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PRIMARY COMMODITY PRICES, THE BUSINESS CYCLE AND THE REAL EXCHANGE RATE OF THE DOLLAR

Heywood Fleisig (Consultant)
Sweder van Wijnbergen

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Abstract

An empirical stylized fact is that primary exporters' terms of trade worsen when the dollar appreciates and improve when the dollar depreciates.In our theoretical analysis,we demonstrate that a depreciation of the dollar will worsen a primary exporters'terms of trade, the smaller the US share in the world market for the primary commodity,the lower the US demand elasticity for that good,and the larger the US share in the exporter's imports.We present empirical findings that support the theoretical analysis.Also,we find strong cyclical sensitivity of real commodity prices and evidence of their secular decline.

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Primary Commodity Prices, the Business Cycle, and the Real Exchange Rate of the Dollar

Heywood Fleisig
Global Analysis and Projections Division
Economic Analysis Projections Department
World Bank

and

Sweder van Wijnbergen
Trade and Adjustment Policy Division
Country Policy Department
World Bank

and

Centre for Economic Policy Research
London

1. Introduction

Under floating exchange rates, a persistent stylized fact has emerged: for exporters of primary products, the terms of trade appear to worsen when the dollar appreciates and to improve when the dollar depreciates (Dornbusch (1985)). As debt grows, this matter becomes more important — dollar exchange rate changes interact with dollar-denominated debt through the terms of trade and substantially change the burden of debt repayment. That, in turn, alters the size of serviceable debt and developing county growth prospects.

This paper proposes an explanation of that phenomenon that follows from the normal play of competitive price-adjusting markets. It finds that a real depreciation of the dollar will worsen the terms of trade of a primary-product exporter the smaller the share of the United States in the world market for that good, the lower the U.S. elasticity of demand for those goods, and the higher the elasticity of demand of other industrial country importers and, finally, the larger the share of U.S. goods in the imports of the primary-product exporter.

The second part of the paper presents some empirical findings that confirm this model at the aggregate level. The theoretical results strongly constrain the elasticity of the terms of trade with respect to the real exchange rate to lie between zero and one. Our more disaggregated results are more mixed in support. More likely, however, better results await taking account of disparate supply conditions and of relative shifts in industrial country GDP to empirically isolate the effects of the exchange rate change.

2. A Simple Model

Consider a 3-region world; two regions (US and GE) produce a final good each. The U.S. and GE good are imperfect substitutes and consumed in all three regions. The third region, BR, produces an intermediate product used in the other two regions. Take the GE good as numeraire; p is the relative price of U.S. goods and q the relative price of the intermediate. We use revenue functions R and R^* to describe production behavior in the U.S. and GE, and expenditure functions R, E^* and $\hat{E}$ to describe consumer behavior in the U.S, GE and BR.

The budget constraint each region faces is:

$$\begin{aligned} &\text{US:} && R(p, q) = E(p, 1; u) \\ &\text{GE:} && R^*(1, q) = E^*(p, 1; u^*) \qquad (1) \\ &\text{BR:} && \hat{Z}q = \hat{E}(p, 1; \hat{u}) \end{aligned}$$

where $\hat{Z}$ is the aggregate supply of primary commodities by BR. P is the relative price of U.S. goods in terms of GE goods. Q is the price of the primary commodity, also in terms of GE goods. U, U^* and $\hat{U}$ are welfare inthe U.S., GE and BR. In the analytical section we only consider the case of fixed commodity supply $\hat{Z}$; introducing price responsive commodity supply is straightforward and left to the interested reader.

Our approach is strictly partial equilibrium in that we investigate the implication of a parametrically determined change in the

real exchange rate between final goods, p, on commodity prices. We therefore can discard final-goods market clearing conditions and concentrate on the market for primary commodities for given real exchange rate p between U.S. an GE goods.

By standard properties of the revenue function, demand for commodities equals minus the derivative of the revenue function with respect to the relevant price, so the primary commodity market clears when:

$$R_q + R_q^* + \hat{Z} = 0. \tag{2}$$

Differentiating and collecting terms yields:

$$\frac{dq}{dp} = \frac{R_{qp}}{-(R_{qq} + R_{qq}^*)} \tag{3}$$

Homogeneity of degree one of the revenue function implies:

$$R_{qq}q + R_{qp}p = 0.$$

We can rewrite (3), therefore, as

$$\frac{p}{q}\frac{dq}{dp} = \frac{R_{qq}}{R_{qq} + R^*_{qq}} \tag{4}$$

or

$$\varepsilon_p^q = \frac{\psi\ \varepsilon_q^u}{\psi\varepsilon_q^u + (1 - \psi)\ \varepsilon_q^g} \tag{5}$$

ψ is the value share of total primary commodity imports going to the U.S. and ε_q^i is the price elasticity of primary commodity demand in country i.

