

A Method for Separating Income and Substitution Effects of Exchange Rate Changes

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ABSTRACT

Regression estimates of exchange rate total effects on aggregate demand are broken into separate income and substitution effects. Total effects (substitution and income) estimates can seem contrary to theory and common sense. Separating them into their two components shows this is not the case. The separation method also provides a simple test to determine if imports are normal or inferior goods. The paper finds consumer imports are normal goods, but investment imports are inferior goods. The paper shows that if import total effects exceed domestic total effects, imports are a normal good. If smaller, they are inferior goods. (JEL: E00, F40, F43)

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1.1. INTRODUCTION: CONSUMER DEMAND

A recent study indicated the U.S. exchange rate was systematically related to the level of consumer spending, particularly on imports (Heim 2008). In this study, demand for domestically produced or imported consumer goods was regressed on a range of variables commonly held to be determinants of consumer spending, including disposable income, interest rates, consumer wealth and the relative price of imports compared to domestic goods, as measured by the exchange rate. Higher exchange rate values indicate more foreign currency can be bought per dollar, which in turn can mean cheaper import prices. An additional determinant, measured by the government deficit, provides a measure of the extent to which consumers are crowded out of the credit market by government borrowing. The spending and tax variables are reported separately, rather than as a net figure, since preliminary testing indicated deficit increases due to increased government spending restrict consumer credit less than tax cuts. Key regression findings are summarized in Table 1 below:

Subscripts of zero on variables, or no subscripts at all, mean the current period value of the variable is used. Subscripts with negative signs indicate the number of years the variable is lagged. The equations are estimated using first differences of the data e.g., $\Delta(C)_0$ to help reduce multicollinearity and autocorrelation problems, and sometimes non-stationarity problems in otherwise highly correlated data.

Adding the exchange rate variable seemed to have a major influence on demand for imported consumer goods, adding 6%-points to explained variance. However, explained variance did not increase in the other two models. These exchange rate coefficients show the total effect of an exchange rate

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change on consumer demand. Below this effect will be separated into its income and substitution effect components.

Table 1: Determinants of Demand for Total, Imported and Domestically Produced Consumer Goods

$\Delta(C)_0$ (t)	$=.63\Delta(Y-T_G)$ (18.2)	$+.47\Delta T_G$ (4.3)	$+ .06\Delta G_0$ (0.5)	$- 6.22\Delta PR_0$ (-3.4)	$+ .60 \Delta DJ_{-2}$ (4.0)	$+ 2.69\Delta XR_{AV}$ (1.5)	$R^2=91\%$ D.W.=1.7
$\Delta(M_{m-ksm})_0$ (t)	$=.06\Delta(Y-T_G)$ (2.8)	$+ .27\Delta T_G$ (4.6)	$- .18 \Delta G_0$ (-1.9)	$- 3.94 \Delta PR_0$ (-2.6)	$+ .26 \Delta DJ_{-2}$ (1.8)	$+4.33 \Delta XR_{AV}$ (2.9)	$R^2=83\%$ D.W.=1.5
$\Delta(C-M_{m-ksm})$ (t)	$=.57\Delta(Y-T_G)$ (16.0)	$+ .20\Delta T_G$ (1.6)	$+ .24 \Delta G$ (1.3)	$- 2.28 \Delta PR$ (-0.7)	$+ .34\Delta DJ_{-2}$ (2.8)	$- 1.64 \Delta XR_{AV}$ (-1.0)	$R^2=74\%$ D.W.=1.8

* Nominal Exchange Rate Used)

Where

C = Total Consumption

M_{m-ksm} = Consumer Imports

$C - M_{m-ksm}$ = Consumer Goods Domestically Produced

$Y - T_G$ = Disposable Income

T_G = Government Receipts

G_0 = Government Spending on Goods & Services

PR_0 = Real Prime Interest Rate

DJ_{-2} = A Wealth Measure: the Dow Jones Composite Average

XR_{AV} = The average nominal exchange rate (trade weighted) for the current and past three years

The Federal Reserve's trade weighted nominal Broad exchange rate was used above; a related study (Heim 2009) used the Federal Reserve's real exchange rate in the same models, and yielded similar results except the exchange rate variable, whose results varied somewhat, as expected. See Table 2.

Adding the exchange rate variable to the total, imports, and domestically produced consumer goods models in Table 2 increases explained variance by 2%, 8% and 0% respectively. Notice the estimated total effect of exchange rates on consumer demand for imports is larger than the estimated total effect on domestic goods, and that the estimated total effect on domestic goods is negative. Later we will show that this implies consumer imports are normal goods and that the substitution effect outweighs the income effect.

