THE DECLINING EXCHANGE RATE: IMPACT ON THE U.S. ECONOMY 2000-2009

JOHN J. HEIM*

ABSTRACT

Using a simplified Klein/Fair econometric model of the U.S. economy, estimated using 1960 – 2000 data, the paper finds that the 12.9% dollar decline 2000-2009 had a positive effect on exports, but mildly negative effects for domestically produced investment and consumer goods. The estimated overall negative effect on the GDP is modest: 1.7% over the nine years, or about a fifth of a percent per year. It is estimated this decline in the dollar reduced the trade deficit $140.7 billion. This decline is estimated to have increased U.S. net asset position by an $88.6 billion.

1. INTRODUCTION

A decline in U.S. real exchange rate may make goods Americans import more expensive, thereby reducing real income. This *income effect* may reduce U. S. demand for both domestic and imported goods. The decline may also cause a *substitution effect* by making imports more expensive, shifting demand toward cheaper American goods. Also, the cheaper U.S. dollar may have a positive income effect by increasing American exports. The paper also estimates the extent to which exchange rate – induced price increases in imports reduce the trade deficit and thereby reduce transfers of U.S. assets to other nations or their citizens, as required to pay for trade deficits.

2. METHODOLOGY

This study examines how real declining exchange rates 2000 – 2009 have affected U.S. demand for domestic and imported goods. It uses a seven behavioral equation model of the U.S. economy (three consumer demand equations, three investment demand equations and an export demand equation) to estimate the GDP and its components. The three consumption equations are for total, domestically produced and imported consumer goods, the three investment equations are for total, domestically produced and imported investment goods. The seventh equation estimated export demand. The econometric approach is patterned after the more detailed (30 behavioral equations) demand – driven econometric models of Ray Fair (2004).

A significant difference between this study and Fair's models is the way in which autocorrelation is treated. Generally, here it is dealt with by first differencing data. In Fair, it is dealt with by leaving the data in levels and using standard autocorrelation control AR(i) variables.

All data used in those studies was taken from the Council of Economic Advisors' statistical appendix to the *Economic Report of the President, 2002, 2001 and 1997.* Exchange rate values 1960 - 1970 were

* Department of Economics, Rensselaer Polytechnic Institute

assumed constant at 1970 levels, per the Bretton Woods protocols. All data are expressed in real 1996 dollars, or converted to same using the GDP deflator in Table B3 of the President's Report.

Each regression below shows the estimated marginal effect (regression coefficient) for the explanatory variables, the t statistic associated with it, the percent of variance explained and the Durbin Watson autocorrelation statistic. Depending on the particular regression test and the number of lags used, our sample size was 36-38 observations from the 1960-2000 period. With this number of observations, throughout the remainder of the paper, marginal effects with a t-statistic of 1.8 are significant at the 8% level, 2.0 are significant at the 5% level and t-statistics of 2.7 are significant at the 1% level

Because of the simultaneity between the total consumption variable (C) in the GDP accounts, or its component part, domestic consumer goods (C_D), and income (Y) inherent in these equations, two stage least squares estimates of disposable income $\Delta(Y\text{-}T_G)_0$ were used. The remaining right hand side variables were used as first stage regressors. Newey-West heteroskedasticity corrections were also made, generally improving t - statistics. Two Stage least Squares was also used with the investment equations because of simultaneity between investment and the economy's growth rate (the accelerator variable).

Following Heim (2007), we then take as our definition of consumer goods and services imports all imports except for imports of capital goods and industrial supplies and materials. These definitions appear to be reasonable, if not exact, given the data available. Separate regressions were then run on total consumer demand, and separately for imported consumer goods alone. Results for the imports equation were subtracted from the results for the total consumption (C) equation, to estimate demand for domestically produced consumer goods. As noted earlier when discussing autocorrelation, the coefficients obtained in this manner (arithmetically) for each variable are exactly the same as those obtained statistically by regressing these same determinants on domestically produced consumer goods ($C\text{-}M_{m\text{-}ksm}$).

