

An Analysis Of The Impact Of The Fall In The Foreign Exchange Value Of The U.S. Dollar From The Mid-1980s To The Mid-1990s On The Output Levels Of The 20 2-Digit SIC U.S. Industries

Edward T. Gullason, (E-mail: gullasoe@dowling.edu), Dowling College

Abstract

This study empirically examines the effects of the downward trend in the foreign exchange value of the U.S. dollar from the mid-1980s to the mid-1990s on the output levels of the 20 individual 2-digit SIC U.S. industries. Despite the fact that theory would predict increases in the output levels of these industries due to their improved international competitiveness, the empirical results show that this is not the case.

I. Introduction

In previous studies, the foreign exchange value of the U.S. dollar has been used as a barometer of the performance of the U.S. industrial sector. This was especially true during the mid-1980s. At that time, the value of the U.S. dollar rose dramatically due, in part, to an increase in U.S. interest rates brought about by increases in the actual and future expected U.S. federal budget deficits, among other factors. In 1985, the U.S. Congress was so concerned about the potential loss of international competitiveness of the U.S. industrial sector as a

result of the rising value of the U.S. dollar, that it requested the U.S. Congressional Budget Office (CBO) to conduct an empirical study examining the relationship between the foreign exchange value of the U.S. dollar and U.S. industrial production, CBO (1985).

Even though the empirical results in this study showed that an increase in the value of the U.S. dollar had only a small negative effect on total U.S. industrial output in the short run, the long-run negative impact was determined to be substantial. Individual 2-digit SIC U.S. industries were not found to be affected in the same way by the increase in the value of the U.S.

Readers with comments or questions are encouraged to contact the author via e-mail.

dollar. Some of these industries experienced declines in output, while others were unaffected.

Theoretically, the rationale for using the foreign exchange value of the U.S. dollar as a barometer for the performance of the U.S. industrial sector appears straightforward. A *ceteris paribus* increase in the value of the U.S. dollar results in increased prices for U.S. industrial output relative to that of other countries. This, in turn, will reduce the relative global competitiveness of the U.S. industrial sector, ultimately resulting in decreased output at both the aggregate and 2-digit SIC industry levels.

From the mid-1980s to the mid-1990s, the foreign exchange value of the U.S. dollar fell rather dramatically. Theory dictates that a *ceteris paribus* decrease in the value of the U.S. dollar will have the opposite effect. The price of U.S. industrial output relative to that of other countries decreases, resulting in an improvement in the global competitiveness of the U.S. industrial sector, and an accompanying increase in output emanating from this sector at both the aggregate and 2-digit SIC industry levels.

In Gullason (1998), it is demonstrated that for the U.S. industrial sector as a whole, this theory is not supported with empirical evidence. At the aggregate level, the decrease in the foreign exchange value of the U.S. dollar from the mid-1980s to the mid-1990s is shown to have no statistically significant effect on U.S. industrial output. The most likely explanation for this empirical finding is that the portion of the entire U.S. industrial sector exposed to global competition was small during this period.

However, this result may not automatically carry over to individual 2-digit SIC U.S. industries. These individual industries are fundamentally different from one another in many respects. It is possible that these industries may have varying degrees of exposure to global competition. Therefore, as was the case in the CBO (1985) analysis, the impacts of changes in the

value of the U.S. dollar, as well as other variables reflecting international economic factors, may not necessarily be the same across these 20 individual 2-digit SIC U.S. industries.

The purpose of this paper is to update the analyses in CBO (1985) for the period from the mid-1980s to the mid-1990s, while simultaneously recognizing and correcting for likely and significant shortcomings in the main empirical model and analyses employed in CBO (1985) in its estimation of the impact of the change in the value of the U.S. dollar on U.S. industrial production at the 2-digit SIC industry level. The empirical techniques developed to account for and to rectify these shortcomings became more widely used subsequent to the publication of CBO (1985). Using these empirical procedures, it will be determined if the fall in the foreign exchange value of the U.S. dollar from the mid-1980s to the mid-1990s resulted in an increase in the output levels of the 20 individual 2-digit SIC U.S. industries, which is what theory would lead one to expect.

II. The Empirical Model

A minor variant of the main empirical model used in CBO (1985) to determine the *ceteris paribus* impact of the change in the value of the U.S. dollar on the output levels of the 20 individual 2-digit SIC U.S. industries is the following:

$$(1) \ln(IP_{it}) = \alpha + \beta \ln(EXVUS_{t-1}) + \gamma \ln(GDP_{t-1}/GDP^*_{t-1}) + \delta \ln(GDP^*_{t-1}) + \eta \ln(PPI_{i,t-1}/PY_{t-1}) + \phi \ln(PPI_{i,t-1}/PPIF_{t-1}) + \lambda \ln(GDPF_{t-1}) + \epsilon_{it}$$

where t is the time index designating the t^{th} quarter, and i indexes the 20 individual 2-digit SIC U.S. industries. ϵ_{it} is the disturbance term for the particular equation being estimated.

The definitions of the variables used, as

well as the data sources utilized can be found in Table 1. Equation 1 can be considered a valid model only if all the variables in this equation are stationary, or, in other words, integrated of

order zero ($I(0)$). A variable is stationary if its mean, variance, and covariance are invariant over time.