Table 2: Determinants of Demand for Total, Imported and Domestically Produced Consumer Goods

$\Delta(C)_0$ (t)	$=.66\Delta(Y-T_G)$ (29.2)	$+ .49\Delta T_G$ (5.7)	$+ .04\Delta G_0$ (0.3)	$- 6.92\Delta PR_0$ (-3.2)	$+ .62 \Delta DJ_{-2}$ (4.9)	$+ 2.83\Delta XR_{AV}$ (3.2)	$R^2=91\%$ D.W.=1.7
$\Delta(M_{m-ksm})_0$ (t)	$=.11\Delta(Y-T_G)$ (6.3)	$+ .30\Delta T_G$ (5.0)	$- .20 \Delta G_0$ (-2.0)	$- 5.00 \Delta PR_0$ (-3.5)	$+ .34 \Delta DJ_{-2}$ (4.5)	$+3.03 \Delta XR_{AV}$ (5.6)	$R^2=85\%$ D.W.=1.8
$\Delta(C-M_{m-ksm})$ (t)	$=.55\Delta(Y-T_G)$ (16.2)	$+ .19\Delta T_G$ (1.5)	$+ .24 \Delta G$ (1.3)	$- 1.92 \Delta PR$ (-0.6)	$+ .28\Delta DJ_{-2}$ (1.9)	$- .20 \Delta XR_{AV}$ (-0.2)	$R^2=74\%$ D.W.=1.8

*Real Exchange Rate Used

1.2. INTRODUCTION: INVESTMENT DEMAND

Similarly, the (2008a) study indicated the exchange rate played the following role in determining the level of spending on domestic and imported investment goods:

Table 3: Determinants of Demand for Total, Imported and Domestically Produced Investment Goods*

$\Delta I(t) =$									
.28 Δ ACC	+.95 Δ DEP	+1.48 Δ CA ₋₁	+.52 Δ T	-.63 Δ G	-6.40 Δ r ₋₂	-.20 Δ DJ ₋₂	+.16 Δ P ₋₂	+6.92 Δ XR	R ² =.89
(7.9)	(3.2)	(1.0)	(5.6)	(-2.9)	(-3.8)	(-0.8)	(0.9)	(3.8)	DW 1.9
$\Delta(M_{k_{sm}}) =$									
.04 Δ ACC	+.38 Δ DEP	+1.52 Δ CA ₋₁	+.07 Δ T	-.22 Δ G	+1.54 Δ r ₋₂	+.19 Δ DJ ₋₂	-.10 Δ P ₋₂	+2.52 Δ XR	R ² =.70
(1.8)	(4.1)	(2.2)	(2.5)	(-2.1)	(1.3)	(2.6)	(-1.1)	(-2.1)	DW2.4
$\Delta(I-M_{k_{sm}}) =$									
.24 Δ ACC	+.57 Δ DEP	-.04 Δ CA ₋₁	+.44 Δ T	-.41 Δ G	-8.00 Δ r ₋₂	-.38 Δ DJ ₋₂	+.26 Δ P ₋₂	+4.39 Δ XR	R ² =.85
(8.7)	(1.9)	(-0.0)	(5.4)	(-2.0)	(-4.9)	(-1.5)	(1.5)	(1.8)	DW1.6

*Nominal Exchange Rate Used

Where

I = Total Investment Demand

M_{k_{sm}} = Demand for Imported Investment Goods

I-M_{k_{sm}} = Demand for Domestically Produced Investment Goods

ACC = The Accelerator, a measure of the growth rate of the GDP each year

DEP = Depreciation Levels of Capital Equipment

CA₋₁ = % of manufacturing capacity currently being utilized, lagged one year

Δ P₋₂ = Corporate profits, lagged two years

Δ r₋₂ = Real prime interest rate, lagged two years

Other variables used are defined in the consumption equations. Subscripts have the same meanings as before and first differences of the data are again used. Notice that, unlike the consumption equations, in the investment equations the larger estimated total effect of a change in exchange rates on demand is in the domestic demand equation, not import demand. We will show later that this is a sign that investment imports are inferior goods.

These coefficients estimates of the exchange rate total effects, will be separated below into income and substitution effects. The exchange rate does add significantly to the explanatory power of some equations. The exchange rate appears to have a major influence on demand for imported investment goods, adding 6%-points to explanatory power, but also adds 4% to explained variance when added to the total investment demand and 2% to domestically produced investment goods demand models.