Accordingly, the elasticity of the real price of primary commodities, in terms of GE goods, with respect to the real exchange rate between U.S. an GE is positive and below one. In the empirical analysis we will look at commodity prices in terms of U.S. goods, $\hat{q} = q/p$. Clearly simple rearranging yields

$$\varepsilon_p^{\hat{q}} = \frac{-(1 - \psi)\varepsilon_q^g}{\psi\varepsilon_q^u + (1 - \psi)\varepsilon_q^g} \tag{6}$$

What (5) and (6) tell us is straightforward: when the dollar appreciates in real terms against the currencies of other industrial countries, the real commodity price will fall in terms of U.S. goods and rise in terms of "other" industrial countries' goods (GE). The fall in real dollar terms will be the larger, the <u>smaller</u> is the U.S. share in the world imports of that primary commodity, and the <u>lower</u> are U.S. demand elasticities compared with the demand elasticities in other industrial countries. This makes perfect common sense: a large U.S. share or relatively high U.S. demand elasticity will tie commodity prices to those of U.S. goods and so prevent a relative price fall. A large fall in terms of U.S. goods would obviously be bad news for countries like Brazil that export primary commodities and import a lot from the U.S.

For equal demand elasticities $(\varepsilon_q^u = \varepsilon_q^g)$, simple rearranging gives the elasticity for commodity prices expressed in terms of an arbitrary price index $\pi^* = \pi^*(p, 1)$, for example, the CPI of the commodity exporters; define $q^* = q/\pi^*$ and we get

$$\varepsilon_p^{q^*} = \psi - \psi^* \qquad (7)$$

for $\varepsilon_q^u = \varepsilon_q^g$. So, for example, if the share of U.S. goods in the Brazilian CPI exceeds the share of the United States in world primary commodity imports, real primary commodity prices in terms of the Brazilian CPI will fall (assuming equal demand elasticities in all industrial countries). Alternatively, we could look at the commodity exporter's import bundle, assuming again equal demand elasticities $(\varepsilon_q^u = \varepsilon_q^g)$. If the share of U.S. goods in the primary exporter's imports exceeds the U.S. share in world primary commodity markets, the terms of trade of the primary goods exporter will deteriorate if the dollar appreciates.

3. Data and empirical results: primary commodities in aggregate.

As a measure of commodity prices we use the world Bank (1980 dollar) index of all commodities excluding fuel (World Bank ( )). For the price of U.S. goods, we use the U.S. GNP deflator (PNUS); For the price of "other industrial countries" goods (PNGE), we use the corresponding dollar denominated GNP deflator with (1980) GNP weights (OECD NA). We derive the real exchange rate (or, more appropriately,

terms of trade) between the U.S. and other industrial countries from these two indices: RPUO = PNUS/PNGE. Similarly, the real price of commodities in terms of U.S. goods is RPCUS = PNCOM/PNUS.

Finally, we use as the standardized OECD-wide unemployment rate a cyclical indicator from the OECD Economic Outlook. A printout of the variables and detailed information on sources is given in the appendix. A variable using a prefix "L" stands for "natural log of." Using aggregate data, with current and one-period lagged values of the right hand-side variables, we get:

$$\begin{aligned} LRCUS = {} & \underset{(7.40)}{2.50} - \underset{(1.00)}{0.61}\ LRPUO - \underset{(0.28)}{0.16}\ LRPUS(-1) \\ & \underset{(0.50)}{-0.07}\ UNR - \underset{(0.79)}{0.10}\ UNR(-1) \underset{(3.25)}{-0.06}t \qquad (8) \end{aligned}$$

$R^2 = 0.97$ 1970-1984 OLS F=64.4 DW = 2.25 COND = 118

High collinearity between current and lagged variables prevents estimation of the lag structure with any precision, although the overall significance of the variables is high, judging from the F-statistic. Dropping the two variables with lower t-statistic on their coefficient (RPUO(-1) and UNR) yields a substantial improvement in individual significance; the condition number of the datamatrix is much reduced, and, not surprisingly, the total effect of relative prices or for that matter unemployment does not change significantly:

$$LRCPUS = 2.32 - 0.59\ LRPUO - 0.15\ UNR(-1) - 0.07t \qquad (9)$$
$$(13.6)\quad (3.24)\qquad (2.95)\qquad (3.98)$$

$$R^2 = 0.97\ 1970\text{-}1984\ OLS\ F = 125.1\ DW = 2.22\ COND = 34$$

These results show a strong real exchange rate effect: a ten percent real appreciation of the dollar versus other industrial countries leads to a 6 percent decline in commodity prices in terms of U.S. goods, clearly bad news for a country like Brazil that exports primary commodities and imports a great deal from the U.S.