Table 1
Variable Definitions and Sources

IP _i =	U.S. Industrial Production Index for the i th 2-digit SIC U.S. Industry (Total) (Seasonally Adjusted). Source: Board of Governors of the Federal Reserve System.
EXVUS =	Real Effective Exchange Rate for the United States. Source: International Monetary Fund.
GDP =	U.S. Real GDP Measured in Chained 1992 Dollars. Source: U.S. Department of Commerce.
GDP* =	U.S. Real Potential GDP Measured in Chained 1992 Dollars. Source: U.S. Congressional Budget Office.
PPI _i =	Producer Price Index for the i th 2-digit SIC U.S. Industry. (Not Seasonally Adjusted). Monthly data only are provided. Quarterly data were obtained by averaging the indices of the three months of each specific quarter. Source: U.S. Department of Labor.
PY =	GDP Deflator. Source: U.S. Department of Commerce.
PPIF =	0.41 (PPICA) + 0.06 (PPIFR) + 0.10 (PPIGY) + 0.33 (PPIJP) + 0.10 (PPIUK) where the variables in parentheses are the producer price indices for Canada, France, Germany, Japan, and the United Kingdom, respectively. These countries are the U.S.'s five major trading partners. (PPIFR is equal to the average of the Industrial Goods Producer Price Index and the Finished Goods Producer Price Index for France.) Source: International Monetary Fund. The numerical weights W _i in the equation above (where i indexes each of these five countries) are calculated as follows, with all export and import data measured in millions of dollars:
X _i =	$\frac{[1990 \text{ Exports (Domestic and Foreign)} + 1990 \text{ General Imports}] \text{ for Country } i}{[1990 \text{ U.S. Exports (Domestic and Foreign)} + 1990 \text{ U.S. General Imports}]}$
W _i =	$W_i = \frac{X_i}{\sum_{i=1}^5 X_i}$ These numerical weights are intended to reflect the relative degrees to which the U.S. trades with each of its five major trading partners. These weights are very similar to those calculated in CBO (1985). Source for all of the export and import data: <i>Statistical Abstract of the United States 1994</i> .
GDPF =	0.41 (GDPCA) + 0.06 (GDPFR) + 0.10 (GDPGY) + 0.33 (GDPJP) + 0.10 (GDPUK) where the variables in parentheses are real GDP values in 1990 prices for Canada, France, Germany, Japan, and the United Kingdom, respectively, recalibrated in terms of U.S. dollars. The numerical weights are the same as the ones used in the calculation of PPIF. Details regarding how these weights are calculated can be found in the definition of PPIF.

Note: Not all of the variables which are measured in terms of real U.S. dollars have the same base year. Also, not all of the variables which are measured as indices have the same base year either. Arbitrary changes in the base year of a particular variable affect the intercept terms in the ordinary least-squares (OLS) regressions, but have absolutely no impact on any of the other empirical results.

It has been demonstrated in Nelson and Plosser (1982) as well as in many other places that a great number of macroeconomic time series follow random walks, and are consequently nonstationary. In this case, if one were to estimate Equation 1 using ordinary least-squares, one could obtain “spurious results in that conventional significance tests will tend to indicate a relationship between the variables when in fact none exists,” Pindyck and Rubinfeld (1998, p. 513). This problem would not be experienced in the event that a linear combination of the variables are cointegrated, and appropriate modeling is utilized. Ukpolo (1997, p. 53) cites several articles demonstrating that, “cointegration requires that all variable series in a model be integrated of the same order.” In this situation, an error-correction model exists and can be estimated. This model would take into account the short-run dynamic adjustments in the movement toward a long-run equilibrium. The error-correction term demonstrates how fast deviations from the long-run equilibrium are corrected. In the event that the variables in Equation 1 are not integrated of the same order, an error-correction model cannot be used.

Before one can decide which empirical model would be most appropriate to determine the impact of a *ceteris paribus* change in the value of the U.S. dollar on the output levels of the 20 individual 2-digit SIC U.S. industries, one needs to test for the presence of a unit root for each variable in Equation 1, and then to determine the order of integration of each of these variables.

Testing for the presence of unit roots is carried out by using the Augmented Dickey-Fuller (ADF) Test. Following Pindyck and Rubinfeld (1998), Y_t (a macro variable in question) is described by Equation 2 where t is the time index:

$$(2) \quad Y_t = \alpha + \beta t + \rho Y_{t-1} + \sum_{j=1}^p \lambda_j \Delta Y_{t-j} + \epsilon_t$$

where $\Delta Y_t = Y_t - Y_{t-1}$. Unlike the situation for the Dickey-Fuller (DF) Test, the Augmented Dickey-Fuller (ADF) test allows for the possibility of serial correlation in ϵ_t , and simultaneously allows one to test for the presence of a unit root. For each variable Y_t , one first estimates the unrestricted regression using OLS:

$$(3) \quad Y_t - Y_{t-1} = \alpha + \beta t + (\rho - 1)Y_{t-1} + \sum_{j=1}^p \lambda_j \Delta Y_{t-j}$$

and then the restricted regression:

$$(4) \quad Y_t - Y_{t-1} = \alpha + \sum_{j=1}^p \lambda_j \Delta Y_{t-j}$$

Following Pindyck and Rubinfeld (1998, p. 510), “a standard F ratio is calculated to test whether the restrictions ($\beta = 0, \rho = 1$) hold.” F ratios greater than or equal to one’s previously chosen critical value obtained from distributions tabulated by Dickey and Fuller (as opposed to standard F -distributions) would lead one to fail to reject the hypothesis that the variable Y_t is not a random walk, indicating the absence of a unit root. The macro variable in this instance would be considered stationary.