We note that the regression results indicate that for every single - point (~ 0.8%) decline in nominal Broad exchange rate from 2000 levels, making imports more expensive, there appears to be a \$4.39 billion decrease in demand for domestically produced investment goods as well as a 2.52 billion decrease in demand for imported investment goods. We will show later this finding for domestic goods is not nearly as irrational as it appears to be at first blush. It is totally consistent with our estimates of the sum of

income and substitution effects for investment goods, particularly our estimates showing investment goods, as a group, are inferior goods and that this trait is transmitted through the substitution effect.

Results for the same investment demand model using the real Broad exchange rate (Heim 2009), are presented in Table 4 below. They were very similar; with the total effect estimates above not changing much for any of the variables, except the exchange rate, which was expected:

Table 4: Determinants of Demand for Total, Imported and Domestically Produced Investment Goods*

$\Delta I(t) =$									
.28 Δ ACC	+1.37 Δ DEP	+ .69 Δ CA ₋₁	+ .52 Δ T	- .61 Δ G	-8.46 Δ r ₋₂	- .10 Δ DJ ₋₂	+ .35 Δ P ₋₂	+4.97 Δ XR	R ² = .89
(6.9)	(4.7)	(0.4)	(5.3)	(-3.4)	(-3.5)	(-0.4)	(2.0)	(4.2)	DW 2.3
$\Delta(M_{ksm}) =$									
.05 Δ ACC	+ .46 Δ DEP	+1.25 Δ CA ₋₁	+ .07 Δ T	- .14 Δ G	+1.12 Δ r ₋₂	+ .30 Δ DJ ₋₂	- .11 Δ P ₋₂	- .40 Δ XR	R ² = .64
(1.9)	(4.5)	(1.4)	(2.0)	(-1.7)	(0.7)	(3.4)	(-1.09)	(-0.7)	DW2.1
$\Delta(I-M_{ksm}) =$									
.24 Δ ACC	+ .91 Δ DEP	- .15 Δ CA ₋₁	+ .45 Δ T	- .47 Δ G	-9.59 Δ r ₋₂	- .40 Δ DJ ₋₂	+ .47 Δ P ₋₂	+5.37 Δ XR	R ² = .88
(7.8)	(3.0)	(-0.4)	(6.0)	(-2.9)	(-7.3)	(-1.9)	(4.1)	(4.1)	DW2.1

*Real Exchange Rate Used

Adding the exchange rate variable increases explained variance in the total, imports and domestically produced goods models by 4, 0 and 5% respectively.

Ultimately, the sign of the total effect of an exchange rate change on spending is the sum of its two parts: the “pure” income effect and the substitution effect. If the substitution effect is negative, and large, it may “swamp” the positive income effect, and leave a negative sign. If not, the sign may be positive. For example, by separating the total effects of a change in exchange rates in tables 1-4 above into their separate income and substitution effects, we can explain results which otherwise seem illogical, or at least puzzling. We (again) note that the regression results indicate that for every single - point decline in the nominal exchange rate (imports more expensive) there appears to be a \$4.39 billion decrease in demand for domestically produced investment goods and a 2.52 billion decrease in demand for imported investment goods. The decrease in import demand is understandable since if import prices are increasing, the real income effect is negative. Further, if investment goods are normal goods, the increase in relative import prices should cause further movement out of imports. However, we do not find demand for domestically produced investment goods increases. This may be because the negative income effect swamps the positive substitution effect, or if imports are an inferior good, the overall effect may be out of domestic goods because both effects are negative. To know for certain, we must parse out the separate income and substitution effects.

There is a simple method for breaking down the total effect of an exchange rate change into its income effect and substitution effect components, so that we can resolve such questions. The method will use information we already have on the estimated total effect of exchange rate changes on and the information inherent in the following identities for domestic (D) and imported (M) goods:

$$\text{Total \$ Effect (T}_D\text{)} = \$ \text{ Income Effect (I}_D\text{)} + \$ \text{ Substitution Effect (S}_D\text{)}$$

$$\text{Total \$ Effect (T}_M\text{)} = \$ \text{ Income Effect (I}_M\text{)} + \$ \text{ Substitution Effect (S}_M\text{)}$$

Since economic theory holds that *the real value* of (pure) substitution effects are symmetric except for sign, this means that in money terms

$$S_D = - (S_M)$$

i.e.,
$$T_D - I_D = - (T_M - I_M)$$

Since T_D and T_M are known from regression analysis, this leaves us with one equation in two unknowns: I_D and I_M , *the dollar value* of the pure income effect. However, we will show that these two pure income effects must be the same. Therefore, we have but one equation in one unknown to solve, which is a simple task. This will be done further below.

