1987

Devaluation, Short-Run Supply Response, and the J-Curve

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Economics Honors Seminar

February 17, 1987

Acknowledgements

I would like to thank the Jerome Davis research fund for the grant which supported this paper. Thanks also to Larry Sjaastad of the University of Chicago. For moral support Christopher H. Anderson and Andrea Volpe get a tip of the acknowledgements hat. For comments and suggestions made at various points during the research and writing of this paper I wish to thank Luis Fernandez, James Zinser, Robert Piron, and especially Edward Gamber, all of Oberlin College.

I. Introduction

Currency devaluation is a powerful although poorly understood tool. Theories which describe post-devaluation behavior are in abundance, although agreement over these theories is not. Among the theories used to describe post-devaluation behavior is the J-curve phenomenon. This theory describes the role of lags in the response of net exports (trade balance) to currency movements. In the case of a depreciation this means that there will be a period immediately after devaluation when net exports will not increase but may in fact decrease (Figure 1). This paper will explore the contribution of the supply curve, in the short-run, to the shape of the J-curve. The speed with which supply responds to devaluation will be directly related to the length of the J-curve.

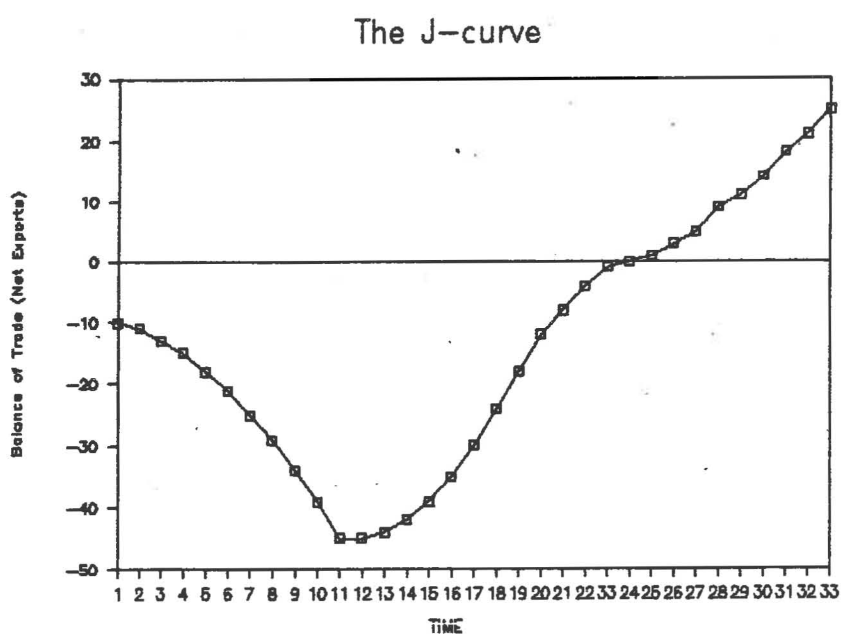


Figure 1

American international trade has seen a significant downturn during the 1980s. The trade deficit has been running at record high levels. Much of this problem has been attributed to the extremely high value of the dollar on international markets. Beginning with the third quarter of 1984 a concerted international effort to devalue the dollar was undertaken in an attempt to alleviate the trade imbalance (Figure 2). It was hoped that as the terms of trade shifted favorably towards the United States an improvement in trade flows would materialize. This has not happened, during the two years following devaluation the trade balance continued to deteriorate (Table 1, Figure 3). Perhaps the improvement will arrive shortly, two years have passed and little improvement has occurred. This paper sets out to offer an explanation for the lengthy adjustment period (J-curve) which the U.S. is experiencing.

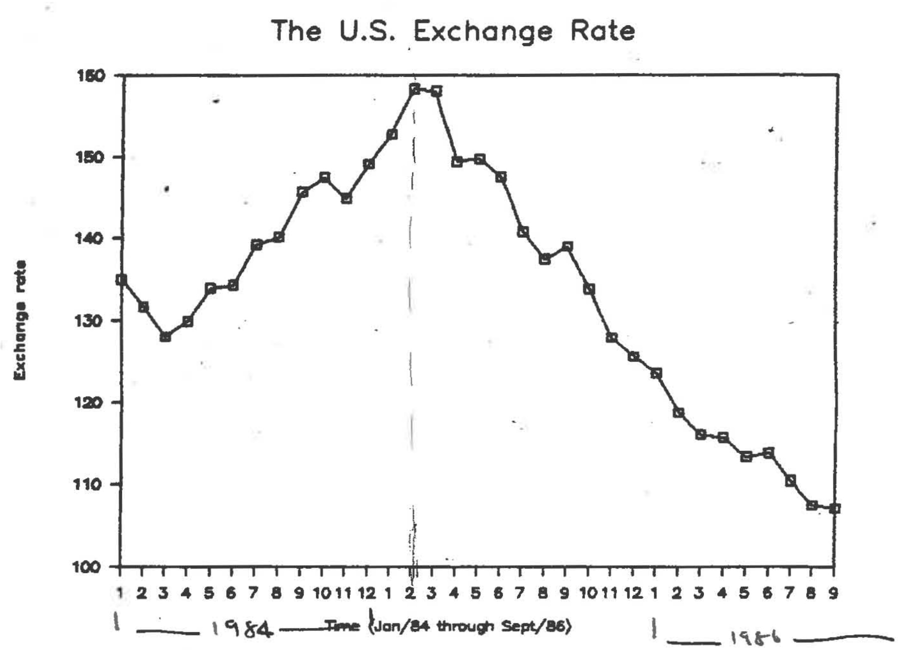


Figure 2[1]

Table 1
United States Balance of Trade[2]
(seasonally adjusted, millions of dollars)

Time	BOT	Time	BOT
1983/8	-6,132	1985/3	-9,683
9	-5,195	4	-10,516
10	-7,300	5	-11,271
11	-6,052	6	-11,987
12	-5,678	7	-9,219
1984/1	-8,260	8	-8,660
2	-8,935	9	-14,315
3	-9,044	10	-10,811
4	-10,846	11	-12,290
5	-7,619	12	-13,734
6	-7,723	1986/1	-14,999
7	-12,440	2	-11,160
8	-8,531	3	-13,059
9	-10,199	4	-10,797
10	-8,372	5	-12,842
11	-8,936	6	-12,694
12	-6,791	7	-16,414
1985/1	-8,896	8	-11,871
2	-10,131	9	-11,177

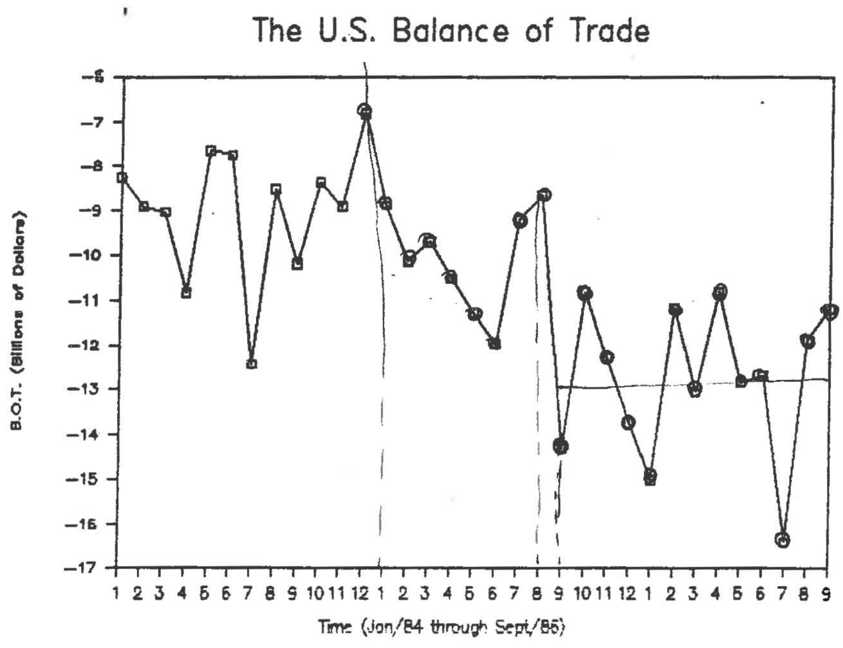


Figure 3

The perverse behavior of the balance of trade after a devaluation is a poorly understood phenomenon, although there has been much descriptive work done on the subject. Few empirical studies have quantified the relationship between changes in exchange rates, supply response and the J-curve. Literature concerned with this seemingly important effect is lacking a cohesive theory, although many are presented.

This paper will attempt to empirically illustrate the contribution of short-run supply adjustment to the U.S. J-curve. I plan to study, on the major industry division level (2 digit SIC), 15 manufacturing sectors of the United States. Their supply movements will be calculated in terms of total short-run adjustment. These statistics will then be compared to the trade balance (J-curve) for the U.S. to see if the supply movements of U.S. manufacturers can explain the continued drop in U.S. international trade. If the theory is supported few industries will adjust quickly in the short-run, reflecting the slow adjustment of aggregate trade variables. Studies relating to the subject of supply response generally deal with movements in aggregate variables. To the best of my knowledge supply response relating to the J-curve has never been measured on such a disagrregated level.

