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DOES WORLD INVESTMENT DEMAND DETERMINE U.S. EXPORTS?

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ABSTRACT

An important but apparently neglected fact about U.S. exports is that export variation over time is dominated by variation in exports of capital goods and industrial supplies rather than consumer goods. This fact suggests that world investment demand rather than world consumption demand may be an important yet neglected determinant of U.S. exports. This paper documents a remarkably robust statistical relationship between U.S. exports and world investment demand, and shows that controlling for world investment changes other aspects of traditional export demand equations. To the extent that world investment behaves differently than world consumption, this finding may lead to a revision of current thinking about the ultimate determinants of U.S. exports and the mechanisms through which world economic shocks are transmitted to the U.S. economy.

Does World Investment Demand Determine American Exports?

Andrew M. Warner[1]

1. Introduction.

American export performance in the last twenty years has been marked by an empirical regularity which has yet to receive substantial attention in the international economics literature. The regularity concerns the importance of exports of capital goods and industrial supplies for U.S. export performance. Simply stated, capital goods and industrial supplies exports account for a large share of the growth and variability of total U.S. merchandise exports since 1967.

This fact suggests that world investment demand may be an important and under-represented determinant of U.S. exports. It has been common practice in both theoretical and empirical models of the international economy to relate trade flows to foreign GNP growth and to motivate the relationships with an appeal to consumer demand theory. This practice seems poorly suited to a world where consumer goods typically account for a much smaller share of trade flows in general and of U.S. exports in particular than they do of GNP in most countries.[2] We have an opportunity to be more precise about international economic linkages by examining the relationship between trade on the one hand and distinct components of spending such as consumption and investment separately on the other hand.

This paper takes one step in this direction by examining the separate effects of world consumption

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[1]The author is a staff economist in the Division of International Finance. This paper represents the views of the author and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or other members of its staff. Helpful comments from Susan Collins, Peter Hooper, Larry Katz, Larry Summers, Jeffrey Williamson and workshop participants at the Division of International Finance are gratefully acknowledged, as is the effective research assistance of Glenn Yamagata. Errors remain my own.

[2] Capital goods plus industrial supplies that can reasonably be associated with investment (building materials plus metals) account for nearly half of U.S. exports (47 percent in 1990), while investment (private plus government) typically accounts for 25-30 percent of foreign GDP (33 percent in Japan). Consumer goods account for about 25 percent of U.S. exports, while private and government consumption accounts for 65-75 percent of GDP.

and world investment on U.S. exports over the past quarter of a century. All of the main points in this paper can be made within the context of a traditional export demand model similar to the models in Krugman and Baldwin (1987), Helkie and Hooper (1988) and numerous other studies surveyed in Goldstein and Khan (1985). Our modification is simple: Instead of regressing U.S. exports on the rest of the world's GNP, as is the common practice, we use both world consumption demand (C+G) and investment demand (I) separately.[3]

Although this modification is simple, we show that it yields strong and perhaps surprising results, and has important implications for understanding the underlying causes of the recent boom in U.S. exports. The evidence indicates that U.S. exports have been determined by foreign investment demand rather than foreign consumption demand. This suggests that movements in world investment demand specifically rather than consumption demand is one of the crucial engines of growth for the U.S. economy. To the extent that world investment is determined by different variables than those that determine world consumption, this result may change our views about the ultimate determinants of U.S. exports and the mechanisms through which world economic shocks are transmitted to the U.S. economy.

The closest paper to this in the literature is Burda and Gerlach (1989), who also use the commodity composition of U.S. trade as a point of departure, but their focus is on the durables/non-durables distinction rather than capital goods/non-capital goods. They motivate their paper by pointing out that the deterioration in the durable trade balance can account for most of the deterioration in the overall U.S. trade balance in the early 1980s. They mention that the capital goods component of durables explains much of the movements in durables but do not pursue this to focus on investment. Their argument instead is that U.S import and export price movements in the 1980's were viewed as temporary, and that therefore

[3] Throughout this paper, investment is real public and private investment spending, and consumption is real public and private consumption spending. We ignore other components of GNP, such as changes in inventories, net factor income, because we want to condition on variables which are clearly demand variables. But in any case, we also tried using all non-investment components of GNP rather than consumption and found that it had only a trivial effect on the results.

an additional speculative demand element can explain much of the deterioration in the U.S. trade deficit during this period. Our results for exports indicate that after controlling for foreign investment demand, the intertemporal price effects that Burda and Gerlach emphasize are not statistically significant.