2. OTHER EMPIRICAL ESTIMATES OF INCOME AND SUBSTITUTION EFFECTS

Elmendorf (1996) has excellent estimates the total effect of changes in interest rates on consumption, but does not break them down into income and substitution effects. Baker, Gruber and Milligan (2003) examined the impact of Canada's government retirement programs on work incentives, but, again, did not attempt to separate the total effect of the onset of retirement income into income from substitution effects. Others have attempted to separate these two effects, but have used "hypotheticals", such as "what if" survey responses, instead of data to estimate one of the effects. The other effect is then inferred from indirect evidence. For example, Kimball and Shapiro (2008) estimated income effects of a income increase by asking survey respondents "what if" they won a sweepstakes. How would their work habits change if they won an independent income for life? Using these responses as "income effects", restrictions from labor theory, and known total effects of approximately zero, they inferred substitution effects of a magnitude similar to income effects.

3. INCOME AND SUBSTITUTION EFFECTS IN THEORY

In standard economic theory, utility is derived from consumption. Utility varies as the combination of goods consumed changes. The combinations considered here are domestically produced goods and imported goods. (D) represents the bundle of domestically produced goods consumed by businesses (investment goods) or consumers (consumer goods); (M) represents the bundle of investment or consumer imports. The utility relationship is given as

$$\text{Utility (U)} = f(D, M)$$

One example of this relationship might be

$$U = D \cdot M$$

$$\rightarrow D = U/M$$

i.e., utility grows in both D, M subject to diminishing returns. This function provides us with an example of a standard – shaped hyperbolic indifference curve in which U is increasing in D, M.. For example, we might find (were utility cardinally countable),

$$U = 100 = D_{10} * M_{10}$$

$$U = 400 = D_{20} * M_{20}$$

Where the subscripts on D, M represent the real quantities consumed. Consumers (and businesses) choose utility maximizing combinations of D and M, given their budget constraints

$$P_D * D = \text{Budget (B)} - P_M * M$$

If the budget is 20 and prices are $P_D = P_M = \$1$, the feasible combinations of goods the consumer can buy with a the budget is given by $(D = 20 - M)$, where “20” might be interpreted as \$20 billion and $U = 100$ at utility maximization. The combination of goods that fully expends the budget and provides the highest utility level is $D=10$ and $M=10$. Other purchasable combinations provide lower utility, for examples

$$D_{=18} = 20 - M_{=2} \Rightarrow U = 15 * 5 = 36$$

$$D_{=15} = 20 - M_{=5} \Rightarrow U = 15 * 5 = 75$$

$$\underline{D_{=10} = 20 - M_{=10} \Rightarrow U = 10 * 10 = 100}$$

$$D_{=5} = 20 - M_{=15} \Rightarrow U = 15 * 5 = 75$$

$$D_{=2} = 20 - M_{=18} \Rightarrow U = 15 * 5 = 36 \quad \text{Etc....}$$

We can see the *dollar amounts of each good which maximize utility are the same*: ($\$1 * D = \$1 * M = 10$). In this specific case, the quantities are also the same. In the more general case dollar equivalence will remain, but quantity equivalence will not. Theory suggests the ratio of the goods selected is inversely related to the ratio of their prices, which implies that for budget (income level) changes, prices remaining constant, utility maximization requires allocation of equal money amounts to both products when income changes. This is true for any income change, from zero income on up. We can measure this “pure income effect” by simply increasing the consumer’s budget without changing the relative prices of (D,M). If income doubles, the vertical and horizontal intercepts on the budget constraint double, but the slope of the budget line (P_M/P_D) remains the same. It now touches the new (and higher) indifference curve where the new curve has the same marginal rate of substitution (MRS) as before. Therefore, both before and after the change

$$\text{MRS} = \partial D / \partial M = P_M / P_D \quad (\text{Prager, 1993})$$

$$\text{Which implies} \quad \partial D * P_D = \partial M * P_M$$

$$\text{Or in discrete terms} \quad \Delta D * P_D = \Delta M * P_M$$

Clearly this indicates that (except for sign) the money value of substitution effects must be identical. The dollar amount substituted out of one good must equal the amount substituted into the other.

This formulation also clearly indicates that if incomes change *not due to price changes, i.e., prices remaining constant*, we have a “pure income effect”. In order for the above condition above to be met if income is increasing, *spending on both goods must change by the same amount*, no matter what the initial income level. This must hold for all budget levels, e.g., $\Delta 2D * P_D = \Delta 2M * P_M$, etc.