Investment imports were defined using the same process as imports of capital goods plus imports of industrial supplies and materials (M_{ksm}), i.e., total imports minus consumer imports.

Preliminary testing suggested that exchange rates have some lagged effects that go back as far as three years ago, so the average exchange rate for those years (XR_{Av0123}) was used.

3. THE CONSUMER DEMAND MODEL:

Heim (2008b) found that regression results on a modified Keynesian function of the following type explained about 90% of the variance in consumer spending in the 1960 - 2000 period:

$$C = \beta_1 + \beta_2 (Y\text{-}T_G) + \beta_3(T_G - G) - \beta_4 (PR). + \beta_5 (DJ)_{-2} + \beta_6 (XR)_{AV0123} \quad (1)$$

where

$(Y\text{-}T_G)$ = Total income minus taxes

$(T - G)$ = The government deficit

PR = An interest rate measure, the Prime Rate, for the current period.

DJ_{-2} = A wealth measure, the Dow Jones Composite Average, lagged two years

XR_{AV} = The trade - weighted real exchange rate (XR), averaged four years.

Our regression findings for consumer demand model are as follows:

Demand for Domestically Produced Consumer Goods

$$\Delta(C- M_{m-ksm})_0 = .55\Delta(Y-T_G)_0 + .19\Delta T_{G(0)} + .24\ \Delta G_0 - 1.92\ \Delta PR_0 + .28\Delta DJ_{-2} - .20\ \Delta XR_{AV0123} \quad R^2=74\% \quad (6)$$

(t)	(16.2)	(1.5)	(1.3)	(-0.6)	(1.9)	(-0.2)	D.W.= 1.8	

4. THE INVESTMENT DEMAND MODEL

The demand for Investment goods may also decline when the exchange rate declines, lowering real business income and raising import prices. How much of the decreased will be for domestic goods compared to imports depends on the marginal propensities to invest (MPI_D or MPI_M) in those goods in response to a change in the economy's real growth rate (i.e., the "accelerator effect") caused by a declining exchange rate. A secondary decrease in Investment may occur due to multiplier effects of the original change, reducing savings, causing increased crowd out effects.

The variables included in the investment equations are

ΔACC = An accelerator variable $\Delta(Y_t - Y_{t-1}) = \Delta\ GDP_t$

ΔDEP = Depreciation,

ΔCAP_{-1} = A measure of last year's capacity utilization level

$\Delta PROF_{-2}$ = A measure of business profitability two years ago

The other variables have the same meanings they had in the consumption equations. The parameters in this investment demand model were estimated to be:

Demand For Domestically Produced Investment Goods

$$\Delta(I-M_{ksm}) = .24\Delta ACC + .91\Delta DEP - .15\Delta CAP_{-1} + .45\ \Delta T_G - .47\Delta G - 9.59\Delta r_{-2} - .40\ \Delta DJ_{-2} + .47\ \Delta PROF_{-2} + 5.37\ \Delta XR_{AV0123} \quad R^2=.88 \quad (11)$$

t=	(7.8)	(3.0)	(-0.4)	(6.0)	(-2.9)	(-7.3)	(-1.9)	(4.1)	(4.1)	DW =2.1

5. THE EXPORTS DEMAND MODEL (USING THE REAL BROAD EXCHANGE RATE INDEX)

There is also an increase in income that occurs because of the increase in exports associated with the decline of the exchange rate. A rough estimate of this effect can be obtained by regressing exports on the 4-year average exchange rate above and the growth in the American GDP over the 1960-2000 period. The income variable serves as a proxy for the growth in our major trading partners' incomes over this period. The results are as follows:

$$\Delta X_0 = .12\ \Delta(Y_{AV12}) - 2.86\ \Delta XR_{AV0123} + .68\ AR(3) \qquad R^2= 53\% \qquad (12)$$

(t)	(5.3)	(-2.6)	(5.4)	D.W.= 2.1

6. THE TAX GROWTH MODEL

Part of tax growth is exogenous, i.e., varies with legislative changes in tax rates. However, part is endogenous, i.e., dependent on income growth from year to year. The results of this regression are:

