate profit determination.

7. See Ma and Kao [13] for a detailed discussion of this point.
8. Values of U.S. merchandise exports and imports are obtained from various issues of *Federal Reserve Bulletin*.
9. Since the revised exchange rate is in the first-difference form, all other variables are also first differenced.
10. One cointegrating vector simply means the existence of a long-run economic relationship in the levels of the variables. However, more than one cointegrating vector can exist in a multivariate system. In general, it can be viewed that the more cointegrating vectors there are, the more stable the system will be in the long run.
11. Main criticisms include overparameterization and inability to draw policy implications from autoregressive statistics unless some structural interpretations are made.
12. Each variable is lagged four quarters. Seasonal dummies were excluded because of their insignificant t-values.

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### NOTES

1. An earlier study by Finkel and Tuttle [4] found a significant inverse relationship between the U.S. trade balance and the aggregate profit margin of the American corporation.
2. The degree of price adjustments for importables and exports depends on whether the goods are homogeneous or differentiated. The more substitutable the goods are, the more producers will adjust prices to changes in the exchange rate.
3. This is EBIT plus depreciation allowances.

4. ER, MP, and R were lagged two quarters and CU, LC, and Y were lagged one quarter to allow for the time lapse between changes in these variables and sales and profit accounting.
5. There are several solutions to the multicollinearity problem, including dropping variables, which are all ad hoc measures. See Maddala [14:280-295] for a detailed discussion.
6. Ma and Kao [13] used this method to gauge the impact of changes in foreign exchange rate on stock prices, but it is also applicable to corporate profit determination.
7. See Ma and Kao [13] for a detailed discussion of this point.
8. Values of U.S. merchandise exports and imports are obtained from various issues of *Federal Reserve Bulletin*.
9. Since the revised exchange rate is in the first-difference form, all other variables are also first differenced.
10. One cointegrating vector simply means the existence of a long-run economic relationship in the levels of the variables. However, more than one cointegrating vector can exist in a multivariate system. In general, it can be viewed that the more cointegrating vectors there are, the more stable the system will be in the long run.
11. Main criticisms include overparameterization and inability to draw policy implications from autoregressive statistics unless some structural interpretations are made.
12. Each variable is lagged four quarters. Seasonal dummies were excluded because of their insignificant t-values.

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