Hence we conclude this standard theoretical formulation shows that the money value of the “pure” income effect must be the same for two goods when income changes, prices constant. The money value

of pure substitution effects are also the same (except for sign). These two findings are of key importance in inferring income and substitution effects from data on total effects.

As an example, suppose the consumer or businesses' budget is doubled, with prices remaining constant at $\$1 = P_D = P_M$. The budget constraint then becomes $(\$1 \cdot D = \$40 - \$1 \cdot M)$ or $(D = 40 - M)$. As shown below, no other combination of goods purchasable with the \$40 budget yields as much utility as twice the original quantities and money expenditures on each.

$$D_{=30} = 40 - M_{=10} \Rightarrow U = 10 \cdot 30 = 300$$

$$D_{=25} = 40 - M_{=15} \Rightarrow U = 15 \cdot 25 = 375$$

$$\underline{D_{=20} = 40 - M_{=20} \Rightarrow U = 20 \cdot 20 = 400}$$

$$D_{=25} = 40 - M_{=15} \Rightarrow U = 25 \cdot 15 = 375$$

$$D_{=30} = 40 - M_{=10} \Rightarrow U = 30 \cdot 10 = 300 \quad \text{Etc.}$$

Of course, utility is counted ordinally, not cardinally, so we don't know that 100 is really the initial value of U , or that 400 its later value. Nonetheless, standard utility theory shows what is shown in the utility curve above: utility increases in D and M , utility curves are convex, everywhere dense, and don't cross (Wold and Jureen, 1953). This gives them the same general shape, leading to the same results.

We can see the dollar equivalence of the pure income effect, since any optimal solution leaves the ratio of goods consumed inversely equal to the ratio of their prices, as before. Hence, $D \cdot P_D$ stays equal to $M \cdot P_M$. The total effect is a pure income effect, since relative prices remain the same. The money value of the income effect is the same for both imports and domestically produced goods.

The result is not dependent on the indifference curve shape, provided it is broadly convex to the origin, i.e., allows for diminishing marginal utility. Other forms will yield the same result.

Hence, the results are the same: the money value of income effects for D , M are the same and the substitution effects are the same (except for sign). Further support for this conclusion is given in the next section, where we show that the only way to explain our empirical results for total effects is by assuming this same equivalence of income and substitution effects.

Does this also hold if the relative prices of goods is different from the ratio used above (i.e., $1/1$)? The example below assumes a relative price ratio of $(\$2_D / \$1_M = 2)$, yielding a budget constraint of

$$\$2D = 20 - \$1M \rightarrow D = 10 - 1/2M \quad \text{Then we have}$$

$$D_{=9} = 20 - M_{=2} \Rightarrow U = 9 \cdot 2 = 18$$

$$D_{=8} = 20 - M_{=4} \Rightarrow U = 8 \cdot 4 = 32$$

$$D_{=5.5} = 20 - M_{=9} \Rightarrow U = 5.5 \cdot 9 = 49.5$$

$$\underline{D_{=5} = 20 - M_{=10} \Rightarrow U = 5 \cdot 10 = 50}$$

$$D_{=2} = 20 - M_{=16} \Rightarrow U = 2 \cdot 16 = 32$$

$$D_{=1} = 20 - M_{=19} \Rightarrow U = 1 \cdot 19 = 19 \quad \text{Etc.}$$

If the consumer's income doubles,

$$D_{=18} = 40 - M_{=4} \Rightarrow U = 18 \cdot 4 = 72$$

$$D_{=16} = 40 - M_{=8} = \rightarrow U = 16 * 8 = 128$$

$$D_{=10.5} = 40 - M_{=19} = \rightarrow U = 10.5 * 19 = 199.5$$

$$\underline{D_{=10} = 40 - M_{=20} = \rightarrow U = 10 * 20 = 200}$$

$$D_{=4} = 40 - M_{=32} = \rightarrow U = 4 * 32 = 128$$

$$D_{=1} = 40 - M_{=38} = \rightarrow U = 1 * 38 = 38$$

Etc....

Again we notice that the utility – maximizing combination of goods doubles for both goods when income doubles. Other examples will show the same. Since price ratios are unchanged, there are no substitution effects to modify this proportionality result.

In the current case

$$MRS = \partial D / \partial M = P_M / P_D \quad (\text{Prager, 1993})$$

$$\text{Which implies} \quad \partial D * P_D = \partial M * P_M$$

$$\text{Or in discrete terms} \quad \Delta D * P_D = \Delta M * P_M$$

$$\text{i.e.,} \quad \Delta D * (\$2) = \Delta M * (\$1)$$

which implies $M = 2D$. Pure income effects do not always result in equal quantities of both goods selected, but always do result in equal money expenditures on the two goods when incomes change from any level to another.