$\Delta T_G = .26\ \Delta(Y)$ $R^2 = 47\%$ (13)

(t) (7.7) D.W.= 1.4

Both the consumption and investment equations above show a positive effect on demand of an increase in tax revenues, presumably by reducing crowd out caused by government deficits. Therefore, in calculating the full effects of a rise in real income due to exchange rate changes, it is important to also measure the secondary boost to income resulting from additional taxes collected as income grows. We might also define tax changes that are government - enacted, i.e., exogenous, as approximately ΔT_{EX} , where

$\Delta T_{EX} = \Delta T_G - .26\ \Delta Y$ (or) $\Delta T_G = .26\ \Delta(Y) + \Delta T_{EX}$ (14)

We say "approximately, because T_{EX} also contains the regression error term.

7. A MODEL FOR CALCULATING MULTIPLIER, ACCELERATOR AND CROWD OUT EFFECTS OF EXCHANGE RATE CHANGES

To illustrate how these terms are used further below, the following definitions of the multiplier and accelerator are presented, using simplified versions of our above consumption and investment equations for ease of exposition:

The GDP (Y) is comprised of consumer goods (C), investment goods (I), goods and services produced for the government (G) and net exports (X-M):

$Y = C + I + G + (X-M)$ (15)

Domestic demand for all consumer goods, imported and domestically produced, can be written:

$C = (c_0 + m_0) + (c_1 + m_{c1})(Y-T_G) + (c_2 + m_{c2})\ T_G + (c_3 + m_{c3})\ G$ (16)

where $(Y- T_G)$ is total income generated producing the GDP minus total taxes; $c_1 + m_{c1}$ are the marginal propensities to consume domestic and imported goods, T_G and G represent the variables measuring the extent to which consumer credit is crowded out by the government deficit. The disaggregated form of the deficit is used (T_G ,G separately) instead of just (T_G - G) because testing above indicates that the effects of the two variables on crowd out are different.

Demand for investment goods in this simple model of the economy might be described as

$I = I_0 + (I_1 + m_{I1})\ \Delta Y - (I_2 + m_{I2})\ r + (I_3 + m_{I3})\ T_G + (I_4 + m_{I4})\ G$ (17)

where ΔY is a Samuelson "accelerator" variable, indicating I grows (accelerates) in response to the general growth in the economy, r is the real interest rate, $(I_1 + m_{I1})$ are the marginal propensities to purchase domestically produced or imported investment goods ut of a change inY. $(I_2 + m_{I2})$ are the marginal propensities to invest when interest rates change. T_G + G represent the investment credit crowd out variables, again disaggregated, and the marginal impact of crowd out is $(I_3 + m_{I3})$ or $(I_4 + m_{I4})$ depending on whether it is caused by taxes or government spending.

Import demand might be expressed as

$$M = M_C + M_I = m_0 + m_{c1}(Y-T) + m_{I1}\Delta Y - m_{I2} r + (m_{c2} + m_{I3}) T_G + (m_{c3} + m_{I4}) G \quad (18)$$

i.e., the demand for imported consumer or investment goods is driven by the same variables as is domestic demand. Substituting (16), (17) and (18) into equation (15) gives

$$Y = (c_0 + I_0 - m_0) + c_1 (Y - T_G) + I_1 \Delta Y - I_2 r + G + X + (c_2 + I_3) T_G + (c_3 + I_4) G \quad (19)$$

using the marginal propensity to consume domestically produced goods from the Section 3 and 4 regressions above. However, if we separate $I_1 \Delta Y$ into its separate components, $I_1 Y$ and $- I_1 Y_{-1}$, and recollect our current year Y terms, we get a modified multiplier (or multiplier/accelerator) coefficient that combines traditional multiplier and accelerator effects.