For an individual variable, one should reach the same conclusion regarding the presence or nonpresence of a unit root regardless of the value that is chosen for p , the number of lags of $\lambda_j \Delta Y_{t-j}$ chosen to be included in Equations 2, 3, and 4.

Augmented Dickey-Fuller (ADF) Tests were conducted on all of the variables in Equation 1 for each of the 20 individual 2-digit SIC U.S. industries at the 5 percent level. F ratios were calculated for each variable for values of p from 1 to 5. The results obtained (too voluminous to include in this study, but available from the author upon request) indicate numerous disturbing inconsistencies. As just one example,

for the variable [$\ln(\text{EXVUS}_{t-1})$], one would fail to reject the hypothesis that this variable is not a random walk for values of p equal to 1, 2, and 3 while in the instance where p is equal to 4 and 5, one would reject the hypothesis that this variable is not a random walk.

Despite the existence of rigorously determined and well-established procedures for choosing the value for p "based on some summary statistic criterion for ε_t ; such as, the Schwartz or Akaike Information Criterion, or the highest significant lagged value of the autocorrelation function for the first differenced series," (Gordon (1995, p. 188)), Gordon (1995) demonstrates that these criteria can dictate the use of *different* values for p , resulting in inconsistent conclusions which could be drawn regarding whether or not a particular variable is stationary based on the empirical results of the ADF test.

Another possible explanation for the inconsistencies in the empirical results of the ADF tests in this study is that the time period under analysis is too short to allow the time-series variables in question to display a long-run pattern where short-run fluctuations wash out. Expanding the time period under consideration, and thereby increasing the number of degrees of freedom is not an option since the focus of this study is on the relatively short time regime from the mid-1980s to the mid-1990s during which the foreign exchange value of the U.S. dollar had a distinct downward trend. Results of the ADF tests appear to indicate that it is very likely that most of the variables in Equation 1 are nonstationary, and are not integrated of the same order. Thus, it is unlikely that there will be cointegrating relationships among them. Consequently, an error-correction model cannot be estimated.

Therefore, the most appropriate option available is to estimate Equation 1 for each individual 2-digit SIC U.S. industry where all the dependent and independent variables are expressed in first differences. This model which is estimated for each industry is Equation 5:

$$(5) \quad \Delta \ln(\text{IP}_t) = \alpha' + \beta' [\Delta \ln(\text{EXVUS}_{t-1})] \\ + \gamma [\Delta \ln(\text{GDP}_{t-1}/\text{GDP}^*_{t-1})] \\ + \delta' [\Delta \ln(\text{GDP}^*_{t-1})] \\ + \eta' [\Delta \ln(\text{PPI}_{t-1}/\text{PY}_{t-1})] \\ + \varphi' [\Delta \ln(\text{PPI}_{t-1}/\text{PPIF}_{t-1})] \\ + \lambda' [\Delta \ln(\text{GDPP}_{t-1})] + \varepsilon_t'$$

By first-differencing, one effectively eliminates any possibility of spurious regressions. However, this differencing may result in the loss of information regarding long-run relationships among the variables since the levels information is discarded when first-differencing occurs. In this study, this does not pose a serious problem given that this estimating equation never purported to capture the long-run relationships among the variables, but instead only those during the brief time regime from the mid-1980s to the mid-1990s that the foreign exchange value of the U.S. dollar followed a distinct downward trajectory.

If it is the case that the variables in Equation 5 are not integrated of the same order (and it cannot be conclusively determined given the weak power of the ADF test due to the relatively short time period under investigation) one could argue that the coefficient estimates obtained by estimating Equation 5 by industry would not be consistent.

Equation 5 captures nonlinearities. A coefficient estimate is interpreted as the percentage change in the dependent variable resulting from a one-percent change in an independent variable, *ceteris paribus*.

Equation 5 is estimated using quarterly data. The time period covered for each individual industry equation estimation varies slightly by industry due to data availability issues. These periods are from the mid-1980s to the mid-1990s. The specific time period covered for each individual industry equation estimation is contained in Table 2.

Table 2
Empirical Estimates of Equation 5 for Each of the 20 Individual 2-Digit SIC U.S. Industries

LUMBER AND PRODUCTS
 (1985:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_i) = & 0.01 + 0.01 [\Delta \ln (EXVUS_{t-1})] + 1.56 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] - 1.43 [\Delta \ln (GDP^*_{t-1})] \\ & (0.39) \quad (0.06) \qquad \qquad \qquad (2.16) \qquad \qquad \qquad (0.56) \\ & - 1.27 [\Delta \ln (PPI_{i,t-1}/PY_{t-1})] + 1.17 [\Delta \ln (PPI_{i,t-1}/PPIF_{t-1})] - 0.01 [\Delta \ln (GDPF_{t-1})] + \varepsilon_{it} \\ & (2.04) \qquad \qquad \qquad (2.13) \qquad \qquad \qquad (0.03) \end{aligned}$$

Total R² = 0.18; Estimation Method: OLS.

FURNITURE AND FIXTURES
 (1985:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_i) = & 0.01 - 0.06 [\Delta \ln (EXVUS_{t-1})] + 1.72 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] - 2.10 [\Delta \ln (GDP^*_{t-1})] \\ & (1.14) \quad (0.39) \qquad \qquad \qquad (3.28) \qquad \qquad \qquad (1.15) \\ & - 0.89 [\Delta \ln (PPI_{i,t-1}/PY_{t-1})] + 0.88 [\Delta \ln (PPI_{i,t-1}/PPIF_{t-1})] - 0.01 [\Delta \ln (GDPF_{t-1})] + \varepsilon_{it} \\ & (1.20) \qquad \qquad \qquad (2.15) \qquad \qquad \qquad (0.11) \end{aligned}$$

Total R² = 0.31; Estimation Method: OLS.