4. DERIVING INCOME AND SUBSTITUTION EFFECTS OF EXCHANGE RATE CHANGES WHEN TOTAL EFFECTS ARE KNOWN

Regression coefficients (β) in the demand functions above provide estimates of the total effect on domestic and imported goods demand, i.e.,

$$\text{Total Effect } (T_{DorM}) = (\beta_{DorM}) = \text{Income Effect } (I_{DorM}) + \text{Substitution Effect } (S_{DorM})$$

When only pure income effects are considered, the money (or “real”) value of income effects are the same for both groups of goods: imports and domestic. Substitution effects are also the same in money value, except for sign. Using this means that our domestic and imported investment goods equations above become two equations with two unknowns (I and S) to be solved, where, from above, we take $(S_D) = (- S_M)$ and $I_D = I_M$.

4.1. INVESTMENT DEMAND: DERIVING INCOME AND SUBSTITUTION EFFECTS FROM ESTIMATED TOTAL EFFECTS:

Below, six cases are evaluated to determine income and substitution effects of exchange rate changes on investment goods. An additional six cases test consumer goods in the same way.

- Cases 1 and 3 test, whether imported investment goods, as a group, are normal goods. Nominal and real exchange rate changes are tested separately).

- Cases 2 and 4 test whether imports should be considered an inferior good, with the inferiority trait passing through the substitution effect (again, nominal and real exchange rates changes are tested separately).

Using the method described, these four tests, applied separately to investment and consumption, lead this study to conclude

- consumer imports are normal goods (as a macroeconomic grouping).
- investment imports are inferior goods (as a macroeconomic grouping), with the inferiority trait passing through a negative substitution effect.

Details of these tests are provided in sections 4.1.(1-4) and 4.2.(1-4) below.

4.1.1. CASE 1: IMPORTS ARE NORMAL INVESTMENT GOODS; NOMINAL EXCHANGE RATE USED TO ESTIMATE TOTAL EFFECTS

Assume income(I) and substitution (S) effects are normal for investment goods when import prices fall due to an increase in exchange rates: i.e.,

$$I_D, I_M > 0; (I_D = I_M); \quad S_D < 0, S_M > 0, (-S_D = S_M)$$

Let

$$\text{Income Effect}_D (I_D) + \text{Substitution Effect}_D (S_D) = \$4.39B = \text{Total Effect}_D \text{ Estimate}$$

$$\text{Income Effect}_M (I_M) + \text{Substitution Effect}_M (I_M) = \$2.52B = \text{Total Effect}_M \text{ Estimate}$$

$$\text{Total Effect:} \quad = I_D + S_D = \$4.39B \quad | \quad = I_M + S_M = \$2.52B$$

$$\rightarrow S_D = -I_D + 4.39 \quad | \rightarrow \quad S_M = -I_M + 2.52$$

$$\rightarrow \quad \underline{-S_D = I_D - 4.39} \quad | \quad \underline{\hspace{10em}}$$

$$-S_D \quad | \quad = S_M$$

therefore

$$I_D - 4.39 = -I_M + 2.52$$

$$(I_D + I_M) = 2 I_D = 6.91 \quad (\text{since } I_M = I_D)$$

$$I_D = \$3.455B$$

But, though we know income and total effects, we cannot deduce from them substitution effects consistent with our assumption of normality, which requires substitution out of domestic goods and into imports. No negative number for substitution effects, when added to positive income effects of 3.455B, will give use a total effect greater than the income effect alone, i.e., 4.49B for domestic goods. No positive substitution effect into imports, when added to a positive income effect of 3.455B will give us the smaller total effect of 2.52 billion we have estimated..

$$\text{Income Effect:} \quad \$ +3.455B \quad I_D \quad \$ +3.455B \quad I_M$$

$$\underline{+\text{Substitution Effect}} \quad \underline{\$ - ?} \quad S_D \quad \underline{\$ + ?} \quad S_M$$

$$\text{(Must =)Total Effect} \quad \$ = 4.39 B \quad T_D \quad \$ = 2.52 B \quad T_M$$

Conclude: Hypothesis that investment imports as a group are a normal goods leads to irrational result