The final results of this paper indicate that following devaluation of the dollar the short-run supply response of U.S. industries is negligible. This finding lends itself to previous studies which have indicated that demand is highly inelastic over the same period.[3] The poor performance of U.S. international trade and the length of the U.S. J-curve are in agreement with this finding.

The remainder of this paper is organized as follows: Section II contains a selective review of the relevant literature. Section III develops the theory which is to be tested. Section IV describes the model which is used and how it is measured. Section V describes the data used in this study. Section VI presents the results. Section VII analyzes and explains the results. Section VIII describes some of the econometric difficulties encountered while measuring the model. Finally, Section IX concludes the paper with an agenda for future research.

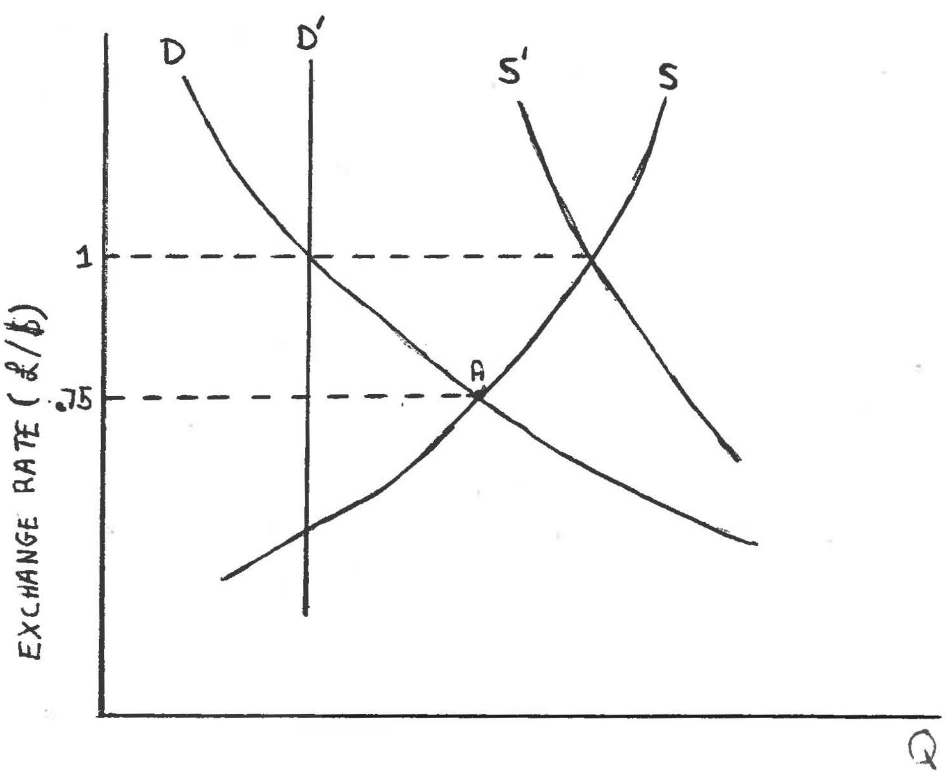
II. Literature Review

Following a devaluation the trade balance is frequently seen to deteriorate over the short-run. "It has become an accepted fact, however, that in many cases the trade balance worsens over the short term in response to a devaluation...."[4] The deterioration of the trade balance is called the J-curve and was first reported by the National Institute for Economic and Social Research after the British Devaluation of 1967.

Many keen observations which may help explain the J-curve are in existence. For example, Rudiger Dornbusch has made a number of interesting observations. He points out that the adjustment of goods prices is very sluggish when compared with that of asset markets: "There is no very persuasive theoretical support for the slow adjustment of goods markets but the facts clearly point in this direction."[5] One obvious implication of this is that the exchange rate alters faster then adjustments in the goods markets. This suggests that following devaluation import prices rise quickly and that the supply of home goods is unable to meet increased demand. The result is that consumers are forced to pay more for foreign goods until the home industries can respond with higher output.

Robert Gordon presents Dornbusch's idea in a more formal manner. He indicates that in the short-run the supply and demand for foreign exchange are radically different from their long-run counter parts (figure 4). Initially the £/$ exchange rate is set to 1. At this rate there is an excess supply of dollars; Americans wish to buy many British goods. In an attempt to alleviate this situation the dollar is devalued to

there is an increasing rift between the short-run curves D' and S' as the exchange rate decreases. A careful look at S' explains why it slopes downward. Foreign goods continue to become more expensive due to the falling £/$ ratio. In the short run the supply of American goods is inelastic. In order to continue purchasing goods, American consumers must purchase increasingly expensive foreign goods. The result of this is that larger amounts of dollars must be sold to finance higher foreign price purchases. As the price of the dollar drops, the quantity of dollars sold increases.



The International Money Market[6]
Figure 4

D' is vertical because the goods market is slow to respond to price changes. As the exchange rate continues to fall foreign goods continue to become more expensive. Eventually home producers will increase production in response to increased demand. However, this increase takes place over time, up to five years in some cases. This explains why the trade balance initially deteriorates. Supply expands slower than the drop in exchange rates. In other words, prices of foreign goods rise faster than the home producers can substitute cheaper home goods. This causes home consumers to purchase expensive foreign goods because cheap American substitutes are not available. Dornbusch sums up this argument nicely:

> This reversal of direction of the trade effect - which is known as the J-curve and is exemplified by the aftermath of the 1967 U.K. devaluation - is ascribed to a slow adjustment of export prices and physical trade flows in contrast with the rapid increase in import prices.[7]

In a 1973 paper, Magee presents the currency-contract hypothesis for the J-curve. Magee proposes that the J-curve may be attributable to the currency in which contracts are denominated. If importers obtain contracts denominated in foreign currency they will lose money after a depreciation. The scenario is as follows: Joe Importer contracts to purchase a good costing 100 francs one year from now. When the contract was negotiated the price of foreign exchange was 1 franc per dollar. During the ensuing year a devaluation of the dollar takes place so that now 1 franc buys 2 dollars. Joe must pay $200 to get the 100 francs he will require to pay off his contract. If a devaluation had not occurred Joe would only have required $100 to pay off the contract. The devaluation resulted in an additional $100 debit to the trade balance as a result of contractual obligations.

Magee points out that currency contracts applies to exporters also. Joe's brother Bob is an exporter. He contracts to export a giant Kielbasa costing $100. When the contract, which is denominated in francs, was written the value of foreign exchange was 1 franc per dollar. After the devaluation Bob receives only 50 francs for his kielbasa rather then the 100 francs he would have received had the devaluation not occurred.

The currency contract effect does not have to be negative for the home country. A contract denominated in home currency is unfortunate for the foreign trader. In this case Joe pays $100 for his goods. However, this $100 is worth only 50 francs. The French importer suffers a decline in his expected revenue of 50 francs. Joe is unaffected, indicating that a deterioration in the US balance of trade does not occur.

The point which Magee is making is that contracts denominated in foreign currency are bad for the home country after a devaluation. They result in higher outflows paid for imports and smaller inflows earned on exports. The combination of these two effects can certainly account for the downward trend in the J-curve until contracts can be renegotiated.

The currency contracts theory can only partially explain the J-curve. It is generally acknowledged that the trough of the J-curve occurs approximately two years after the start of a devaluation.

> .....and even in the United States, with its relatively high cumulative elasticity, export income in foreign currency following a depreciation would not reach its initial level until two years after the year of a depreciation of the dollar and would not exceed that level until the third year.[8]

It is doubtful that enough foreign currency contracts are written far enough in advance to account for the trade drop off. Perhaps a year's worth of deterioration can be accounted for by contracts, less than a year when the futures market is considered.

The futures market for currency adds another aspect to the currency contracts question. A smart importer would go into the futures market everytime a contract was agreed upon. By purchasing the future rights to foreign currency at a specified rate, any loss due to a devaluation would be covered. The post devaluation price of foreign currency would not apply to the transaction, the futures contract price would.

Looking back to Joe Importer, we see that he would not have lost an additional $100 had he entered the futures market. When Joe negotiated the import contract he could have entered the futures market and purchased the right to buy Francs at an assured level. The future price of Francs would have affected Joe's negotiations and the import contract would be altered to fit Joe's new budget. The end result is that Joe is safe when the devaluation hits. He pays the futures contract price rather then the higher current market price. The only person who loses on the deal is the futures trader.

Futures contracts imply that the J-curve can be avoided; importers and exporters will be covered from loss. Futures contracts are available for only 6 months, however the J-curve lasts for at least 2 years. At some point a downturn in trade revenues will be felt in spite of futures contracts, which offer protection for a limited time. The J-curve is not a problem exclusively created by middlemen or contracts. A more structural fault is indicated.