STONE, CLAY, AND GLASS PRODUCTS
 (1985:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_i) = & 0.001 + 0.06 [\Delta \ln (EXVUS_{t-1})] + 1.33 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] + 0.21 [\Delta \ln (GDP^*_{t-1})] \\ & (0.07) \quad (0.41) \qquad \qquad \qquad (2.77) \qquad \qquad \qquad (0.12) \\ & + 0.26 [\Delta \ln (PPI_{i,t-1}/PY_{t-1})] + 0.51 [\Delta \ln (PPI_{i,t-1}/PPIF_{t-1})] + 0.03 [\Delta \ln (GDPF_{t-1})] + \varepsilon_{it} \\ & (0.42) \qquad \qquad \qquad (1.44) \qquad \qquad \qquad (0.25) \end{aligned}$$

Total R² = 0.29; Estimation Method: OLS.

PRIMARY METALS
 (1985:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_i) = & 0.02 + 0.20 [\Delta \ln (EXVUS_{t-1})] + 2.20 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] - 1.96 [\Delta \ln (GDP^*_{t-1})] \\ & (0.90) \quad (0.73) \qquad \qquad \qquad (2.45) \qquad \qquad \qquad (0.59) \\ & - 0.54 [\Delta \ln (PPI_{i,t-1}/PY_{t-1})] + 1.12 [\Delta \ln (PPI_{i,t-1}/PPIF_{t-1})] - 0.17 [\Delta \ln (GDPF_{t-1})] + \varepsilon_{it} \\ & (0.75) \qquad \qquad \qquad (1.07) \qquad \qquad \qquad (0.69) \end{aligned}$$

Total R² = 0.34; Estimation Method: OLS.

Table 2 (continued)

FABRICATED METAL PRODUCTS
(1985:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_t) = & 0.02 + 0.05 [\Delta \ln (EXVUS_{t-1})] + 0.84 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] - 2.55 [\Delta \ln (GDP^*_{t-1})] \\ & (0.96) (0.59) \qquad (2.52) \qquad (0.90) \\ & - 0.63 [\Delta \ln (PPI_{t,t-1}/PY_{t+1})] + 0.63 [\Delta \ln (PPI_{t,t-1}/PPIF_{t-1})] - 0.01 [\Delta \ln (GDPF_{t-1})] + \varepsilon_{it}' \\ & (1.03) \qquad (2.00) \qquad (0.08) \end{aligned}$$

Total R² = 0.60; Estimation Method: EML; Lags Included in the EML Estimation: 1.

INDUSTRIAL MACHINERY AND EQUIPMENT
(1985:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_t) = & 0.02 + 0.18 [\Delta \ln (EXVUS_{t-1})] + 1.69 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] - 1.48 [\Delta \ln (GDP^*_{t-1})] \\ & (1.56) (1.16) \qquad (3.35) \qquad (0.73) \\ & - 0.39 [\Delta \ln (PPI_{t,t-1}/PY_{t+1})] - 0.39 [\Delta \ln (PPI_{t,t-1}/PPIF_{t-1})] + 0.25 [\Delta \ln (GDPF_{t-1})] + \varepsilon_{it}' \\ & (0.39) \qquad (0.99) \qquad (2.00) \end{aligned}$$

Total R² = 0.40; Estimation Method: OLS.

ELECTRICAL MACHINERY
(1986:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_t) = & 0.03 + 0.01 [\Delta \ln (EXVUS_{t-1})] + 0.21 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] - 3.28 [\Delta \ln (GDP^*_{t-1})] \\ & (1.63) (0.16) \qquad (0.61) \qquad (0.96) \\ & - 0.47 [\Delta \ln (PPI_{t,t-1}/PY_{t+1})] + 0.23 [\Delta \ln (PPI_{t,t-1}/PPIF_{t-1})] + 0.01 [\Delta \ln (GDPF_{t-1})] + \varepsilon_{it}' \\ & (0.59) \qquad (0.77) \qquad (0.13) \end{aligned}$$

Total R² = 0.61; Estimation Method: EML; Lags Included in the EML Estimation: 1.

TRANSPORTATION EQUIPMENT
(1985:4 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_t) = & -0.01 + 0.34 [\Delta \ln (EXVUS_{t-1})] + 2.74 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] + 2.41 [\Delta \ln (GDP^*_{t-1})] \\ & (0.59) (1.39) \qquad (3.34) \qquad (0.84) \\ & - 1.08 [\Delta \ln (PPI_{t,t-1}/PY_{t+1})] + 1.04 [\Delta \ln (PPI_{t,t-1}/PPIF_{t-1})] - 0.01 [\Delta \ln (GDPF_{t-1})] + \varepsilon_{it}' \\ & (1.61) \qquad (1.69) \qquad (0.07) \end{aligned}$$

Total R² = 0.39; Estimation Method: OLS.