Again using our regression results above. we can further augment this function by noting that the tax component (T_G) of the "crowd out" variables in both the consumption and investment equation grows as income grows, as shown in our tax growth model above. Also, our consumption and investment regressions above suggest that a rise in taxes depresses consumption spending by decreasing disposable income -$.57B for each billion increase in T_G, but that the same rise in taxes stimulates consumer spending by +$.20B and investment spending by +$.44B, more than offsetting the negative impact of taxes on disposable income, for a net effect of +$.09B. Hence,

$$(-c_1 + c_2 + I_3) T_G = (-.55 + .19 + .45) T_G = (.09) T_G = (.09)(.26\, Y + T_{EX}) = .02\, Y + .09\, T_{EX}$$

Using this formulation and recombining the Y terms gives a further modified multiplier we will call the "Multiplier/Accelerator/Crowd Out" ("M/A/C") multiplier:

$$\Delta Y = \frac{1}{(1-c_1-I_1-[-c_1+c_2+I_3][.26])} [- c_1 \Delta T_{EX} - I_1 \Delta Y_{-1} - I_2 \Delta r + \Delta G + \Delta X + (c_2+I_3) \Delta T_{EX} + (c_3+I_4) \Delta G] \quad (23)$$

where the numerical value of M/A/C multiplier becomes $\frac{1}{(1-.55-.24-.02)} = 5.26$

This is the multiplier we will use to calculate the effect of a change in the exchange rate on income.

9. THREE METHODS FOR CALCULATING THE IMPACT ON THE GDP OF A CHANGE IN THE EXCHANGE RATE

Three separate methods, all yielding the same results, are used to compute the effect of a change in the exchange rate on the GDP (Y):

Method 1: Use marginal effects estimates from the above domestic investment, consumption and export regressions to estimate the initial change in domestic consumption, investment and the GDP resulting from a one index point drop in the trade weighted exchange rate. Apply the M/A/C multiplier (5.26) to the result

Method 2: Use the method favored in many large scale econometric models of the economy (Fair 2003, Pindyck & Rubinfeld 1991). This involves separately estimating ΔC_D, ΔI_D, ΔG and ΔX (using the equations above), and simply summing the results to get ΔY

Method 3: Formally Construct a Keynesian IS curve, and predict ΔY from its determinants and the multiplier implied by the function. It is a slightly more formal presentation of Method 1.

9.1 Method 1

$ + 0.20B (Billion) - Total Estimated Effect (Positive Substitution Minus Negative Income Effect) Of A One Point Exchange Rate Decline On Demand For Domestically Produced Consumer Goods (C_D)

$ - 5.37B - Total Effect (Negative Substitution plus Negative Income Effect) Of Decline In Demand For Domestically Produced Investment Goods (I_D)

$ + 2.86B - Increase In Exports (X)

$ - 2.31B - Initial Net Decline in Real U.S. Income from 1 point Exchange Rate Decline:

x 5.26 - Multiplier/Accel/Crowd Out (M/A/C)Effect

$ -12.15B - Decline in Real Income (Y) after Multiplier/Accel/Crowd Out (MAC)Effects

- 3.16B - Δ Taxes Due To M/A/C Effect @ Historic .26 Rate (.26*12.15 = 3.16B)

$ - 8.99B - $\Delta(Y-T_G)$ = Decline In Disposable Income Associated With A One Point Decline In The Exchange Rate

To see the impact of decreased credit availability (crowd out) due to decreased tax collections:

- $0.60B = ΔC_D Due to Crowd Out Effect, Caused By Decreased Taxes = (.19)($ -3.16B)
- $0.95B = ΔC_M Due to Crowd Out Effect, Caused By Decreased Taxes = (.30)($ -3.16B)

With this information we can summarize the changes in consumption and saving resulting from the decrease in disposable income of $ 8.99B as follows:

$ - 8.99B $\Delta(Y-T_G)$	$ - 8.99B $\Delta(Y-T_G)$	$ - 8.99B $\Delta(Y-T_G)$
x .55 MPC_D	x .11 MPC_M	x .34 MPS (1 -.55 -.11)
$ - 4.94B ΔC_D (Multip. Effect)	$ - 0.99B ΔC_M (Multip. Effect)	$ - 3.06B Δ Savings (Reduction
$ +0.20B Initial ΔXR_{0123} Effect	$ - 3.03B Initial ΔXR_{0123} Effect	in Domestic Funds Available)
$ -0.60B Crowd Out Effect	$ - 0.95B Crowd Out Effect	
$ -5.34B Total ΔC_D	$ - 4.97B Total ΔC_M	