Magee presents a tentative explanation for continuing deterioration in the balance of trade even after contracts run out. After the currency-contract stage ends, a new stage called "pass through" is entered. In "pass through" prices of imports and exports begin to respond to the devaluation. Home good prices will rise because they are now relatively cheaper on the world market which will raise demand for home goods. In the home country devaluation causes foreign prices to increase. The trade balance effects of foreign good price increases in the home country may be ambiguous.

> In theoretical, partial equilibrium terms, the pass-through effort depends on the elasticities of export supply and import demand of the country and its trading partners.[9]

In other words, if demand for a foreign good is inelastic then a price increase will not adversely affect quantity purchased and the home country's trade situation will deteriorate. On the other hand, if demand is elastic an import price will have a negative effect on the quantity of imports purchased. The higher price being offset by decreased purchases of imports. In this case the home country will not experience much or any deterioration of the balance of trade.

Elasticity of demand for imports and exports has been the subject of many investigations.[10] Goldstein and Khan review the results of 10 studies concerning short and long-run elasticity of demand for imports and exports. Estimates of short-run (6 month) elasticities range from -0.07 to -1.52; Long-run estimates range from -0.54 to -3.88. Although fairly inconclusive, these results are representative of the literature. The interpretation of these results is difficult because of the variety of export series' utilized. The number of countries analyzed ranges from 8 to 25 with an equally wide assortment of commodity groups. Elasticity of demand's effect on post-devaluation adjustment, including pass through, is a popular topic. Goldstein and Khan's article indicates that although the role which elasticity of demand plays is generally agreed upon, the magnitude of the role is not.

Elasticity of supply also plays an important role in the pass-through period. If supply is inelastic then no benefits are gained from a devaluation. Following a devaluation of the dollar the foreign price of US goods would fall. However, with inelastic supply no new US goods would be produced. The lower foreign prices would quickly be bid up by an amount equal to the gains from devaluation. A similar chain of events would occur inside the US. The devaluation would raise foreign good prices causing US good prices to be bid up by an amount equal to the devaluation. Thus, the dollar value of imports remains unchanged. In neither of these cases were lower prices "passed through" to consumers. The end result is that the trade deficit will continue decreasing; nothing has changed.

Estimates of supply elasticities, as applied to pass through, are almost non-existent. In particular, short run estimates are extremely difficult to locate. An excellent review of the literature, Goldstein and Khan's Income and Price Effects in Foreign Trade, mentions this problem. "Because the evidence on export supply elasticities is so meagre, the policy implications that one can draw from this evidence are likewise thin."[11]
In this same article a review of seven studies is presented. Each study measured the supply-price elasticity for exports. Results for the US ranged from 2.1 to 12.2, illustrating the lack of cohesion surrounding this topic. No mention is made of short run elasticities.

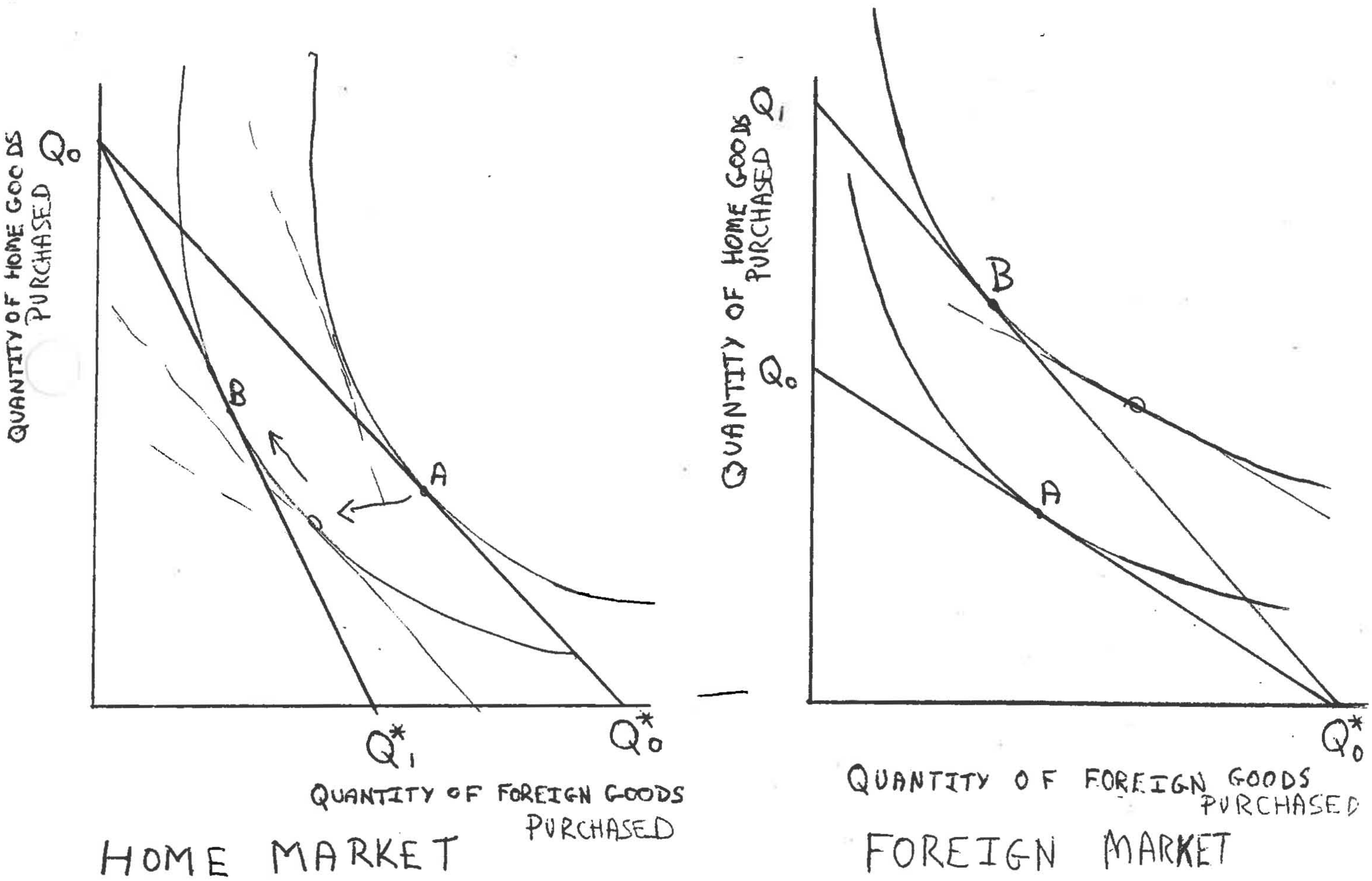
Bushe, Kravis, and Lipsey measure quantity response to a change in relative prices. They find that it takes the US three years for export quantities to change enough to offset a price change. Quantity response at the time of the price change is -0.22; after one year, -0.38; after two years, -0.40 and after three years, -0.27.[12] This indicates a sluggish supply response after devaluation.

Both the pass through and currency-contract theories are not perfect. In order for either of them to cause the J-curve several questionable requirements must be fulfilled. Is demand for many goods extremely elastic as the pass through theory requires? Are enough contracts delineated in foreign currency as the currency contract idea hypothesizes? Both theories seem to be unlikely because of these restrictions. Unfortunately, these two theories are amongst the most well accepted explanations for the J-curve.

III. Theory

The effects of a devaluation may be illustrated using indifference curves. Two markets must be represented, home and foreign (Figure 4). Figure 4 shows the relative quantity of goods purchased in each market. In the home market a devaluation will raise the price of foreign goods and shift the budget line from $Q_0Q^*_0$ to $Q_0Q^*_1$ (where * denotes a foreign variable). The new bundle of goods B has a higher ratio of home goods purchased to foreign goods purchased. This will result in an improvement of the balance of trade for the home country. The foreign market will see a decrease in the price level of U.S. goods causing the budget line to shift out from $Q_0Q^*_0$ to $Q_1Q^*_0$. The new bundle of goods B has a higher ratio of U.S. goods to foreign goods then the original bundle A.

Point B is a long-run bundle, it is not immediately attainable. Prices do not immediately shift to long-run levels, therefore the budget lines do not immediately shift to allow B to be attained. There are an infinite number of intermediate budget lines along which the true path of adjustment is formed due to the gradual adjustment of prices. The path will connect the old bundle A with the new bundle B. At some point during adjustment the trough of the J-curve will be achieved due to shifting trade flows. As the path of adjustment moves closer to B, a form of import substitution takes place. The ratio of foreign goods purchased to homes goods purchased begins to deteriorate. This is due to home goods becoming relatively cheaper, allowing consumers to increase purchases of home goods. It is not clear where the trough occurs on the adjustment path because inferences about revenue cannot be made from figure 5. The trough must occur before B is achieved at which point all adjustment has taken place and relative prices favor the home country. Supply-Demand analysis can be used to plot out the adjustment path. The gradual adjustment of price, which was not shown in figure 5, becomes obvious under this analysis.