Section 2 contains a brief description of the model we use and a survey of the consensus elasticity estimates in the literature. Section 3 follows with descriptive statistics documenting the importance of capital goods exports in total exports, and describes the world investment and consumption data constructed for this paper. Section 4 presents the main results from regressing U.S. exports on world consumption and investment. Subsequent sections expand on this basic evidence, and the conclusions are in section 9.

2. Model.

We frame the analysis within a standard export demand and supply model which is also known as the "imperfect substitutes model" (Goldstein and Khan, 1985). Demand for our exports in foreign countries depends on foreign real income or expenditure (Y^*), the price of our export goods (P^x), the price of foreign goods expressed in a common currency (P^*/E), and possibly other variables (Z). The expected sign on (P^*/E) is positive, in keeping with the assumption that other foreign goods are substitutes for U.S. export goods rather than complements.

$$X^d = D(Y^*, P^X, \frac{P^*}{E}, Z) \tag{1}$$

The supply of exports depends positively on export prices and inversely on the price of other U.S. goods (P), and other variables (K). One interpretation for the presence of other U.S. goods prices in this equation is that they serve as a proxy for wages and intermediate input prices that would shift the supply curve.

$$X^s = S(P^X, P, K) \tag{2}$$

Equations (1) and (2) are standard Marshallian demand and supply equations and the usual estimation issues apply. Some researchers treat P^x as predetermined and estimate (1) alone. Others estimate (1) with instruments for P^x or focus on reduced forms.[4] Further, since theory suggests that demand is homogenous of degree zero in all nominal prices, the prices in equation (1) are typically constrained to enter as price ratios, P^xE/P^*.

Apart from the familiar theoretical and empirical issues raised by any empirical application of demand theory, the recent trade literature has been especially concerned with issues such as the choice between expenditure (C+I+G) or income (GNP); whether to distinguish secular from cyclical variations in income; and whether to use permanent or transitory income. Of particular relevance for this paper is the issue of whether the scale elasticity lies above one. Researchers focus on this issue because a value above one is unlikely to be a stable, long run parameter, because it implies that exports will eventually exceed GNP, although it may still be relevant for policy simulations in the near future.

To summarize the magnitude of the elasticity estimates in the literature, the mean of the income elasticity estimates in the studies surveyed in Goldstein and Khan (1984) is 1.40, and the mean of the estimated price elasticities is -1.19. The mean of the income elasticities used in the six policy simulation exercises reported in Bryant, Holtham, and Hooper (1988), is 1.27 and the mean price elasticity is -0.75. Other recent estimates of the income elasticity are 2.6 (Krugman and Baldwin, 1987) and 1.9 (Hooper and Mann, 1988).

3. Data.

Table 1 reports statistics to show that much of the growth and variance of total exports since 1967 reflects growth and variance of exports of capital goods and industrial supplies, which is of interest

[4] These two statements are based on the comprehensive survey of trade studies and their estimation techniques in Marquez (1992).

because both of these are likely to be related to investment demand rather than to consumption demand.[5] The table reports means, variances and average growth rates of several kinds of exports as a percent of GNP, using quarterly data in 1982 dollars between 1967 and 1990. The first column shows that capital goods exports have averaged 2.24 percent of GNP, and 35 percent (2.24/6.34) of all merchandise exports, and that exports of industrial supplies have averaged 1.75 percent of GNP, and 28 percent of all exports. The second column shows that capital goods exports have by far the largest variance of all the categories. Furthermore, if we split exports into two groups: capital goods and industrial supplies on the one hand and all the rest on the other hand; capital goods and industrial supplies have a variance of 0.80, other exports have a variance of just 0.19 and the covariance is 0.36. This shows that a substantial share of the variance of exports can be attributed to variance in capital goods plus industrial supplies. The third column in table 1 shows further that capital goods exports have also grown more rapidly than other exports. This growth has been especially rapid since 1985, so that by 1990, capital goods exports comprised 47 percent of all merchandise exports.