The results also suggest a significant downward trend in primary commodity prices for given final goods price structure (7 percent a year), supporting the Prebisch (1950) hypothesis of a secular decline in real primary commodity prices and a strong pro-cyclical effect: a one percentage point decrease in unemployment throughout the OECD would raise real commodity prices (in terms of either final good) with 15 percent, or, using an Okun's law type rule of thumb, one percentage point extra output growth in the OECD will lead to a 5 percent improvement in real commodity prices.

4. Empirical Results: disaggregated commodity groups.

The same qualitative results showld be replicable with individual commodities. Since relative prices between different primary commodities have changed over the period under consideration, aggregation bias may exist in the aggregate results reported above. We

have, therefore, repeated the analysis for four more disaggregated commodity groups: food, non-food agriculture, copper, and minerals and metals (for a precise description of the classification see World Bank ( )). In each case we estimated the general form of our basic equation, with two lags on the real exchange rate and OECD unemployment included, in addition to a time trend and the lagged endogenous variable. We then subsequently removed the variables with lowest significance, to arrive at the results reported below.[1/]

Consider first the relative price of non-food agricultures in terms of US goods, RPAUS

$$\Delta LRPAUS = \underset{(0.14)}{0.01} - \underset{(2.70)}{1.60}\ \Delta LRPUO - \underset{(1.76)}{0.16}\ \Delta UNR - \underset{(2.46)}{0.21}\ RAUS(-1) \qquad (10)$$

$$R^2 = 0.42 \quad \hat{\rho} = -.47 \quad 1970\text{-}1984$$

The low R^2 is a consequence of first differencing: estimating the nnmerically equivalent equation in levels of endogenous variable yields an R^2 of .96. The results indicated cyclical effects similar to the overall equation , although less precisly estimated; a strong autoregressive price trend (the negative lagged endogenous variable); and finally a very strong negative real exchange rate effect. In fact

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1/ The results of the unrestricted equations plus the data are available on request.

the strongly negative term is inconsistent with the model dreived above, since it is larger in absolute value than the upper limit derived from our theory, one.

The same result obtains for the other agricultural price index, food RPFUS:

$$\underset{}{LPFUS} = \underset{(13.4)}{3.01} - \underset{(6.04)}{1.55}\ LRPUO - \underset{(4.76)}{0.27}\ UNR - \underset{(2.35)}{0.04}\ t \qquad (11)$$

$$R^2 = 0.98 \quad \hat{\rho} = -0.35 \quad 1970\text{-}1984$$

We find, once again, a stong negative real exchange rate effect and strong cyclical dependence. As with non-food agriculture, the exchange rate effect exceeds its theoretical limit of one (in absolute value).

The two metal price indices we tried fitted our theoretical priori betteer. In examing the the price equation for copper (RPCOUS:) for example, we found that

$$\Delta RPCOUS - \underset{(2.05)}{1.91} - \underset{(0.85)}{0.90}\ \Delta LRPUO - \underset{(0.86)}{0.16}\ \Delta UNR$$
$$- \underset{(2.60)}{0.82}\ LRPCOUS(-1) - \underset{(2.09)}{0.11}\ t \qquad (12)$$

$$R^2 = 0.47 \quad 1970\text{-}1984 \qquad (12)$$

Although estimated with much less precision on the individual parameters, the point estimates do satisfy the theoretical constraints derived in section 2.

Finally the price index for all mineral and metals, LRPMUS:

$$LRPMUS = 2.15 - 0.06\ UNF(-1) - 0.10 * t \qquad (13)$$
$$\quad (16.9)\ (1.47) \qquad\qquad (6.40)$$

$R^2 = 0.98$ 1970-1984

The results indicate a complete absence of real exchange rate effects; metal and mineral prices are apparently tied almost completely to the U.S. market with no significant impact coming from changes in the U.S. — other industrial countries real exchange rate. There is moreover, a weak cyclical effect and a strong negative time trend.

5. Conclusion

In this paper we set out to explain an empirical regularity that has emerged at least since the break-down of the Bretton Woods system of fixed exchange rate parities: for exporters of primary products, the terms of trade appear to worsen when the dollar appreciates in real terms, and to improve when the dollar depreciates.

In the theoretical analysis we present a simple explanation that follows from the normal play of competitive price-adjusting markets. It finds that a real depreciation of the dollar will worsen the terms of trade of a primary-product exporter the smaller the share of the United States in the world market for that good, the lower the U.S. elasticity of demand for those goods, and the higher the elasticity of demand of other industrial country importers and, finally, the larger the share of U.S. goods in the imports of the primary-product exporter.

The empirical results presented in the next section confirm this model at the aggregate level. We furthermore find a strong cyclical sensitivity of real commodity prices: a one percentage point increase in the unemployment rate in the OECD is shown to lead to a fall in real commodity prices of 15 percent. We finally find strong support for the Prebisch (1950) hypothesis of secular decline in real commodity prices.

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