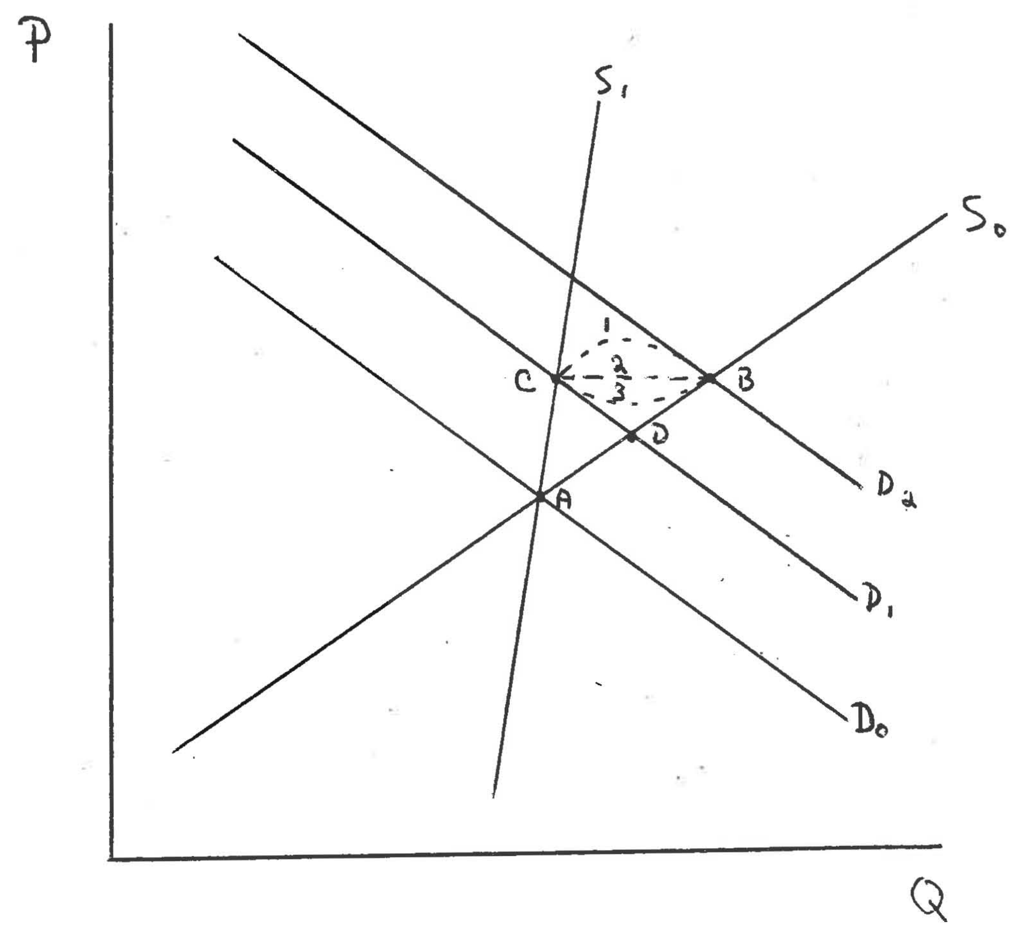
Long-run effects of Devaluation
Figure 5

Prior to the devaluation figure 6 shows a stable equilibrium at A. When devaluation begins, demand shifts towards

U.S. goods, as shown in figure 5. This will eventually cause a shift to new demand D_2^*, with equilibrium B. However, B is not immediately attainable because it is on the long-run supply curve S_0 and long-run demand D_2^*. Instead the new equilibrium is C, which is on the short-run supply curve S_1 and short-run demand D_1. C is not a stable equilibrium due to the fact that it is the intersection of two short-run curves. Therefore, supply and demand must begin adjusting towards long-run equilibrium at B.

Demand is shifting during this period because the exchange rate is altering. Generally, it takes time for the full currency effect to be felt. Demand for U.S. goods will continue to increase as the exchange rate drops. Supply will be driven by rising prices caused by expanded demand. This will cause production of home goods to expand. Eventually supply and demand must both end up at their long-run curves S_0 and D_2. The length of this adjustment is dependent on the short-run elasticities of both supply and demand. The higher the elasticity the faster the short-run adjustment. The total effect on the balance of trade is dependent on the long-run elasticities.

Improvement of the J-curve is heavily dependent on the short-run response of supply and demand. A quick adjustment means that more revenue will be earned quickly. There are three basic paths which can trace the adjustment from C to B. These are labelled 1, 2, and 3. Path 1 indicates a relatively slow supply response relative to demand. Home prices will remain high and the substitution from foreign goods to home goods will be slow. An adjustment path of this configuration will increase the length of the J-curve. Path 2 indicates that supply and demand shift at the same rate. Trade flows will begin to favor the U.S. in a shorter period of time then for path 1. The J-curve associated with path 2 is smaller then for path 1. Path 3 is the preferred path, supply adjusts faster than demand causing prices to favor the U.S. very quickly. Substitution to U.S. goods will favor the U.S. after a comparatively short period of time. The J-curve associated with this path is small.



Short and Long-run Effects of Devaluation
Figure 6

An exact representation of the J-curve can be shown by obtaining the derivative of the definition of the balance of trade. The balance of trade is defined as

(1) $$PQ - P^*Q^* = B.O.T.$$

Where P and P^* are the price level of exports and the price level of imports. Q is home goods sold abroad and Q^* is foreign goods sold in the home country.

The J-curve is simply the balance of trade during a particular length of time following a devaluation. Differentiating (1) gives this dynamic aspect to the definition.

(2) $$(PdQ + QdP) - (P^*dQ^* + Q^*dP^*) \gtreqless 0$$

When (2) is greater than 0 the J-curve will be upward sloping. When (2) is less than 0 the J-curve will be downward sloping. The trough of the J-curve is reached when (2) is equal to 0.

The effect on the J-curve of the three adjustment paths shown in figure 6 can be explicitly shown by rearranging (2).

(3) $$(PdQ - P^*dQ^*) + (QdP - Q^*dP^*) \gtreqless 0$$

The two terms are simply grouped to show the total quantity and price effects of a devaluation. Further simplification yields:

(4) $$\frac{QPdQ}{Q} - \frac{Q^*P^*dQ^*}{Q^*} + \frac{PQdP}{P} - \frac{P^*Q^*dP^*}{P^*} \gtreqless 0$$

Finally, QP is defined as exports and Q^*P^* as imports from (1).

(4a) $$\left[X\frac{dQ}{Q} - I\frac{dQ^*}{Q^*}\right] + \left[X\frac{dP}{P} - I\frac{dP^*}{P^*}\right] \gtreqless 0$$

Where X is exports and I is imports. X and I serve as weighting functions so that initially a small change in an import variable may have a larger effect then a large change in an export variable. This is because a country which devalues its currency probably imports much more then it exports. Theory tells us that after a devaluation the sign of the first term must be positive, export quantities will be increasing while import quantities will be decreasing. The sign of the second term must be negative, export prices will be falling while import prices will be rising.

The sign on the first (quantity) term is positive because figure 5 indicates that home output will increase after devaluation, therefore dQ/Q is greater than 0. dQ^*/Q^* will most likely have a negative sign because quantity of imports should be decreasing. It is possible that quantity of imports will not decrease. In this case the sign on the first term in (4a) will still be positive due to the size of the export adjustment.

The sign for the second (price) term is negative. The result of devaluation is that export prices will fall because home currency is worth less, therefore dP/P is less than 0. The opposite happens to import prices, they increase due to the devaluation, therefore dP^*/P^* is greater than 0. The sum of the second term will be positive.

In order for the J-curve to reach its trough (4a) must equal 0. This can only happen when total quantity adjustment is the same as total price adjustment. In order for the J-curve to slope upwards quantity must be adjusting faster then price.

This result can be applied directly to the three adjustment paths in Figure 6. Path 3 is the fastest adjustment path on the diagram because initially quantity is adjusting faster then price. It is clear from this that supply response plays an important role in determining the length of the J-curve. Supply must respond quickly to devaluation stimulated demand, otherwise the negative price effect will outweigh the positive quantity effect for a period of time during which the J-curve will not improve.

IV. Model and Methodology

The model used to measure supply response is simply that shown in Figure 6. Both supply and demand are expressed as functions of other variables. Each function is for a specific industry, with a total of 15 sets of equations. The exact specifications are:

$$S_{it} = f(P_{it}, S_{it-1}, t)$$
$$D_{it} = g(P_{it}, Y_t, \Pi_t, t)$$

Where S_{it} is the level of production for the i^{th} industry at time t, P_{it} is the wholesale price for the i^{th} industry at time t, Y_t is the level of GNP at time t, and Π_t is the exchange rate at time t. The price term in the supply equation and the exchange rate term in the demand equation are the sum of an 18 period lag structure ($\sum_{t=1}^{18} P_t, \sum_{t=1}^{18} \Pi_t$). This is to account for short-run (here defined as 18 months) effects of exchange rate movements on production. The total effect of 18 months worth of devaluation on price and therefore on supply are what is of interest to this study.