Table 2 (continued)

INSTRUMENTS

(1985:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_{it}) = & -0.0001 - 0.04 [\Delta \ln (EXVUS_{t-1})] + 0.06 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] + 0.78 [\Delta \ln (GDP^*_{t-1})] \\ & (0.02) \quad (0.37) \qquad \qquad \qquad (0.18) \qquad \qquad \qquad (0.65) \\ & + 0.02 [\Delta \ln (PPI_{i,t-1}/PY_{t-1})] - 0.37 [\Delta \ln (PPI_{i,t-1}/PPIF_{t-1})] - 0.002 [\Delta \ln (GDPPF_{t-1})] + \varepsilon_{it} \\ & (0.04) \qquad \qquad \qquad (1.44) \qquad \qquad \qquad (0.02) \end{aligned}$$

Total R² = 0.09; Estimation Method: OLS.

MISCELLANEOUS MANUFACTURES

(1986:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_{it}) = & -0.005 + 0.18 [\Delta \ln (EXVUS_{t-1})] + 1.06 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] + 2.06 [\Delta \ln (GDP^*_{t-1})] \\ & (0.35) \quad (1.09) \qquad \qquad \qquad (1.73) \qquad \qquad \qquad (1.00) \\ & - 0.39 [\Delta \ln (PPI_{i,t-1}/PY_{t-1})] + 0.25 [\Delta \ln (PPI_{i,t-1}/PPIF_{t-1})] + 0.12 [\Delta \ln (GDPPF_{t-1})] + \varepsilon_{it} \\ & (0.34) \qquad \qquad \qquad (0.58) \qquad \qquad \qquad (0.93) \end{aligned}$$

Total R² = 0.14; Estimation Method: OLS.

FOODS

(1985:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_{it}) = & 0.01 - 0.02 [\Delta \ln (EXVUS_{t-1})] + 0.02 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] - 0.95 [\Delta \ln (GDP^*_{t-1})] \\ & (2.92) \quad (0.25) \qquad \qquad \qquad (0.14) \qquad \qquad \qquad (1.67) \\ & + 0.18 [\Delta \ln (PPI_{i,t-1}/PY_{t-1})] + 0.02 [\Delta \ln (PPI_{i,t-1}/PPIF_{t-1})] + 0.02 [\Delta \ln (GDPPF_{t-1})] + \varepsilon_{it} \\ & (1.06) \qquad \qquad \qquad (0.19) \qquad \qquad \qquad (0.50) \end{aligned}$$

Total R² = 0.34; Estimation Method: EML; Lags Included in the EML Estimation: 1.

TOBACCO PRODUCTS

(1985:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_{it}) = & -0.02 - 0.09 [\Delta \ln (EXVUS_{t-1})] + 2.21 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] + 2.51 [\Delta \ln (GDP^*_{t-1})] \\ & (0.84) \quad (0.22) \qquad \qquad \qquad (1.59) \qquad \qquad \qquad (0.64) \\ & + 0.59 [\Delta \ln (PPI_{i,t-1}/PY_{t-1})] - 0.36 [\Delta \ln (PPI_{i,t-1}/PPIF_{t-1})] + 0.08 [\Delta \ln (GDPPF_{t-1})] + \varepsilon_{it} \\ & (0.55) \qquad \qquad \qquad (0.35) \qquad \qquad \qquad (0.23) \end{aligned}$$

Total R² = 0.30; Estimation Method: EML; Lags Included in the EML Estimation: 3.

Table 2 (continued)

TEXTILE MILL PRODUCTS

(1985:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_{it}) = & 0.01 - 0.06 [\Delta \ln (EXVUS_{t-1})] + 1.11 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] - 1.84 [\Delta \ln (GDP^*_{t-1})] \\ & (0.79) \quad (0.37) \qquad \qquad \qquad (1.91) \qquad \qquad \qquad (0.91) \\ & - 1.51 [\Delta \ln (PPI_{i,t-1}/PY_{t-1})] + 0.67 [\Delta \ln (PPI_{i,t-1}/PPIF_{t-1})] - 0.08 [\Delta \ln (GDPF_{t-1})] + \epsilon_{it} \\ & (1.94) \qquad \qquad \qquad (1.56) \qquad \qquad \qquad (0.56) \end{aligned}$$

Total R² = 0.19; Estimation Method: OLS.

APPAREL PRODUCTS

(1985:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_{it}) = & 0.003 + 0.05 [\Delta \ln (EXVUS_{t-1})] + 0.36 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] - 1.14 [\Delta \ln (GDP^*_{t-1})] \\ & (0.30) \quad (0.38) \qquad \qquad \qquad (0.84) \qquad \qquad \qquad (0.75) \\ & - 1.26 [\Delta \ln (PPI_{i,t-1}/PY_{t-1})] + 0.74 [\Delta \ln (PPI_{i,t-1}/PPIF_{t-1})] + 0.01 [\Delta \ln (GDPF_{t-1})] + \epsilon_{it} \\ & (1.47) \qquad \qquad \qquad (2.28) \qquad \qquad \qquad (0.09) \end{aligned}$$

Total R² = 0.16; Estimation Method: OLS.

PAPER AND PRODUCTS

(1985:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_{it}) = & -0.001 + 0.26 [\Delta \ln (EXVUS_{t-1})] + 1.06 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] + 0.59 [\Delta \ln (GDP^*_{t-1})] \\ & (0.10) \quad (2.29) \qquad \qquad \qquad (2.92) \qquad \qquad \qquad (0.44) \\ & - 0.51 [\Delta \ln (PPI_{i,t-1}/PY_{t-1})] + 0.29 [\Delta \ln (PPI_{i,t-1}/PPIF_{t-1})] + 0.22 [\Delta \ln (GDPF_{t-1})] + \epsilon_{it} \\ & (1.86) \qquad \qquad \qquad (0.85) \qquad \qquad \qquad (2.55) \end{aligned}$$

Total R² = 0.36; Estimation Method: OLS.