The data on investment and consumption in the rest of the world are based on the data in Summers and Heston (1991), which reports data on national investment and consumption in a common set of prices (1985 international prices), and therefore is a natural data set to use for international aggregation. In general, the world aggregates are averages of national data for 31 countries, where the list of countries was chosen to cover all major U.S. trading partners.[6]

There are two sets of world aggregates for both consumption and investment. The first set simply

[5] This is an admittedly rough classification because some industrial supplies can reasonably be associated with consumption, but disaggregated data on exports of industrial supplies is only easily available beginning in 1978.

[6] The 31 countries, organized by region, are Argentina, Bolivia, Brazil, Canada, Chile, Colombia, Ecuador, Mexico, Peru, Uruguay, Venezuela, Australia, China, Hong Kong, India, Indonesia, Japan, S. Korea, Singapore, Taiwan, Thailand, Austria, Belgium, France, Germany, Italy, Netherlands, Spain, Sweden, United Kingdom, and Israel.

sums consumption and investment across countries and then divides by the number of countries to keep the number of digits manageable. These averages are labelled WI and WC for "world investment" and "world consumption". For example,

$$WI_t = \frac{1}{31} \sum_{j=1}^{31} I_{jt} , \tag{3}$$

where investment is simply total investment spending in a country in constant 1985 dollars, translated at purchasing power parity exchange rates. This simple method of aggregation has only recently been made possible by the availability of the Summers and Heston data, and hence has not been common in trade studies. The more typical method of aggregation in the trade literature is to set all country variables to 100 in a base year and then to aggregate using export shares.[7] For comparability, we also computed a set of aggregates using this method, with 1982 chosen arbitrarily as the base year,

$$WIB_t = \sum_{j=1}^{31} \alpha_j \left[\frac{I_{j,t}}{I_{j,1982}} \right] 100 , \tag{4}$$

where the "B" indicates the use of bilateral export shares[8], denoted α_j, and where "I" is the same Summers and Heston investment data.[9] In practice, much of the difference between these two aggregation schemes comes from the treatment of a few countries. For example, Canada's share of U.S. exports, and therefore its weight in WIB is 0.253, which is far higher than Canada's share in world investment, and

[7] For example, Helkie and Hooper (1988).

[8] The fraction of U.S. exports going to a particular country in 1989.

[9] Since we estimate regressions in logs, the units in which these are measured is not a substantive issue.

therefore its weight in the WI aggregate (calculated as $I_{can,1982}/WI_{1982}*31$) of 0.036. Similarly, Mexico's weight in WIB (0.081) also exceeds it's weight in world investment (0.046). Of course, this is counterbalanced by the opposite pattern for many of the other countries, notably Japan (0.144 in WIB versus 0.176 in world investment) and Germany (0.055 versus 0.076). Finally, a pair of world consumption aggregates and a world GNP aggregate were also constructed along similar lines; and all the data and further details are in the data appendix.

The time series data on world investment (WI and WIB) and exports (X) is displayed in figure 1, with all series scaled so that 1967=100. The export data is total merchandise exports in 1982 dollars. The figure highlights the strong co-movement of the world investment aggregates and U.S. exports and is thus a graphical representation of the main finding of this paper. U.S. exports rose and then fell around the first oil shock of 1973, while Western European and Japanese investment rates were following the same cycle. Exports recovered in the late 70's when investment was strong throughout the world, led by Western Europe and the debt-financed Latin American investment boom. Exports fell sharply in the early 1980s. At the same time, European investment was collapsing after the 1979 oil shock and the 1981 recession, and LDC investment was collapsing after the debt crisis of 1982. LDC investment remained sluggish in the 1980s, but the dramatic upswing in U.S. exports after 1985 lines up nicely with the equally dramatic Western European investment boom associated with the anticipation of the 1992 reforms and the rise in Japanese investment. In fact, most of the rise in U.S. exports since 1985 which has attracted attention is concentrated in capital goods and industrial supplies.[10]

Figure 2 displays the world consumption indexes, WC and WCB. These series are clearly much

[10] Real merchandise exports increased by 200 billion 1982 dollars annual rates between 1984 and 1990. Real exports of capital goods and industrial supplies increased by $157 billion during the same period, accounting for 79 percent of the increase in total exports. Additional unpublished data, obtained from the BEATRADE database at the Department of Commerce, on exports by product and destination indicate that 65 percent of the increase in capital goods exports between 1984 and 1990 were sent to the OECD countries. The only significant recipients in the less developed world were the Asian newly industrializing countries (19 percent) and Mexico (6.3 percent).