Time is included simply to account for any general growth trend. Both demand and supply naturally increase over time due to such factors as increased population, expanded work force, and technological change.

Previous production is assumed to be an important aspect of supply because many industries cannot quickly alter their level of output. They are highly dependent on past levels of next period. Contracts must be fulfilled and factory space utilized in order for an industry to operate effectively. Because previous production is so important for determining current levels of production it has great explanatory power in the supply equation.

Price of the good is another major determinant for driving supply. Basic microeconomic analysis tells us that as price alters so will output. In this case a price increase due to shifting demand will stimulate output. Price also plays a part in determining the level of demand. This is particularly true when looking at the international market where substitutes abound. A slight variation in price may cause a fairly sizeable drop in demand. This variable should have a wide range of values depending on the industry.

Real GNP is important in explaining the level of demand. Consumption is directly related to GNP by the marginal propensity to consume. As GNP increases so will consumption; for this reason GNP is a good general measure of demand.

The exchange rate is the key motivating variable in this study. Demand should be partially dependent upon this variable. In the earlier theory section of this paper it was shown that quantity of goods demanded shifts due to relative price changes. The exchange rate is the key to causing relative price changes. The parity price relationship between home prices and foreign prices can be expressed as follows:

$$P = eP^{*} \tag{5}$$

Where P is home price for a good, P^{*} is foreign price for a good and e is the exchange rate. When a currency is devalued e increases and foreign goods cost more unless P^* is lowered. If this is the case the price increase of foreign goods due to devaluation does not materialize. A rise in e is offset by a drop in P^*. Home consumers do not see any alteration in the relative price of goods and therefore demand will not shift towards home goods. As Magee would say, relative price changes must be passed through in order to be effective. Of course the parity price equation does not have to hold in order for consumers to be indifferent about a good. Japanese cars are a fine example of this. Japanese cars are perceived to be of higher quality then American cars, therefore a consumer may be willing to pay more money for the Japanese car. In any case a growth in the yen/dollar exchange rate must be equalled by a drop in Japanese car prices or some demand will shift to the cheaper U.S. car.

Due to relative price changes caused by exchange rate movements the supply curve will begin to shift. Basic economic theory teaches that supply movements and demand movements are interrelated. As demand expands prices will rise and supply will begin to increase. In this case a devaluation will increase e, causing demand to increase for home goods due to a favorable shift in relative prices. As demand increases supply will also expand due to higher prices as per Figure 6.

The two equation model described above contains the crucial elements for explaining the J-curve. Demand plays an important role in determining a country's balance of trade after a devaluation. Demand shifts due to changing relative prices caused by shifts in the exchange rate. Also important to the adjustment process is the reaction of supply to movements in demand. If demand increases while supply lags behind then little is gained through devaluation other then higher prices. A coordinated adjustment between both supply and demand is necessary for resolution of the J-curve. This simple model contains the crucial linkages between the exchange rate, demand, and supply which are of the utmost importance in determining the path of the J-curve.

The measurement of supply adjustments due to changes in the exchange rate is achieved through careful measurement of the model described above. The use of an 18 period lag on the exchange rate and on price allow for the measurement of total short-run supply movements attributable to changes in demand brought on by devaluation (changes in the exchange rate).

The estimation of this model is by no means a trivial task. The specification of the model utilizes a simultaneous equation system with lagged endogenous variables and a high degree of autocorrelation. In the specification Y_t, t, and π_t are considered exogenous. S_t and P_t are considered endogenous. The lagged values of S_t and P_t are considered lagged endogenous variables and normally would be thought of as predetermined. This would allow the equation to be estimated using standard instrumental variables techniques, such as two stage least squares. However, the high degree of autocorrelation in the specification complicates matters; lagged endogenous variables can no longer be classified as predetermined. Least squares estimation methods cannot be employed in this instance because estimations will be biased and inconsistent.

The method utilized to measure this system was developed by Ray Fair.[13] This method was used because it accounts for the three major forms of bias present in the specification: simultaneity, lagged endogenous variables, and serial correlation.

Only the supply equation was explicitly measured because demand results are of less interest to this study. To this end the demand specification plus exogenous supply variables and lagged values of all the independent variables in the supply equation are used as instruments to estimate endogenous variables in the supply equation. Once the endogenous variables have been purged of their simultaneity bias through this instruments process an iterative technique is used to account for serial correlation and estimate the supply equation.

In total 15 sets of equations had to be estimated. One set for each industry in the study. The industries measured and their SIC classifications appear in table 2.

Table 2
Classification of Measured Industries

Title	SIC#	Title	SIC#
Food and Kindred Products	20	Textile Mill Products	22
Apparel and Textile Products	23	Lumber and Wood Products	24
Furniture and Fixtures	25	Paper and Allied Products	26
Chemicals and Allied Products	28	Petroleum and Coal Products	29
Rubber and Misc. Plastics	30	Leather and Leather Products	31
Stone, Clay, and Glass Products	32	Primary Metal Industries	33
Fabricated Metal Products	34	Machinery, except Electrical	35
Electric and Electronic Equipment	36		

V. Data

Data was collected for an 11 year period spanning from 1974 to 1984. All observations are monthly.

t is the time trend variable. It is a series starting with 1 and ending with 132, the total number of observations in the system.

S_{it} is the level of production for the i^{th} industry. Production is measured by an index with base year 1977. All data is seasonally adjusted. The series was compiled by the U.S. Federal Reserve Bank and is similar to that published monthly in the U.S. Federal Reserve Bulletin, table 2.13. This series was used in log form.

P_{it} is the whole sale price for the i^{th} industry. Wholesale prices are measured by an index with base year 1967. This data appears in current labor statistics published by the bureau of labor statistics. This data was transformed into logs.

Y_t is the level of real GNP. This data was collected from a data set compiled by Litterman and interpolated using quarterly GNP data. For information on this series see Doan, Litterman, and Sims (1983).

π_t is the exchange rate. This series is an index, with base year 1973, of the weighted average exchange value of the dollar against the currencies from other G-10 countries plus Switzerland. The index is published in the Federal Reserve Bulletin, table 3.28. This data was used in log form.

VI. Results

Results from the estimations appear in table 3. In each case production is the dependent variable. The industry represented in the regression is identified by SIC code and a short abbreviation.

Table 3
Selected Regression Results
Industrial production and exchange rates

Ind. Variable	Food (20)	Tex (22)	App (23)	Lum (24)	Furn (25)
Constant	0.7353*	0.5262	0.5262	0.5732	2.311*
	(0.274)	(.724)	(0.723)	(0.396)	(1.03)
t	0.0005	.0002	0.0002	0.0007	0.0021*
	(0.001)	(.0005)	(.0006)	(0.001)	(0.001)
S_{t-1}	0.8806*	0.9491	0.9491	0.9368	0.9092*
	(0.052)	(.031)	(0.032)	(0.035)	(0.041)
P_t	0.392	-0.5822	-0.0582	0.028	-0.3952
	(.274)	(.724)	(0.724)	(.396)	(1.03)
D.W	1.28	1.14	1.14	1.23	1.12
St. Err.	.009	0.018	0.018	0.031	0.020

Ind. Variable	Paper (26)	Chem (28)	Pet (29)	Rub (30)	Lea (31)
Constant	1.3298*	0.8132*	0.6501*	1.1729*	0.2325
	(0.479)	(0.299)	(0.282)	(0.644)	(0.228)
t	0.0013	0.0008*	0.0003	0.0012	-0.0008*
	(0.001)	(0.0003)	(0.001)	(0.001)	(0.0003)
S_{t-1}	0.8863*	0.9456*	0.9084*	0.9254*	0.8922*
	(0.052)	(0.036)	(0.043)	(0.036)	(0.051)
P_t	-0.1647	-0.1129	-0.0418	-0.1712	0.0583
	(0.479)	(0.299)	(0.282)	(0.644)	(0.227)
D.W.	1.31	1.08	1.50	1.13	1.23
St. Err.	0.018	0.015	0.026	0.032	0.033

Ind. Variable	SCG (32)	Pmet (33)	Fmet (34)	Mach (35)	Elec (36)
Constant	1.1823 (0.620)	1.0538 (0.878)	1.0198 (0.654)	1.7459 (0.585)	5.8492 (1.621)
t	0.0013 (0.001)	0.0006 (0.0007)	0.0009 (0.0006)	0.0022 (0.0008)	0.0076 (0.002)
S_{t-1}	0.9434 (0.045)	0.9208 (0.069)	0.9552 (0.0476)	0.9411 (0.029)	0.6633 (0.081)
P_t	-0.1846 (0.620)	-0.1330 (0.878)	-0.1610 (0.654)	-0.2989 (0.586)	-0.9269 (1.621)
D.W.	1.10	1.09	1.01	0.92	1.69
St. Err.	0.022	0.048	0.016	0.016	0.065

Notes

D.W. is the Durbin-Watson statistic.