4.1.2. CASE 2: IMPORTS ARE INFERIOR INVESTMENT GOODS; NOMINAL EXCHANGE RATE USED TO ESTIMATE TOTAL EFFECTS

However, If we assume that imports are an inferior good, i.e., the substitution effect is negative i.e., out of imports as they become cheaper and positive i.e., into domestic goods, and that the inferiority trait is passed through the substitution effect, we get

Income Effect:	\$ +3.455B	I_D	\$ +3.455B	I_M
Substitution Effect	\$ +.935B.	S_D	\$ - .935B.	S_M
Total Effect	\$ = 4.39 B	T_D	\$ = 2.52 B	T_M

which is consistent with our earlier estimates for income effects and total effects, and consistent with our earlier finding that income and substitution effects (in absolute terms) had to be the same for both groups of goods. This example indicates that as a macroeconomic aggregate, imported investment are an inferior good based on our regression coefficient estimates of total effects of a change in nominal exchange rates. The conclusion, theory requires the money value of "pure" income effects to be the same for both types of goods. The conclusion, theory requires substitution effects for both types of goods to be the same in money terms, except for sign

4.1.3. CASE I.3: IMPORTS ARE NORMAL INVESTMENT GOODS; REAL EXCHANGE RATE USED TO ESTIMATE TOTAL EFFECTS

Using the same methods as above, it can be shown that the income effect is \$2.485 billion and that no normal goods substitution effect, when added to it, can give us the total effects previously obtained.

Income Effect:	\$ +2.485B	I_D	\$ +2.485B	I_M
Substitution Effect	\$ - ?	S_D	\$ + ?	S_M
Total Effect	\$ = 5.37 B	T_D	\$ = - .40 B	T_M

Conclude: Irrational result: no substitution out of D and into M can lead to our estimated total effects of \$5.37B and \$-0.40B respectively. This implies incorrectness of original hypothesis that D, M are normal goods.

4.1.4. CASE I.4: IMPORTS ARE INFERIOR INVESTMENT GOODS; REAL EXCHANGE RATE USED TO ESTIMATE TOTAL EFFECTS

However, If we (again) assume that imports are an inferior good, i.e., the substitution effect is negative for imports as they become cheaper and positive for domestic goods, and that the inferiority trait is passed through the substitution effect, we get

Income Effect:	\$ +2.485B	I_D	\$ +2.485B	I_M
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Substitution Effect	\$ +2.885B. S _D	\$ - 2.885B. S _M
Total Effect	\$ = 5.37 B T _D	\$ = -.40 B T _M

which is consistent with our earlier estimates for income effects and total effects. This example, using real exchange rates, matches our earlier results using nominal rates. It indicates that as a macroeconomic aggregate, imported investment goods are inferior goods, based on 1) our regression coefficient estimates of total effects of a change in real exchange rates; 2) the conclusion, theory requires the money value of “pure” income effects to be the same for both types of goods; 3) the conclusion, theory requires substitution effects for both types of goods to be the same in money terms, except for sign.

4.2. CONSUMPTION DEMAND: DERIVING INCOME AND SUBSTITUTION EFFECTS FROM TOTAL EFFECT ESTIMATES OF A CHANGE IN EXCHANGE RATES

Are consumer imports also inferior goods? Using the above methods we now examine the sensitivity of consumer demand to a change in either the nominal or real exchange rate, using estimates of the total effect from the regression coefficient results presented in Section 1 above.

Coefficient On Exchange Rate Variable

	<u>Nominal</u>	<u>Real</u>
Total Effect Estimate (T _D):	\$ - 1.64B	\$ - .20B
Total Effect Estimate (T _M):	\$ + 4.33B	\$ +3.03B

4.2.1. CASE 1: IMPORTS ARE NORMAL CONSUMER GOODS; NOMINAL EXCHANGE RATE USED TO ESTIMATE TOTAL EFFECTS

Assume: When import prices fall due to a change in exchange rates, income and substitution effects are normal: i.e.,

$$I_D, I_M > 0; I_D = I_M \quad S_D < 0, S_M > 0; -S_D = S_M$$

Let

$$\text{Income Effect}_D (I_D) + \text{Substitution Effect}_D (S_D) = -1.64 \text{ Total Effect}_D \text{ Estimate}$$

$$\text{Income Effect}_M (I_M) + \text{Substitution Effect}_M (I_M) = +4.33 \text{ Total Effect}_M \text{ Estimate}$$

$$\begin{array}{l|l} \text{Total Effect} = I_D + S_D = \$ -1.64B & I_M + S_M = \$4.33B \\ \rightarrow S_D = -I_D -1.64 B & S_M = -I_M + 4.33B \\ \rightarrow -S_D = I_D + 1.64B & \hline & -S_D \quad | = S_M \end{array}$$

$$(I_D + 1.64) = (-I_M + 4.33)$$

$$\text{And since } I_M = I_D \quad I_D + I_M = 2 I_D = 2.69$$

$$I_D = \$1.345B$$

Because we know Income and total effects, we can deduce the substitution effects from this information. Our estimates are consistent with the assumption of normality for consumer imports:

Income Effect:	\$ +1.345B	I_D	\$ +1.345B	I_M	\$ +1.345B	I_D	\$ +1.345B	I_M
Substitution Effect	\$ - ?	S_D	\$ + ?	S_M	\$ -2.985B	S_D	\$ +2.985B	S_M
Total Effect	\$ = -1.64B	T_D	\$ = +4.33B	T_M	\$ = -1.64B	T_D	\$ = +4.33B	T_M

Conclude: The results support the correctness of original hypothesis that unlike investment goods, imported consumer goods, as a group, are normal goods.

4.2.2. CASE C.2: M ARE INFERIOR CONSUMER GOODS; NOMINAL EXCHANGE RATE USED TO ESTIMATE TOTAL EFFECTS

However, If we had assumed that imported consumer goods are an inferior good, i.e., the substitution effect is negative for imports as they become cheaper, and positive for domestic goods, we can see that with our estimated income effect of \$1.345B for both types of goods, no negative number for the import substitution effect could be added to the income effect(+1.345B) to get our estimated total effect for imports (+4.33B). Similarly, no positive valued substitution effect into domestic consumption could be added to the 1.345B income effect to get our estimated total effect of (-1.64B). We therefore reject the hypothesis that consumer imports are inferior goods.

4.2.3. CASE C.3: IMPORTS ARE NORMAL CONSUMER GOODS; REAL EXCHANGE RATE USED TO ESTIMATE TOTAL EFFECTS

Using the methods described earlier, we know Income and total effects, the substitution effects we deduce from this information our results are consistent with the assumption of normality for consumer imports:

Income Effect:	\$ +1.415B	I_D	\$ +1.415B	I_M	\$ +1.415B	I_D	\$ +1.415B	I_M
Substitution Effect	\$ - ?	S_D	\$ + ?	S_M	\$ -1.615B	S_D	\$ +1.615B	S_M
Total Effect	\$ = - .20B	T_D	\$ = +3.03B	T_M	\$ = - .20B	T_D	\$ = +3.03B	T_M

Conclude: The original hypothesis that D, M are normal goods appears correct, assuming our income and total effect estimates are correct.

4.2.4. CASE C.4: IMPORTS ARE INFERIOR CONSUMER GOODS; REAL EXCHANGE RATE USED TO ESTIMATE TOTAL EFFECTS

However, If we had assumed that imports are an inferior good, i.e., the substitution effect is negative for imports as they become cheaper and positive for domestic goods, we can see that with our estimated income effect of \$+1.415B for both types of goods, no negative number for the import substitution effect could be added to the income effect to get our estimated total effect for imports (\$3.03B). Similarly, no positive valued substitution effect for domestic consumption could be added to the \$+1.415B income effect to get our estimated total effect of \$ - .20B. We therefore reject the hypothesis that consumer goods imports are an inferior good.

REFERENCES

- Baker, M., and J. Gruber, and K. Mulligan. 2003. "The retirement Incentive Effects Of Canada's Income Security Programs". *The Canadian Journal of Economics*. Vol. 36 (2).
- Elmendorf, Douglas. 1996. "The Effect of Interest Rate Changes on Household Saving and Consumption: A Survey". Finance and Economics Discussion Series 96-44. Board of Governors of the Federal Reserve System. June.
- Heim, John J. 2008. "How Falling (Nominal) Exchange Rates Have Affected The U. S. Economy And Trade Deficit". *Journal of International Business and Economics*. Vol. VIII, (1).
- Heim, John J. 2009. "How Falling (Real) Exchange Rates Have Affected The U. S. Economy And Trade Deficit". *Proceedings of the 61st Annual Conference of the New York State Economics Association, Vol. 1: 44-53*.
- Kimball, Miles, and Matthew Shapiro. 2008. "Labor Supply: Are the Income and Substitution Effects Both Large Or Both Small?" Working Paper 14208, National Bureau of Economic Research. July.
- Prager, J. 1993. *Applied Microeconomics*. Boston: R. J. Irwin, Inc.
- Wold, H., and L. Jureen. 1953. *Demand Analysis*. Wiley Publications in Statistics. New York: John Wiley & Sons.