more smooth than the world investment series and consequently do not line up with many of the year to year changes in exports as the investment series do. Figure 3 displays the price of U.S. exports relative to foreign consumer prices in dollars. Since we are offering nothing new concerning the appropriate price variables in export equations, these price indices are similar to those used in Helkie and Hooper (1988), (except that we use total rather than non-agricultural export prices as they use and of course that we are using updated versions of their variables). Export prices are the fixed-weight (1982 weights) merchandise export price index from the National Income and Product Accounts. The exchange rate is an index of 18 country exchange rates, measured in units of foreign currency per dollar, weighted by shares in U.S. non-agricultural exports. The foreign price index is a similarly weighted index of consumer prices for the same 18 countries.

4. The Basic Results.

Table 2 presents the initial estimates of a standard export demand equation (equation 1) with world investment (WI) and consumption (WC) as regressors rather than world GNP. The initial regression on the left of the table reports least squares estimates of a specification with lags for the dependent variable and each of the independent variables. We used two lags of the real exchange rate to match the standard practice in estimating trade equations. The sample begins in 1967, since the export price index is first available in that year and ends in 1990, using annual data.[11]

The results in general suggest that world investment is a more important determinant of U.S. exports than world consumption. The regression on the left includes a number of statistically insignificant terms; nevertheless, the coefficient on contemporaneous investment is highly significant (T=6.206) and is close to unity (0.948). In contrast, no other estimated coefficient is significant at conventional levels.

The second regression on the right of table 2 drops several of the insignificant lags and estimates a more simple specification.[12] The coefficient on contemporaneous investment is again close to one (0.944) and is highly significant (T=8.606). The coefficient on contemporaneous consumption is not significant (T=0.526) and is small in magnitude (0.099) when compared with the investment coefficient. The coefficients on the first and second lag of the relative price of exports variable are both individually significant (T=5.306 and 3.486) and sum to -0.686, which is closer to zero than the consensus estimate of about -0.9 from more traditional export demand equations.

The regressions reported in table 2 follow much of the empirical trade literature in treating export prices as predetermined. This assumption was tested by comparing instrumental variables and least squares estimates of the simplified model on the right of table 3. To perform this comparison, we

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[11] Since we use two lags on the price variable, the sample size is 22.

[12] We tested these exclusion restrictions and found that the data do not even come close to rejecting them. Further tests for serial correlation, heteroscedasticity and normality of the residuals failed to reject the view that the errors are white noise and normally distributed.

focussed on a less restrictive model which introduced P^x and E/P^* as separate regressors. The reason is that P^x rather than P^xE/P^* is the relevant endogenous variable. The instrument suggested by equation (2), would be a measure of the prices of goods produced by U.S. firms for the domestic market. We used two lags of the U.S. producer price index as instruments for the two lags of P^x. Essentially, the identifying assumption is that the U.S. PPI affects the supply decisions of U.S. exporters but does not affect demand in foreign countries. To permit comparisons and to perform a specification test, we also estimated a parallel least squares version of this unrestricted regression.

To conserve space the instrumental variables estimates are not shown explicitly but the results will be briefly summarized. The sum of the estimated P^x coefficients was very close to zero in both the instrumental variables estimation (0.003) and the least squares estimation (-0.010). Neither sum was individually significant. A test of the hypothesis that the P^x coefficients were equal across the OLS and IV regressions (this is a Hausman test where the null is no misspecification or that P^x is exogenous) is presented in table 2. This test fails to reject equality, with a significance level of 0.21. In light of this evidence, we will treat the price variable as predetermined in the remaining econometrics to improve efficiency.[13]

To check the sensitivity of these results to the way we aggregated the consumption and investment data, table 3 presents the same regressions with the more traditional trade-weighted index number aggregates, WIB and WCB. These results are similar to the earlier results on the basic point that investment and not consumption appears to matter for U.S. exports, but differ in that the investment elasticity is somewhat higher and the price elasticity is smaller than before. The lag distribution on the price coefficients also appears to give more weight to the second lag.