St. Err. is the Standard Error of the regression.

Standard Errors of the coefficients are presented in parenthesis under the coefficients. Due to a bug in the computer package used to estimate these equations the standard errors may be biased. Due to this flaw it is not known which coeficients are significant.

R^2 does not appear because it is incompatible with Fair's estimation method.

In all cases the number of observations is 107.

VII. Analysis

The most striking result of this study is that for the manufacturing sector there is no short-run supply response due to changes in demand caused by devaluation as indicated by the coefficient on P_t. P_t is the total response over an 18 month period to a change in demand caused by exchange rate changes. There is a negative correlation between price and exchange rate. As exchange rates fall demand is stimulated causing a rise in prices. This will cause suppliers to respond with increased output. According to this line of reasoning the sign on P_t should be positive, indicating that as prices rise so does production.

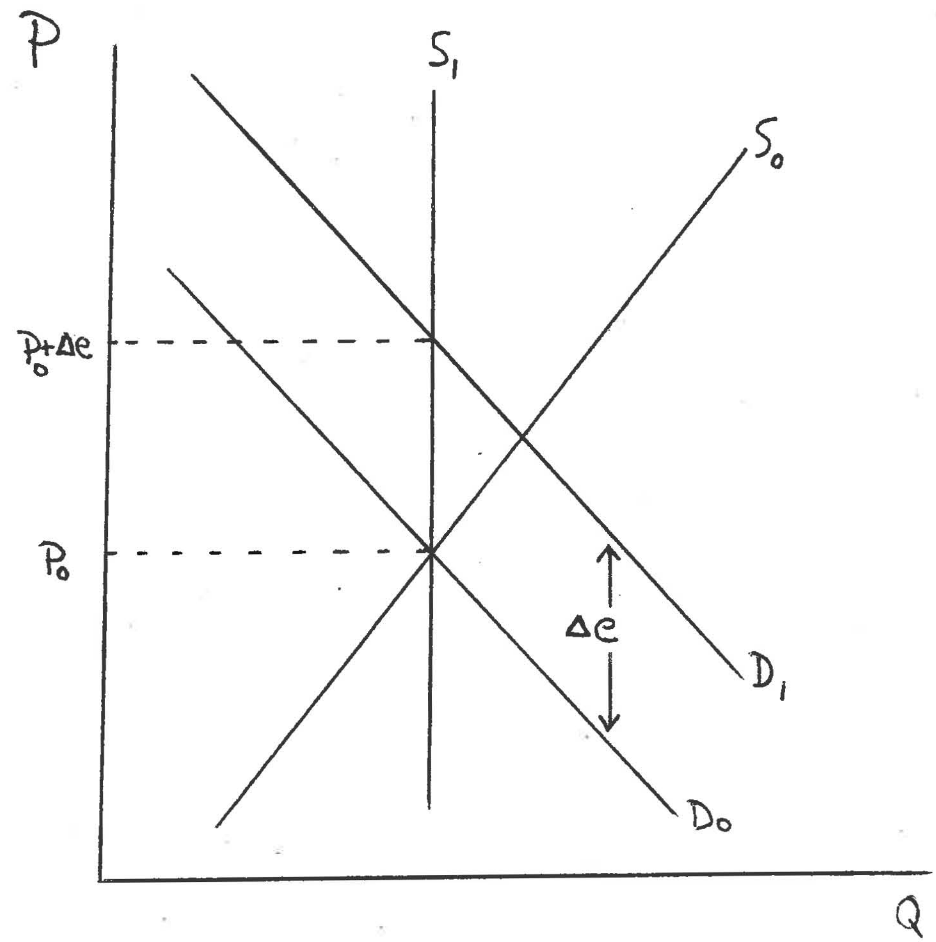
The sign on many values of P_t is negative. At first glance this seems to contradict the theory of increased supply due to higher prices. It appears that supply is riding down the demand curve. Closer investigation reveals that all of the P_t coefficients are indistinguishable from 0. For all industries, we fail to reject the null hypothesis that $P_t = 0$ at the .05 level of significance.

This result seems rather obvious when seen in light of the non-existent U.S. J-curve. It has been two years since the dollar was devalued and the trough of the J-curve has not been reached.

Complete lack of supply reaction is a good reason for the inability of the U.S. economy to improve its trade position quickly after a devaluation. Figure 7 shows what happens after devaluation when there is no supply response. Demand for home goods is stimulated due to improving relative prices, this moves demand by an amount equal to the devaluation from D_0 to D_1. According to the presented results supply is completely inelastic in the short-run (18 months). Therefore the new equilibrium B will exhibit only an increase in price equal to the depreciation with no change in output.

Looking back to (4a) we see that under these conditions the trough of the J-curve cannot be obtained. None of the terms in (4a) change in this case. The result of inelastic supply is that relative prices remain unaltered. The devaluation caused the price level in the home country to increase by an equal amount. Therefore, there is no change in relative prices between home and foreign goods. The trade situation remains unaffected and any deterioration in the balance of trade which was taking place before devaluation will continue.

The most obvious reason for why supply is completely inelastic is that 18 months is not a long enough period to show any alteration. Perhaps manufacturers cannot respond with increased production in such a short period. This argument seems rather implausible, especially in light of currency contract theory. Currency contracts indicates that little adjustment will take place until current contracts run out. Businesses can only use the futures currency market to cover themselves for a maximum of 6 months into the future. This being the case it seems unlikely that many 18 month contracts will be written. After the initial 6 month contract period expires accommodation of the new price regime should begin to alter output. Adjustment may need time to gain momentum, but there is no reason why 12 months of adjustment period leave no appreciable change in supply. There must be an explanation for the total lack of supply adjustment other than complete supply inelasticity.



Devaluation and Inelastic Supply
Figure 7

A more plausible explanation for short-run inelasticity of supply is short-run inelasticity of demand. The problem may lie in a lack of demand adjustment which acted to prohibit the supply side from beginning its response. Looking back to figure 6 we see that in this case after devaluation equilibrium A is still in effect because neither supply nor demand have altered. Since home prices have not increased there is no impetus for supply to increase.

To test the plausibility of this explanation I explicitly measured the demand equation in order to observe price movements in response to exchange rate alteration. The result of this preliminary investigation is that there is no demand adjustment in the immediate 18 month period following a devaluation.[14] This finding is not terribly surprising considering the results of other studies presented earlier. Elasticity of demand seems to be relatively small in the short-run.

The fact that supply is unresponsive in the short-run helps to clarify the debate surrounding the size of demand elasticity. If demand was highly elastic a fairly sizeable jump in price would be expected as relative prices came to favor the U.S. However, a sizeable jump in prices should elicit some response from supply even if it is highly inelastic. The fact that supply did not respond at all seems to indicate that the stimulus for the response was weak. Price did not increase by enough to have a great effect on demand. The most plausible explanation for the small price effect seems to be a small reaction from the demand-side. Supply did not shift because demand had not shifted by a significant amount, in the short-run demand is inelastic.

There are a number of good explanations for the inability of demand to quickly respond to exchange devaluations. Import and/or export prices may not have remained constant while the dollar was dropping. The dollar may not have fallen far enough in 18 months to have a great effect. Finally, many foreign currencies may be pegged to the value of the dollar, confounding attempts to alter relative prices.

In his article on pass-through Magee points out that frequently importers and exporters do not allow the costs and benefits of devaluation to reach the consumer. A foreign company importing goods to the U.S. will not want to lose its market share due to currency depreciation. In an attempt to stave off this loss the company may lower the foreign currency price of its good. This will mean that the dollar price of the good remains constant. Consumers will have no incentive to shift demand to home goods. This phenomenon cannot last indefinitely as the foreign company has lowered the revenues it obtains from imports to the U.S. in order to retain its market share. Eventually they must raise prices or drop out of the market, assuming they were not making much profit before the devaluation and cannot afford a drastic cut in revenues. When this happens demand will shift towards U.S. goods because foreign good prices will increase due to import supply reduction.

Home producers may interfere with pass-through by raising the dollar price of their exports. In this case the falling value of the dollar will mean that U.S. goods have the same value on international markets as they did before depreciation. Foreign consumers see no positive shift in prices towards the U.S. and therefore demand for U.S. goods does not alter. Magee points out that the alteration of prices after devaluation is a common practice. He cites evidence of this behavior from countries such as the U.S., Japan, and West Germany.

Another reason for lackluster demand movements may be explained by the relative price of the dollar both before and after devaluation. The reason for depreciation was that the dollar was able to buy too many foreign goods and other currencies able to buy too few U.S. goods. When the dollar was depreciated it may not have been brought down enough to have a great impact on foreign countries. Perhaps before the dollars fall Japanese companies had a 40% profit margin on goods sold in the U.S. This was possible because the yen price of the good was relatively small so that in dollar terms 40% could be added to the price without causing U.S. consumers to flinch. After devaluation Japanese business may be able to lower the yen price of their good thus keeping dollar prices stable, yet still earn a 10% profit. If this is the case the Japanese business will never be forced to export less to the U.S. due to low revenues, they will still be making a tidy profit. According to an article in the New York Times this is exactly what has occurred.