PRINTING AND PUBLISHING

(1985:2 to 1995:1)

$$\begin{aligned} \Delta \ln (IP_{it}) = & -0.01 + 0.06 [\Delta \ln (EXVUS_{t-1})] + 0.87 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] + 1.97 [\Delta \ln (GDP^*_{t-1})] \\ & (1.09) \quad (0.38) \qquad \qquad \qquad (1.85) \qquad \qquad \qquad (1.18) \\ & - 1.09 [\Delta \ln (PPI_{i,t-1}/PY_{t-1})] + 0.53 [\Delta \ln (PPI_{i,t-1}/PPIF_{t-1})] + 0.03 [\Delta \ln (GDPF_{t-1})] + \epsilon_{it} \\ & (2.04) \qquad \qquad \qquad (1.48) \qquad \qquad \qquad (0.23) \end{aligned}$$

Total R² = 0.21; Estimation Method: OLS.

Table 2 (continued)

CHEMICALS AND PRODUCTS

(1985:2 to 1995:1)

$$\Delta \ln (IP_{it}) = 0.001 + 0.03 [\Delta \ln (EXVUS_{t-1})] + 0.73 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] + 1.07 [\Delta \ln (GDP^*_{t-1})]$$

(0.14) (0.25) (2.02) (0.82)

$$+ 0.06 [\Delta \ln (PPI_{t-1}/PY_{t-1})] - 0.25 [\Delta \ln (PPI_{t-1}/PPIF_{t-1})] + 0.09 [\Delta \ln (GDPI_{t-1})] + \varepsilon_{it}$$

(0.22) (0.67) (1.01)

Total R² = 0.18; Estimation Method: OLS.

PETROLEUM PRODUCTS

(1985:4 to 1995:1)

$$\Delta \ln (IP_{it}) = -0.002 + 0.15 [\Delta \ln (EXVUS_{t-1})] - 0.04 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] + 1.07 [\Delta \ln (GDP^*_{t-1})]$$

(0.20) (0.93) (0.08) (0.55)

$$+ 0.53 [\Delta \ln (PPI_{t-1}/PY_{t-1})] - 0.56 [\Delta \ln (PPI_{t-1}/PPIF_{t-1})] + 0.19 [\Delta \ln (GDPI_{t-1})] + \varepsilon_{it}$$

(1.17) (1.20) (1.48)

Total R² = 0.11; Estimation Method: OLS.

RUBBER AND PLASTICS PRODUCTS

(1985:2 to 1995:1)

$$\Delta \ln (IP_{it}) = 0.02 + 0.13 [\Delta \ln (EXVUS_{t-1})] + 1.42 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] - 1.72 [\Delta \ln (GDP^*_{t-1})]$$

(1.73) (0.96) (3.17) (1.09)

$$- 1.35 [\Delta \ln (PPI_{t-1}/PY_{t-1})] + 0.80 [\Delta \ln (PPI_{t-1}/PPIF_{t-1})] + 0.06 [\Delta \ln (GDPI_{t-1})] + \varepsilon_{it}$$

(3.33) (2.00) (0.55)

Total R² = 0.37; Estimation Method: OLS.

LEATHER AND PRODUCTS

(1985:2 to 1995:1)

$$\Delta \ln (IP_{it}) = 0.001 + 0.15 [\Delta \ln (EXVUS_{t-1})] + 1.05 [\Delta \ln (GDP_{t-1}/GDP^*_{t-1})] - 1.13 [\Delta \ln (GDP^*_{t-1})]$$

(0.07) (0.72) (1.51) (0.45)

$$+ 0.39 [\Delta \ln (PPI_{t-1}/PY_{t-1})] - 0.06 [\Delta \ln (PPI_{t-1}/PPIF_{t-1})] + 0.04 [\Delta \ln (GDPI_{t-1})] + \varepsilon_{it}$$

(0.50) (0.12) (0.25)

Total R² = 0.17; Estimation Method: OLS.

Note: OLS refers to ordinary least-squares; EML refers to the Exact Maximum Likelihood Method.
 Absolute t-statistics are in parentheses.

All of the independent variables are lagged one-quarter. This, for all intents and purposes, renders these variables exogenous. In addition, this empirical formulation recognizes that the independent variables impact upon $[\Delta \ln (IP_t)]$ values with a lag.

Equation 5 was estimated 20 times, once for each individual 2-digit SIC U.S. industry. However, the same estimation technique was not used for all equations. In some instances, the autoregressive parameter estimates at lags 1, 2, 3, 4, and 5 (which are the appropriate lags to examine when quarterly data are employed) were all individually not statistically significant, in which case the specific equation was estimated using ordinary least-squares (OLS).

In other instances, autoregressive parameter estimates were statistically significant, in which case the estimation procedure used is the exact maximum likelihood method. The choice of the order of the autoregressive error model employed is based specifically on the issue of which of the autoregressive parameter estimates are statistically significant. For example, if the autoregressive parameter estimates at lags 3, 4, and 5 are not statistically significant while those at lags 1 and 2 are, the autoregressive error model used is a second-order one.

If, for example, the autoregressive parameter estimates at lags 3 and 5 are not statistically significant while those at lags 1, 2, and 4 are, the only lags that are included in the autoregressive error model estimated are 1, 2, and 4.