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[13] Alternatively, if simultaneity bias really is important, we would expect the estimated price coefficient to drift around over time as supply and demand shocks buffet this market. Yet, to the contrary, recursive estimates reveal a remarkable constancy in the estimated (sum of) coefficients on the export price variable. Hendry and Neale (1988).

5. Nonstationarity and Cointegration.

It is now almost trite to state that conclusions based on time series regressions in levels can be misleading if the underlying data are non-stationary. To address this issue, we present two kinds of evidence. First, we will show that standard Engle-Granger (1987) two-step tests indicate that the regressions in levels can be interpreted as estimates of a co-integrating relationship, and hence these regressions are less likely to be spurious. Second, we will show that an alternative approach to stationarity problems, namely estimating regressions in first differences, actually provides stronger evidence that investment and not consumption matters for U.S. exports.

As a precursor to implementing the Engle Granger test, we examined the integration status of the variables with augmented Dickey-Fuller unit root tests, which are presented in table 4. This table shows that the data generally do not reject the null hypothesis that the variables are I(1) but do generally reject the null that the variables are I(2) (the WCB variable is the exception). Alternative unit root tests which included a linear time trend, as discussed for example in Campbell and Perron (1991), resulted in similar conclusions except for the export variable, which appears to be I(0) in the regressions with a trend term but I(1) in the regressions referenced in table 4 which do not include a trend. Partly because of this ambiguity, while we first treat all the variables as I(1) as required by the Engle and Granger procedure,[14] we also examine regressions in first differences as an alternative remedy for stationarity problems.

The two steps of the Engle and Granger test are first to estimate the regression in levels and then to test whether the residuals from this regression are stationary with Dickey-Fuller unit root tests. In tables 2 and 3 we use the simplified model as the first stage regression in levels, and present the second stage Dickey-Fuller t-statistics in the lower part of the tables. In table 2, the t-statistic is -4.76, which is

[14] This test can produce misleading results if any of the variables in the system are I(0) rather than I(1), because a cointegrating vector which places a unit coefficient on the I(0) variable and zeroes elsewhere would necessarily, and trivially, produce stationary residuals.

virtually the same as the 5 percent critical value of -4.76 obtained from Engle and Woo (1987). In this case the Engle-Granger test finds co-integration at roughly the 5 percent level (a more accurate but confusing way of stating the result is that the test fails to reject non-cointegration). In contrast, the regressions with the index number aggregates in table 3 do not appear cointegrated, since the t-statistic of -3.897 does not reach the 10 percent critical value of -4.420.

Several authors, Shapiro and Watson (1988), Stock and Watson (1989), Christiano and Eichenbaum (1990), Rudebusch (1990), and Toda and Phillips (1991), have emphasized that it is hard to establish reliably the exact integration status of macroeconomic time series, as indeed appears to be the case regarding the export variable and the index number aggregates in our application. Therefore, it seems prudent to examine another approach to stationarity issues.

Table 4 shows fairly clearly that whatever the exact integration status of the variables in levels, the first differences appear much closer to being stationary. Thus we also examine regressions in first differences, which are presented in tables 5 and 6, where table 5 contains estimates using the simple aggregates and table 6 contains estimates using the more conventional trade-weighted index number aggregates. Table 5 shows that the estimated investment coefficient using the simple aggregate is fairly insensitive to first differencing, changing slightly from 0.944 in table 2 to 0.841 in table 5. On the other hand, the same coefficient in the regressions with the index number aggregates changes more substantially from 1.288 (table 3) to 1.005 (table 6). Tables 5 and 6 show further that both consumption coefficients are incorrectly signed and statistically insignificant. Overall, the regressions in first differences serve to reinforce the earlier conclusion that world investment rather than consumption is a key variable determining U.S. exports.

6. Commodity Disaggregation.

The main conclusion so far that investment demand rather than consumption demand accounts for the bulk of export movements is based on regressions with aggregate merchandise exports as the dependent variable. We have also argued that this result makes sense because variation in investment-related export goods has been an important component in variation of total exports. To further check this conclusion and interpretation, we divided exports into investment-related and consumption-related categories and then ran separate regressions with each of these export categories as dependent variables. If our interpretation is correct, we should expect to find the investment variable entering the regression with investment-related exports and not entering the other regression.