> So far, however, most foreign companies have kept price increases in the United States far below the corresponding changes in currency values by accepting lower profit margins and cutting manufacturing and marketing costs. Their strategy has been to make less money in the short-run in order to retain market share in the long-run.[15]

U.S. consumers have seen no shift upward in the price of Japanese goods and will not change their buying habits. Demand will remain unaffected.

Overvaluation of the dollar also affects U.S. exporters. Suppose the yen cost of an American made walkman is y400 while an equivalent Japanese model is only y150. If the dollar is not devalued by a tremendous amount there will be little incentive for Japanese consumers to purchase American walkmen and other goods.

The state of the global economy also plays a part in the determination of demand. Currently world demand is stagnating, growth is very slow. This hinders U.S. attempts to increase exports because few new goods are being bought. A recent newspaper article illustrates this point:

> In Argentina, thanks to the decline of the dollar, a Caterpillar tractor is now priced competitively with a Komatsu model from Japan. But that hardly matters because Argentina is growing too slowly to buy many new tractors - from America, Japan, or any other country.[16]

Until the world economy gets back on track it will be a slow adjustment towards improving the balance of trade.

The final reason for lack of demand movement has to do with currencies pegged to the dollar. A number of sizeable trading partners, South Korea for example, did not experience dollar devaluation. This is because their currencies are pegged to the dollar. When the dollar dropped so did these currencies. In this case no adjustment of demand would occur between the two countries, relative prices have remained the same. South Korea's currency has lost value when compared to the rest of the world, but it has not changed compared to the dollar.

In an article appearing in the New York Times David Hale, chief economist of Kemper Financial Services indicates that many countries have not allowed their currencies to appreciate in relation to the dollar. He says,

> Most countries south of the Tropic of Cancer have permitted their exchange rates to drop to deeply undervalued levels on a purchasing power basis, in order to generate export growth for debt servicing.[17]

The effect of this case is exactly the same as for a pegged currency. Demand cannot shift towards U.S. goods until relative prices change. Many developing countries cannot afford to lose any foreign exchange which is generated by exports to the U.S. because the have huge debts to service. Indirectly the third world debt problem is hampering American trade improvement.

Certainly no individual effect is completely responsible for demand stickiness. Individually each condition contributes something to the total lack of demand movement. It remains to be seen which of these theoretical conditions exists in todays environment.

Shrinking profit margins have been used effectively to hold down ~~many~~ import prices. Headlines such as "Profit Margins Already Slim"[18] are beginning to appear. For the period between January 1985 and June 1986 import prices rose by less then 5% while the dollar lost more then 30% of its value. This indicates that foreign prices of imports must have fallen or import prices would have risen by 30%. Already predictions are being made that foreign prices will soon be going up:

> But now analysts think that foreign producers have cut profitability as much as they can afford and that any further drop in the dollar's value will have to be passed along in higher prices for American consumers.[19]

However these predictions may be in error due to mismeasurement of the dollars value. Measured by the standard Federal Reserve trade weighted measure of 10 major trading partners the dollar is down by 30% The Dallas Federal Reserve Bank uses a different index to measure the dollar's value. It includes 131 countries which trade with the U.S. By this measure the dollar has only depreciated by 5%.[20]

It seems likely that demand for U.S. goods has been poorly stimulated by recent currency movements. Uneven levels of devaluation have meant that the dollar really has lost little value in the overall market although it has lost much against the yen and deutsche mark. Foreign price levels are frequently low enough so that foreign producers have not yet been seriously hurt by the higher relative value of their currency. It is difficult to know how much each effect discussed here has contributed to inelastic demand. The fact remains that after two years of devaluation the U.S. economy has not seen a measurable improvement in its balance of trade.

VIII. Problems

Estimating the model for this paper proved to be a problem filled endeavor. The problems stem from a highly correlated component of the error term which proved to be beyond my capability to correct for. A quick perusal of the Durbin-Watson statistics in table 3 indicates that none of the estimations are free of first order autocorrelation. Plots of the residuals show a high degree of correlation between them and movements in the level of production. There are several possible reasons for the correlation found in this model, a quick review of them may help to shed some light on the subject.

The error term may contain some form of high order autoregressive structure. If this is the case, Fair's estimation method would be ineffective in completely eliminating inefficiency from the results. Fair uses an iterative technique which corrects only for first order autocorrelation.[21]

Take the case of a second order autoregressive term:

(6) $$e_t = p_1 e_{t-1} + p_2 e_{t-2} + u_t$$

An iterative correction for first order autocorrelation identifies p_1 as the only term in the autoregressive structure. This is due to the fact that a correction for a first order autoregressive structure is based on the following model:

(7) $$e_t = p_1 e_{t-1} + u_t$$

An iterative correction for first-order autocorrelation takes on the following form:

(8) $$y_t - \hat{p}_1 y_{t-1} = a(1 - \hat{p}_1) + b(x_t - \hat{p}_1 x_{t-1}) + (e_t - \hat{p}_1 e_{t-1})$$

In this procedure corrected lagged values are being subtracted from contemporaneous values of all variables. This is done to purge the error term of all correlation with past values. p_1 (rho) is the coefficient obtained from the following equation:

(8a) $$\hat{e}_t = p\hat{e}_{t-1} + u_t$$

In practice (8a) is estimated by regressing the estimated residuals on themselves. Unfortunately in the case of (8) the difference between e_t and p_1e_{t-1} is more then just the random component of the error term, u_t. Substituting (6) into the results of the "corrected" equation (8) yields the following structure for the error term:

(9) $$p_2e_{t-2} + u_t$$

More then just the uncorrelated error term u_t is left after correction. Due to the inability of the techniques available to me to correct for higher order serial correlation there is the possibility that my coefficients are inefficient and my standard errors are biased due to a higher order autoregressive structure. There are however, several other possible explanations for the flaw in my estimations.

A second structural model, one with a moving average component may be responsible for the bias. In this case the behavior is generated by a proportion of random disturbances of length x periods.

(10) $$y_t = u_t + e_t + c_1e_{t-1} + c_2e_{t-2} + \dots + c_xe_{t-x}$$

Autoregressive correction methods available to me will not be able to correct for a moving average structure such as this. Even in its simplest form with a disturbance length of 1 period the moving average would confound standard estimations.

(11) $$y_t = u_t + e_t + c_1e_{t-1}$$

Where u_t, e_t, and e_{t-1} are all random variables. An iterative procedure for correcting autocorrelation cannot be applied to even this single period moving average structure because the disturbances are generated by random variables which cannot be properly dealt with.

The result of an iterative correction carried out on a moving average structure will be nothing due to the fact that even a one period moving average structure is equivalent to an infinitely long autoregressive structure. "A complete model of most random processes [moving average] would require an infinite number of lagged disturbance terms (and their corresponding weights).[22] The effect of correcting for first-order autocorrelation is negligible because an infinitely long structure is still left correlated after the correction.

The moving average structure may explain why a number of industries could not be estimated due to non-convergence of rho. The iterative technique was never able to correct the correlation because the autoregressive structure was infinitely long. Therefore it was not altered by the correction process and the amount of autocorrelation present never changed.

The problem may have been due to the form of data which I was using. Monthly production data is highly correlated by nature and may have contributed to the serial correlation problem. I hoped that by transforming the data into first differences I could eliminate this problem. The change in output between periods would not necessarily be highly correlated and therefore much of the correlation bias would be eliminated after the transformation. This idea did not work out due to the fact that many of the estimations failed due to large values of the correlation coefficient p. Few of the estimations performed using first differences yielded useable results. Generally the use of first differences eliminates the effects of a first order autoregressive term. The fact that p was large even after first differences may be indicative of a higher order autoregressive structure as discussed previously.

The final possible explanation for the uncorrected autocorrelation has to do with a misspecification of the model. The high degree of similarity between plots of the residuals and of production seem to indicate that the error term is picking up a fairly important variable which was omitted from the model. In an effort to gauge the effectiveness of this argument several industries were re-estimated with improved specifications of their supply equations. Two variables were added, wages and cost of inputs. These were selected because of their theoretical importance with regards to supply. Estimations were inconclusive as to the effect of these variables on short-run supply adjustment.[23] Additionally the degree of autocorrelation present was not reduced by an appreciable amount. Although the possibility of a misspecification accounting for high autocorrelation is present it seems unlikely after these results.

The estimations presented in this paper are biased for one or more of the reasons discussed above. It seems likely that some form of structure more complex than first-order serial correlation is present in the model. The mystery surrounding the exact form of bias prevents me from knowing the direction in which the estimates will be biased. Techniques to correct for these problems will have to be pursued in future research.