9.2 Method 2:

From the econometric models in Sections 4, we see three variables through which investment is affected by changes in the exchange rate:

1. the decrease in the accelerator income variable in the investment equation, due to the decrease in GDP (including multiplier effects) caused by the one point decline in XR_{AV0123}
2. the decline in tax collections because of the decline in real income caused by the increase in import prices, and
3. through the one point decline in the exchange rate variable

In this case then, the estimated decline in domestic investment will be

$\Delta I_D = \Delta(I\text{-}M_{ksm})$ =.24 ΔACC +.45 ΔT_G + 5.37 ΔXR_{AV0123} = $ - 9.71B

We can also estimate the decrease in demand for imported investment goods as

$\Delta I_M = \Delta(M_{ksm})$ = .05 ΔACC +.07 ΔT_G - 0.40 ΔXR_{AV0123} = $ - 0.43B

By similar reasoning, we see that the changes in the demand for domestic and imported consumer goods are as follows, using the econometric results from Section 3:

ΔC_D = . 55 $\Delta(Y\text{-}T_G)$ +.19 ΔT_G - (0.20) ΔXR_{AV0123} = $ - 5.34B (same result as method 1)

and

ΔC_M = .11 $\Delta(Y\text{-}T_G)$ +.30 ΔT_G + 3.03 ΔXR_{AV0123} = $ - 4.97B (same result as method 1)

So, by Method 2 we have

$\Delta Y = \Delta C_D + \Delta I_D + \Delta G + \Delta X$ = $ - 5.34 – 9.71 + 0 + 2.86 = $ - 12.19B (~Same result as Method 1)

9.3 Method 3: Using the Formal IS Curve Method

$\Delta Y = \Delta C_D + \Delta I_D + \Delta G + \Delta X$

$= (.55\Delta(Y\text{-}T_G) + .19\Delta T_G – 0.20\Delta XR_{AV0123}) + (.24\ \Delta ACC + .45\ \Delta T_G + 5.37\Delta XR_{AV0123}) + 0 - 2.86\ \Delta XR_{AV0123}$

= $ - 12.15 B (Same as Methods 1 and 2)

10. EXCHANGE RATE EFFECTS ON THE TRADE DEFICIT AND U.S. ASSETS

The estimated decline in the U.S. trade deficit resulting from a one point decline in the exchange rate is the sum of the resulting decrease in imports and the increase in exports

$ 4.97B - Decline in C_M

0.43B - Decline in I_M

. 2.86B - Increase in X

$ 8.26B - Decrease in Trade Deficit Associated with a 1 Point Drop in the Exchange Rate

$ - 3.06B - Δ Savings = (.34 MPS)(- 8.99 $\Delta Y\text{-}T_G$)

$ - 3.06B - Decrease In Domestically Owned Wealth (Savings) Resulting From Exchange Rate - Induced Decline in Real Income

11. CONCLUSIONS

The analysis above indicates that when the Federal Reserve's real broad trade - weighted exchange rate index falls by one point, the results are as follows:

Table 3: Exchange Rate Impact on GDP and Trade Balance (Billions of 1996 Dollars)

	Real GDP	Imports	Exports	. Trade Deficit . Dollars (% of GDP)
Actual 2000 Data	$9224.00	$1532.00	$1132.00	$400.00 (4.34%)
Effect of 1Pt. Drop In XR	9211.85	1526.60	1134.86	$391.74 (4.25%)
Effect of 12.9Pt (12.3%)Drop In XR	9066.75	1462.00	1095.11	$293.45 (3.23%)

However, in the perio*d* 2000 – 2009, The U.S. exchange rate dropped even more significantly. The Real Broad Index dropped 12.9 points (12.3%), from 104.8 to 91.9.