To implement this, we divided merchandise exports into exports of capital goods and industrial supplies (mostly investment related) and everything else (consumption related).[15] Except for this change in the dependent variable, the estimated regressions were identical to the simplified specifications in tables 2 and 3. In the first regression with investment-related export goods, the world investment variable, ln(WI), entered with a coefficient of 1.440 (standard error = 0.219), while the consumption variable, ln(WC), was statistically zero (-0.311, s.e. = 0.188), as expected. In the second regression with consumption-related export goods, the same investment variable was statistically insignificant (-0.044, s.e. = 0.232), while the consumption variable was significant (0.784, s.e. = 0.200). Furthermore, the results were qualitatively similar with the more traditional trade-weighted aggregates: the coefficient on ln(WIB) was significant and larger (1.875, s.e. = 0.275) and that on ln(WCB) was again insignificant (-0.352, s.e. = 0.197) in the regression with investment-related exports; and ln(WIB) was not significant (0.194, s.e. = 0.210) while ln(WCB) was significant (0.714, s.e. = 0.150) in the regression with consumption-related exports.

These results provide some insight about what is driving the results for aggregate exports. It is not that foreign consumption spending has no influence on exports, but rather that the part of exports that consumer spending influences accounts for a relatively small share of the level, growth, and year to year variance in total exports. Conversely, investment-related exports account for about half of the level and

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[15] The data are not readily available to further disaggregate industrial supplies prior to 1978.

longer term growth, and probably more of the year to year variance of total exports, and this explains why investment also enters strongly in aggregate export equations.

7. Do Expected Intertemporal Prices Matter?

We also checked whether the standard specification on which we are basing these conclusions is misspecified by failure to consider intertemporal price effects as suggested recently by Burda and Gerlach (1989). Burda and Gerlach claimed that the U.S. trade balance in durable goods was determined partly by changes in expected future prices of traded durable goods in the 1980s. They mention that investment goods are a significant portion of the durable goods aggregate they examine but do not condition on foreign or U.S. investment in their equations (indeed they have no foreign activity variable in their equations despite the fact that the trade balance is partly exports). It is of interest, therefore, to see if we still find their intertemporal price effects even after conditioning on investment.

To examine the intertemporal hypothesis, we obtained data on the price of U.S. durable exports relative to foreign consumer prices.[16] According to the Burda and Gerlach hypothesis, we would expect foreign demand to rise if next period's durable price was expected to be high, holding constant other contemporaneous prices. A direct test of this hypothesis is therefore to see whether the anticipated part of future durable goods prices enters our export regressions with a positive coefficient.

To implement this test we examined instrumental variables estimates of the simplified model in table 2 with future values of the relative durables price variable added to the right hand side. In essence, the instrumental variables procedure we use is based on an additional hypothesis that consumers use time series autoregressions to forecast future durable prices and base their behavior on the predictable component of future prices yielded by these auxiliary regressions. For example, in one specification, the log of current and lagged durable prices were used as instruments for the log of next year's durable price.

[16] We used the deflator for U.S. durable goods exports from the national income and product accounts, P^{xd}, and calculated the ratio of this price to foreign goods prices expressed in a common currency: $(P^{xd})E/P^{*}$.

This specification yielded an insignificant coefficient of -0.063 (s.e. = 0.097) on the durable price variable. Other specifications with alternative lags and leads did not yield significant coefficients and rarely even produced the anticipated positive sign. This evidence does not support the view that, at least after conditioning on foreign investment demand, anticipated durable price movements are an important determinant of U.S. exports.

8. What Accounts for the Recent Increase in U.S. Exports?

It is possible to agree with the above results on the importance of investment yet still believe that for practical forecasting purposes, using GNP is as good as using investment because the two series are likely to be highly correlated (if for no other reason than that GNP includes investment). To investigate whether world GNP is as good a forecasting variable, we compared the forecasts of alternative models that differ only in the selection of activity variable (GNP vs. investment). For this exercise, a world real GNP variable (denoted WGNP) was constructed from the Summers and Heston data set using the same procedures used to construct the other simple aggregates in this paper.[17]

In all other respects the two forecasting models are similar to each other and also mimic the basic specification in levels that was presented in tables 2 and 3. The estimated forecasting equations are displayed in table 7. These equations were first estimated over the period 1967-1984, and then the estimated coefficients plus data on the exogenous variables were used to generate post-sample forecasts of (the log of) U.S. exports between 1985 and 1990. These forecasts can be compared with actual data on exports from 1985 through 1990 to assess the two models. This forecast period was chosen to coincide with the U.S. export boom of the late 1980s, which began in 1985 and which is conventionally attributed

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[17] All the evidence in this section is based on calculations with the simple aggregates. Calculations with the other aggregates do not produce important differences.

mainly to the effects of dollar depreciation.[18] Additional information from this forecasting exercise to be discussed below is in figure 4 (the forecasts) and table 8 (a decomposition of the sources of the forecasts).