There is one final, very important problem with the results presented in this paper. A problem with the computer package used to estimate the equations exists. Fair's method has a defect such that the standard errors of the estimations are biased. Thus, little information can be drawn from the coefficients because there is no certain way to tell whether they are significant or not.

IX. Conclusion

This paper has attempted to ascertain the contribution to the J-curve, in the short-run, of the supply-side of the U.S. economy. The literature on this aspect of the J-curve is lacking much empirical work on this subject and it was hoped that these findings could shed some light on the subject. The results confirmed why the literature on this topic is devoid of results; there is no short-run supply response to currency devaluation. This result was assumed by many to be true based on previous studies and much theoretical work.

Previous work in the area of the J-curve has concentrated on the adjustment of demand after devaluation. Empirical results seem to indicate that demand is inelastic in the short-run. One conclusion which was drawn is that supply may be inelastic due to lack of price response, this assumption is confirmed by my results.

Unfortunately my results are far from perfect. The problems of estimation which I discussed indicate some form of bias is present in my results. Until this error is corrected there will always be some small doubt as to the validity of these findings. It seems clear from the body of theory and previous work surrounding this topic, that my findings are reasonable. I expect the elimination of bias in my estimations to have little effect on the results obtained.

The course for future study on this topic seems to be clear. Improved estimations must first be obtained. I am investigating the use of moving average models and estimation techniques such as ARIMA modeling as a possible solution to my econometric problems. Once the estimation procedure is perfected then the true supply response to devaluation can be measured. My results indicate that this would be a two part procedure. First, demand adjustment must be measured to see when it is reasonable for supply to begin adjusting. The problem with the current study was that supply movements were estimated before substantial demand movements had taken place. Once demand estimations have been completed supply movements must be measured incorporating the lag in demand response within the model. Results from the current study indicate that the lag should be at least 18 months.

Once the previous estimations are performed the question which this study hoped to answer will be obtained; How much of the J-curve is due to lethargic supply response? Results from this study cannot answer that question due to the time frame of investigation. In the initial 18 months following devaluation supply does not adjust simply because demand has not altered enough. This study then concludes that the initial 18 month decrease in the balance of trade after currency devaluation cannot be blamed on sluggish supply response. It has nothing to respond to after 18 months.

Finally, once significant estimations of supply response have been achieved for each industry some interesting policy recommendations can be made. Once it is discovered which industries respond to devaluation fastest then the reasons for their "quickness" can be found. Knowledge about the attributes of an industry which increase adjustment speed may allow other industries to learn how to adjust more quickly. Hopefully this will decrease the size of the J-curve.

Appendix I: Short-run supply adjustment

In order to see how much demand had moved over the 18 month period I was investigating the demand equation from section IV was estimated. The estimation procedure utilized was the Cochrane-Orcutt method. The results for all 15 industries measured are presented below.

Selected regression results: Short-run demand movements and the exchange rate

	Food (20)	Tex (22)	App (23)	Lum (24)	Furn (25)
Constant	2.3967*	0.3266	0.4506	1.5403	1.3308*
	(0.853)	(0.281)	(0.311)	(0.905)	(0.517)
t	-0.0017*	0.0003	0.0003	0.0012*	0.0009*
	(0.0005)	(0.0002)	(0.0002)	(0.0004)	(0.0003)
Y_t	-0.0309	0.0183	0.0074	0.0219	-0.0403
	(0.0706)	(0.019)	(0.0219)	(0.114)	(0.0292)
P_{t-1}	0.6883*	0.9319*	0.9196*	0.7457*	0.8335*
	(0.082)	(0.0343)	(0.0369)	(0.0719)	(0.0606)
π_t	-0.1268	-0.0297	-0.0257	-0.0795	-0.0449
	(0.853)	(0.281)	(0.311)	(0.905)	(0.516)
D.W.	2.03	1.99	1.99	1.86	1.99
St. Err.	0.011	0.003	0.004	0.014	0.004
Adjusted R2	0.992	0.999	0.999	0.957	0.999

	Pap (26)	Chem (28)	Pet (29)	SCG (32)	Pmet (33)
Constant	0.1154	0.7260	0.7588	1.4366	1.0291
	(0.487)	(0.539)	(1.073)	(0.664)	(0.544)
t	0.0004	0.0007	0.0028	0.0015	0.0013
	(0.0004)	(0.0003)	(0.0007)	(0.0005)	(0.0004)
Y_t	0.0492	0.0197	-0.1552	0.0189	0.0954

	(0.034)	(0.399)	(0.0943)	(0.044)	(0.049)
P_{t-1}	0.9272*	0.8904*	0.7937*	0.7891*	0.7522*
	(0.052)	(0.047)	(0.052)	(0.065)	(0.070)
π_t	-0.0308	-0.0715	-0.3140	-0.1138	-0.1065
	(0.487)	(0.539)	(1.073)	(0.664)	(0.544)
D.W.	2.01	2.05	1.59	1.94	1.96
St. Err.	0.005	0.005	0.010	0.006	0.008
Adjusted R^2	0.999	0.998	0.993	0.999	0.997

	Fmet (34)	Mach (35)	Elec (36)
Constant	0.1114	0.1557	0.9591*
	(0.249)	(0.257)	(0.426)
t	0.0003	0.0002	0.0009*
	(0.0002)	(0.0002)	(0.0003)
Y_t	0.0491*	0.0244*	0.0011
	(0.015)	(0.018)	(0.026)
P_{t-1}	0.9324*	0.9613*	0.8516*
	(0.028)	(0.022)	(0.047)
π_t	-0.0329	-0.0324	-0.5531
	(0.250)	(0.257)	(0.426)
D.W.	1.96	2.07	1.96
St. Err.	0.003	0.003	0.003
Adjusted R^2	0.999	0.999	0.999

Notes

Results for industries 30 and 31 have been omitted. These industries proved to be unmeasurable due to large values of rho.

The key to this table is identical to that found in table 3.

Appendix II: Estimations of improved specification

Two variables were added to the original specification in an attempt to improve the predictive capability of the original model. It was hoped that this would eliminate the large bias due to highly correlated residuals. The new supply equation is of the following form:

$S_t = f(S_{t-1}, P_{it}, t, W_{it}, I_{it})$

This equation is identical to that presented in section IV with the addition of two variables, W_{it} (wage) and I_{it} (cost of inputs).

W_{it} is the level of wages for the i^{th} industry paid to production and non-supervisory workers at time t. The series was compiled from data appearing in the survey of current business. This series was used in log form.

I_{it} is the cost of one major input in the production of the final good for the i^{th} industry at time t. This is the same series as used for P_t. The three industries measured and their inputs appear below:

Industry	Input
Apparel	Textiles
Fabricated Metals	Primary Metals
Machinery	Fabricated Metals

Selected Regression Results: Improved Supply Specification

	App (23)	Fmet (34)	Mach (35)
Constant	0.5133	3.038	2.932
	(0.736)	(0.896)	(0.692)
t	0.0002	0.0015	0.0017
	(0.0006)	(0.001)	(0.0007)
S_{t-1}	0.9452	0.8469	0.9527
	(0.032)	(0.067)	(0.039)
W_t	-0.0072	0.2523	0.3991
	(0.078)	(0.117)	(0.159)
I_t	-0.1848	0.4313	-0.4298
	(0.185)	(0.165)	(0.192)
P_t	0.4886	-0.9852	-0.2376
	(0.736)	(0.896)	(0.692)
D.W.	1.13	1.02	1.01
St. Err.	0.018	0.015	0.015

Notes

Same as for table 3.

Endnotes

[1]Source: U.S. Federal Reserve Bulletin, table 3.28.

[2]Source: U.S. Federal Reserve Bulletin, Table 3.11.

[3]See Goldstein and Khan (1985) pp1078-1082 for a variety of estimates.

[4]Dornbusch (1976), p.1171.

[5]Dornbusch and Krugman (1976), p.551.

[6]Gordon (1984), p.613.

[7]Dornbusch and Krugman (1976), p.551.

[8]Bushe, Kravis, and Lipsey (1986), p.259.

[9]Kreinin (1977), p.298.

[10]Results from a number of these studies can be found in : Lawrence (1978); Hickman and Lau (1973); Houthakker and Magee (1969).

[11]Goldstein and Khan (1985), p.252.

[12]Bushe, Kravis, and Lipsey (1986), p.252.

[13]Fair (1970).

[14]Detailed results of this estimation appear in appendix 1.

[15]New York Times (Jan. 16, 1987), p.25.

[16]New York Times (Feb. 4, 1987), p.1.

[17]New York Times (Jan. 12, 1987), p.34.

[18]New York Times (Jan. 16, 1987), p.25.

[19]New York Times (Jan. 16, 1987), p.25.

[20]Wall Street Journal (Jan. 30, 1987), p.16.

[21]For an exact account of how Fair's method corrects for first order autocorrelation see his 1970 article in Econometrica.

[22]Pindyck and Rubinfeld (1981), p.516.

[23]Detailed results of this investigation appear in appendix 2.

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