The determination of which lags were included in the autoregressive error model for a particular 2-digit SIC U.S. industry equation for which it was not appropriate to use ordinary least-squares (OLS), and for which the exact maximum likelihood method is used is based on the type of criteria described above.

Table 2 contains all of the empirical results of the estimations of Equation 5 for each of the

20 individual 2-digit SIC U.S. industries' equations. It is indicated in this table which estimation procedure is used for each equation. In the case where an autoregressive error model is used and estimated using the exact maximum likelihood method, it is indicated in Table 2 which lags are included in the estimation of the model.

III. Examination of the Empirical Results

A fundamental pattern which emerges when one examines the empirical results obtained when Equation 5 is estimated for each of the 20 2-digit SIC U.S. industries is that domestic economic factors are the basic driving forces of the performances of individual U.S. industries. Specifically, the variable which exerts the greatest influence is $[\Delta \ln (GDP_{t-1}/GDP^*_{t-1})]$. This variable captures short-run income effects, and the position of the U.S. economy over the business cycle.

Results at the individual industry level depend upon the specific industry in question. The coefficient estimates of $[\Delta \ln (GDP_{t-1}/GDP^*_{t-1})]$, and their levels of statistical significance across individual U.S. industries are largely consistent with what theory would suggest. The empirical results obtained demonstrate that the following industries have coefficient estimates of $[\Delta \ln (GDP_{t-1}/GDP^*_{t-1})]$ which are greater than one, and are statistically significant: lumber and products; furniture and fixtures; stone, clay, and glass products; primary metals; industrial machinery and equipment; transportation equipment; paper and products; and rubber and plastics products. Almost all of these industries produce durable goods.

The coefficient estimates of $[\Delta \ln (GDP_{t-1}/GDP^*_{t-1})]$ support the fact that the consumption of durable goods is procyclical. During economic contractions, individuals will postpone the purchase of durable goods. Instead, they will simply retain the durable goods they already have. If they break down, they are repaired rather than replaced. During economic expan-

sions, the demand for durable goods rises to a greater extent than U.S. real output. This is partly due to the pent-up demand for durable goods which typically builds during economic contractions.

The purchase of nondurable goods are largely not able to be postponed. This is indicated for a particular industry by either a coefficient estimate of $[\Delta \ln (\text{GDP}_{t-1}/\text{GDP}^*_{t-1})]$ which is positive and less than one and statistically significant, or by a coefficient estimate which is not statistically significant.

The general pattern of the empirical results obtained indicates that the purchase of nondurable goods is not affected very much, or not at all, by movements in short-run income, and hence the movement of the economy through the various phases of the business cycle. It is demonstrated that the coefficient estimates of $[\Delta \ln (\text{GDP}_{t-1}/\text{GDP}^*_{t-1})]$ meet one of these two criteria for the following industries which produce, with some exceptions, nondurable goods: fabricated metal products; electrical machinery; instruments; miscellaneous manufactures; foods; tobacco products; textile mill products; apparel products; printing and publishing; chemicals and products; petroleum products; and leather and products.

$[\Delta \ln (\text{GDP}^*_{t-1})]$ captures the long-run U.S. economic trend. Its coefficient estimate in a particular industry equation estimation indicates the long-run performance trend of the particular industry in question. No individual industry is identified as experiencing unequivocal long-run growth or decline. The empirical results obtained indicate the stability of the shares of total U.S. real output made up of each of the real output levels of the individual industries over the long run. This provides evidence against the notion that the U.S. economy is "deindustrializing."

The general pattern of the empirical results obtained when Equation 5 is estimated for each

of the 20 individual 2-digit SIC U.S. industries indicates that domestic economic factors as measured by $[\Delta \ln (\text{GDP}_{t-1}/\text{GDP}^*_{t-1})]$, $[\Delta \ln (\text{GDP}^*_{t-1})]$, and $[\Delta \ln (\text{PPI}_{i,t-1}/\text{PY}_{t-1})]$ more consistently support what theory would predict regarding their impacts on output in each of these industries as opposed to the factors in Equation 5 that reflect the international economic environment— $[\Delta \ln (\text{EXVUS}_{t-1})]$, $[\Delta \ln (\text{PPI}_{i,t-1}/\text{PPIF}_{t-1})]$, and $[\Delta \ln (\text{GDPP}_{t-1})]$. When one examines the coefficient estimates of the variables capturing international economic factors, it is evident that overall, none of the 20 individual 2-digit SIC U.S. industries are substantially exposed to global competition.

$[\Delta \ln (\text{PPI}_{i,t-1}/\text{PPIF}_{t-1})]$ reflects the price of U.S. industrial output in a particular industry to that of a trade-weighted average of the U.S.'s five largest trading partners (the United Kingdom, Canada, France, Germany, and Japan). $[\Delta \ln (\text{EXVUS}_{t-1})]$ reflects a separate dimension of the price of U.S. industrial output relative to that of other countries. When there is a *ceteris paribus* decrease in $[\Delta \ln (\text{EXVUS}_{t-1})]$, theory dictates a resulting decrease in the price of U.S. industrial production at all SIC industry levels relative to that of other countries, and an increase in the global competitiveness of individual U.S. industries.

If a particular industry was significantly exposed to global competition, one would expect the coefficient estimates of $[\Delta \ln (\text{EXVUS}_{t-1})]$ and $[\Delta \ln (\text{PPI}_{i,t-1}/\text{PPIF}_{t-1})]$ to be consistently negative and statistically significant.