The first finding to note from this exercise is that the model with just investment fits the data better than the model with just GNP, even though GNP equals investment plus other variables and in this sense has more information than does investment. In table 7, the estimated standard error for the forecasting equation with just investment is 0.0259, while the standard error for the GNP model is slightly higher, at 0.0286. More telling evidence is that when the two models are estimated over the entire sample (1967-1990), rather than 1967-1984 as in table 7, the standard error of the investment equation is 0.022, while that of the GNP equation is 0.037, which is about 68 percent higher. Therefore, it appears from this evidence that the non-investment variables in GNP add noise to the export equations, and this seems especially true during the last half of the 1980s.[19]

As may be expected from this evidence on the poorer fit of the GNP model in the latter half of the 1980s, the two models also differ in their ability to forecast the recent 1985-1990 U.S. export boom. To show this, figure 4 presents the out-of-sample forecasts from the two models and a series of vertical bars which are approximate 95 percent confidence intervals for the forecasts.[20] The top panel presents the forecasts for the model with GNP and the bottom panel presents the forecasts for the model with

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[18] Incidently, since the estimated equations do not include lagged dependent variables (which were found to be insignificant in these equations and in tables 2 and 3) the distinction between static and dynamic forecasts is not applicable here.

[19] The GNP variable was also insignificant when added to the equation with investment.

[20] The vertical distance of the bars represent four standard errors of the forecast errors, two on either side of the forecast line. These standard errors are calculated as the variance of y_t - $x_t\beta$ (β is the vector of sample estimates in this case) i.e. the square root of the diagonal elements of $\sigma^2[I+x_t(X'X)x_t']$, where σ^2 is the estimated standard error of the equation, X is the data matrix for the sample period, and x_t is the data vector for a given year during the forecast period. The calculations were performed in PC-GIVE 6.0, and are further described in Hendry (1989) p. 47.

investment. Overall, the investment model tracks actual exports closer than the GNP model. By 1990, exports even lie above the approximate 95 percent confidence band of the GNP model, while the investment model tracks quite closely. Furthermore, a statistical test of the forecast performance of the two models is given by the Chow F-statistics in the bottom of table 7. These statistics indicate whether the forecast errors differ significantly from the in-sample residuals.[21] The F-statistic for the GNP model (2.950, significant at the 0.057 level) provides evidence that the equation is not constant across the sample and the forecast periods. With only the GNP model to work with, this test might appear to signal a structural break in export determination; but the same test with the investment model strongly rejects any structural break, (the F-statistic is 0.22 which is not even close to significance) and instead suggests that the failure to condition on investment is responsible for the apparent structural break in the GNP model. Therefore, it appears that the recent growth in world investment demand is an important reason why exports have grown strongly in recent years.

The third finding to note from these forecasts is that the two models differ in terms of the importance placed on dollar depreciation in accounting for the 1985-1990 export boom. To show this, we present a simple accounting exercise in table 8, where the change in exports between 1985 and 1990 is broken down into the part attributable to each of the right hand side variables in the equations plus the residual. It should be clear that by presenting this accounting exercise, we are not necessarily asserting that the right hand side variables are exogenous but rather just pointing out a difference in the two models that would be relevant for researchers who wish to treat the right hand side variables as exogenous (or at least predetermined with respect to exports). The summary at the bottom of the table shows that the conventional model which uses GNP would attribute 57 percent (0.346/0.604) of the increase in exports to dollar depreciation, 33 percent (0.198/0.604) to world GNP growth, and 10 percent (0.060/0.604) would

[21] Under the null of no structural change, with fixed regressors, the Chow [1960] statistic follows an F distribution with, in this case, 10 and 5 degrees of freedom. With stochastic regressors, this is the asymptotic distribution or the approximate distribution in finite samples.

be left unexplained. In contrast, the investment model would attribute less of the increase to dollar depreciation (42 percent), and would of course attribute more to the world investment boom (53 percent), and less would be left unexplained (4 percent). Therefore, to the extent that one is convinced that the investment model is preferable, the conventional practice of using GNP in export regressions has caused researchers to attribute too much of the recent export boom to the depreciating dollar, and has led them to miss (or at least to underestimate) the importance of the recent increase in world investment demand.