Using the 12.9 point drop in the real broad Index during the 2000-09 period, suggests that this would have been associated with a decrease in the GDP over the 9 year period of $157.25 billion, or 1.7% of the GDP. This drop would also have been associated with a drop in the trade deficit of $106.6 billion. As a percent of the GDP, the trade deficit would drop 1.11 percentage points, from 4.34% to 3.23% of GDP *ceteris paribus*. (In 2005 dollars, the GDP decline would have been $207.6 billion, the trade deficit decline $140.7 billion. Percentage changes would remain the same.)

Using the numbers from Method 2, and multiplying them by 12.9, we can disaggregate the total GDP change into its component parts:

$$\Delta Y = \Delta C_D + \Delta I_D + \Delta G + \Delta X$$

$$-\$157.25 \sim= -\$68.88 - \$125.26B + 0 + \$36.89B$$

The $157.25B decrease in GDP associated with the estimated 12.9 point (or 12.3%) 2000-09 decline in exchange rates, would have resulted in a 1.7% decrease in 2000 - level real GDP, *ceteris paribus*. However, Bureau of Economic Analysis data indicated the real GDP grew 15.7% during the 2000-2009 period. Presumably, had the exchange rate decline not occurred, it would have grown 1.7% more, increasing the average annual growth rate slightly - less than one fifth percent per year from 2.74% to 1.93%.. The actual annual growth rate appears to have been lower than it might have been had the exchange rate not declined, but not much. Thus, the evidence indicates that the cheaper dollar of the 2000-2009 period did have a small negative effect on the U.S. GDP, consumption and investment overall, but these effects were swamped by larger scale macroeconomic events going on at the same time (e.g., post 9/11/01 military build up, increased investment spending).

The $8.26 billion decline in the U.S. Trade deficit associated with a one point drop in the real Broad exchange rate index reduces the need for annual transfers of U.S. assets (including dollars) to foreign ownership. Other transfers are still needed to pay for the remaining trade deficit. Hence, there is a decline in the amount of U.S. owned assets that have to be transferred to the rest of the world to pay for the U.S.'s excess of imports over exports. Subtracting the decrease in U.S. assets (decline in new savings of $3.06 billion) associated with the decline of the exchange rate, we estimate each point decline in the exchange rate increases U.S. ownership of assets $5.2 billion, or $67.1 billion for the nine year period. (In 2005 dollars, $88.6 billion).

REFERENCES

_____. *Economic Report of the President*. Washington. U.S. Government Printing Office. 2002 , 2001 and 1997, 2010, 2009 Reports

Fair, R. 2004. *Estimating How the Macroeconomy Works*, Appendix A: U.S. Model. 2004 Available at http://fairmodel.econ.yale.edu/rayfair/pdf/2003A.PDF

Heim, J. J. 2007. "Does A Strong Dollar Increase Demand for Both Domestic and Imported Goods?" *Journal of International Business and Economics.*7(3): 12-22.

Heim, J.J. 2008a. "The Consumption Function." *Review of Business Research* 8(2): 18-36.

Heim, J.J. 2008b. "What Determines Market Demand for Investment Goods?" *International Journal of Business Strategy* 6(1): 67-80.

Heim, J. J. 2008c. "How Falling Exchange Rates 2000 - 2007 Have Affected the U.S. Economy And Trade Deficit." *RPI Working Papers in Economics, No. 803, Department of Economics, Rensselaer Polytechnic Institute*, January 2008.

Heim, J. J. 2009. " A Method For Separating Income And Substitution Effects Of Exchange Rate Changes On Aggregate Demand." *Journal of International Finance and Economics.* Vol. 9(3).

Jorgenson, D. 1971."Econometric Studies of Investment Behavior: A Survey." *Journal of Economic Literature*, 9(4), pp. 1111-47.

Keynes, J.M. 1964. *The General Theory of Employment, Interest and Money*. New York: Harcourt, Brace and World, Inc.

Mankiw, N. G. 2010. *Macroeconomics.* New York: Worth Publishers. p. xxiii.

Samuelson, P. 1939. "Interactions Between the Multiplier Analysis and the Principle of Acceleration." *Review of Economics and Statistics* 21(2): 75-78.