In order for it to be demonstrated that the *ceteris paribus* downward trend in the foreign exchange value of the U.S. dollar from the mid-1980s to the mid-1990s caused growth in a particular 2-digit SIC U.S. industry, the coefficient estimate of $[\Delta \ln (\text{EXVUS}_{t-1})]$ in an industry equation should be negative and statistically significant. For no individual industry is this the case.

When a minor variant of Equation 1 was estimated by industry over an earlier time period in CBO (1985), the empirical results obtained predicted an improvement in the performance of several industries as a result of a *ceteris paribus* fall in the value of the U.S. dollar. These results are quite possibly manifestations of spurious regressions since the macro variables included in that equation were most likely nonstationary.

If a particular industry faced significant global competition, one would expect the coefficient estimate of $[\Delta \ln (\text{GDPP}_{i,t})]$ to be positive and statistically significant. This variable reflects the impact of the overall performance of the economies of the U.S.'s five largest trading partners on the demand for U.S. industrial output at the 2-digit SIC industry level. Only for two industries—industrial machinery and equipment; and paper and products—are the coefficient estimates of $[\Delta \ln (\text{GDPP}_{i,t})]$ positive and statistically significant. This indicates that for these two industries, an increase in foreign demand which emanates from expanding foreign economies will cause an improvement in the performance of these industries, demonstrating a certain amount of their exposure to international economic forces. However, the point estimates are not very large, indicating that even for these industries, an improvement in the performance of the economies of the U.S.'s five largest trading partners results in only modest improvements.

IV. Conclusions

The empirical results obtained in this paper indicate that as was the case for the U.S. industrial sector as a whole, the downward trend in the foreign exchange value of the U.S. dollar from the mid-1980s to the mid-1990s has not resulted in an improvement in individual 2-digit SIC U.S. industries as theory would lead one to expect.

Even though there are other possible explanations for the empirical results obtained based

on the empirical analysis of the U.S. industrial sector as an entire entity in Gullason (1998), the most likely explanation is that none of the 20 individual 2-digit SIC U.S. industries were exposed to global competition to a significant extent during this time period. This is supported by the pattern of the empirical results obtained. Domestic economic factors fairly consistently exert a great deal of influence on the output levels of the 20 individual 2-digit SIC U.S. industries. Almost none of the variables reflecting the global economic environment have a statistically significant impact on the output levels of these industries.

It has been demonstrated in the literature that U.S. exports and imports of industrial output are greatly impacted upon by the value of the U.S. dollar, see Ceglowski (1989), CBO (1984), and CBO (1985). Results obtained in this article are easily reconciled with these studies. This is demonstrated by the fact that the portions of each of the 20 individual 2-digit SIC U.S. industries exposed to global competition are so small that changes in the value of the U.S. dollar do not have statistically significant impacts on an individual industry's entire base.

The empirical results demonstrate that the downward trend in the foreign exchange value of the U.S. dollar from the mid-1980s to the mid-1990s did not result in the strengthening of the 20 individual 2-digit SIC U.S. industries as theory would lead one to expect. Therefore, the foreign exchange value of the U.S. dollar proves to be a poor barometer of the performance of each of the individual 20 2-digit SIC U.S. industries. This demonstrates that any attempt on the part of the U.S. government to improve performance in the U.S. industrial sector by engaging in policies designed to reduce the value of the U.S. dollar would be ineffectual.

Suggestions for Future Research

Analyses of the empirical relationship between the foreign exchange value of the U.S.

dollar and U.S. industrial output at either the macro or micro level will remain important research topics. If studies of this type are undertaken in the future, the empirical results obtained may not necessarily be consistent with what economic theory would suggest since a wide variety of factors such as the extent of international exposure of the U.S. industrial sector, and future institutional constraints, laws, and regulations will clearly impact the foreign exchange value of the U.S. dollar – U.S. industrial output relationship overall in an unpredictable manner. □

Research support provided by Dowling College is gratefully acknowledged. The author assumes responsibility for any errors and/or omissions.

References

1. Ceglowski, Janet, "Dollar Depreciation and U.S. Industry Performance," *Journal of International Money and Finance*, Vol. 8, No. 2, pp. 233-251, 1989.
2. Gordon, Daniel V., "Optimal Lag Length in Estimating Dickey-Fuller Statistics: An Empirical Note," *Applied Economics Letters*, Vol. 2, No. 6, pp. 188-190, 1995.
3. Gullason, Edward T., "Has the Fall in the Foreign Exchange Value of the U.S. Dollar Since 1985 Strengthened the U.S. Industrial Sector?" *American Economist*, Vol. 42, No. 1, pp. 76-81, 1998.
4. Nelson, Charles R. and Charles I. Plosser, "Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications," *Journal of Monetary Economics*, Vol. 10, No. 2, pp. 139-162, 1982.
5. Pindyck, Robert S. and Daniel L. Rubinfeld, *Econometric Models and Economic Forecasts*, Irwin McGraw-Hill, Boston, Massachusetts, 1998.
6. Ukpolo, Victor, "Wage Growth and Inflation in the United States: Further Evidence from Johansen's Cointegration Approach," *American Economist*, Vol. 41, No. 1, pp. 53-58, 1997.
7. U.S. Congressional Budget Office, *Analysis of the Deterioration in U.S. Trade Performance*, U.S. Congressional Budget Office, Washington, District of Columbia, 1984.
8. U.S. Congressional Budget Office, *The Dollar in Foreign Exchange and U.S. Industrial Production*, U.S. Congressional Budget Office, Washington, District of Columbia, 1985.

Notes