9. Implications and Conclusions.

This paper presents evidence that world investment demand and not world consumption demand has been an important determinant of U.S. exports since 1967. In particular, the rise in world investment demand in the late 1980s is an important reason why the U.S. economy experienced an export boom during that period, and the paper presents further evidence that failure to consider this influence can lead analysts to over emphasize the role of dollar depreciation in generating strong export performance. Casual examination of the data suggest that these results are reasonable because exports of capital goods and industrial supplies account for much of the growth and variance of total U.S. merchandise exports.

The paper also attempts to take the "con" out of the econometrics[22] by showing that the basic finding of the importance of world investment demand and the unimportance of world consumption demand is robust to a number of specification changes.

To the extent that world investment demand has different determinants than world consumption demand, this finding may change views about the ultimate determinants of U.S. exports and U.S. growth, and possibly also allow a more precise analysis of the economic mechanisms at work. It is also worth noting that capital goods are a real growth industry for the U.S. economy. Between 1967 and 1989, while the share of manufacturing output in total GDP remained fairly steady, the share of capital goods production (excluding defense and autos) in total manufacturing rose from 28 to 38 percent. Over the

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[22] Leamer (1983).

same period, the share of U.S. capital goods production that was exported rose from 20 to 45 percent. Capital goods exports increased from only 1.37 percent of GDP to 3.97 percent -- nearly three times as much as in the late 1960s.[23]

While the capital goods sector has grown domestically, it has also been a growing world industry. In the past two decades, the fraction of investment spending in total world GNP (measured as WI/WGNP) has risen from 22 percent to 26 percent. If this trend continues, it is likely that the U.S. economy will continue to benefit, and therefore probably has an interest in stimulating world investment demand.[24] Although the investment data in this paper stops in 1990, further fragmentary investment data for 1991 indicates that investment demand in the non-German OECD slowed significantly, but that the slack was offset by strong demand from Germany, Mexico, Venezuela, Korea, Singapore, Taiwan and Saudia Arabia. Real export data through November 1991 show that exports rose more than 7 percent from their level in 1990 and most of the rise was in capital goods and industrial supplies. Strong exports in 1991 have probably served to diminish the severity of the current recession. In the longer term, the United States stands to benefit from a revival of investment spending in Latin America (if stabilization is successful) and numerous countries in the former Soviet block (if reform is successful).

[23] Although imports of capital goods have also increased, it is worth noting that this increased import penetration has not been sufficient to crowd out domestic production since the facts show that capital goods production as a share of GDP has increased, as mentioned in the text, from 28 to 38 percent.

These statements are based on the gross product originating by industry data (value added) described in De Leeuw, Mohr and Parker (1991), and obtained from the Bureau of Economic Analysis on a computer tape. Capital goods are defined as non-electric machinery (sic 35), electrical machinery (sic 36), all transport equipment except motor vehicles (sic 37 minus 371), and instruments and related products (sic 38).

[24] A counter-argument is that U.S. producers may not benefit in the long run if foreigners invest in industries that compete with U.S. exports. For example, Hooper (1990) has argued that the faster growth of productive capital stocks abroad has been a factor that has tended to depress U.S. net exports over time, ceterus paribus. While this is possible, it is less relevant to the extent that the investment takes place in non-traded sectors, or in other sectors which do not produce substitutes for U.S. exports.

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Table 1

Statistics on Major Categories of U.S. Exports

	Exports as a percent of GNP		
Export Category	Mean	Variance	Growth
	(1)	(2)	(3)
Autos	0.67	0.015	0.4
Capital Goods, except Autos	2.24	0.484	4.0
Consumer Goods, except Autos	0.40	0.014	3.6
Foods, Feed, and Beverages	0.77	0.028	2.3
Industrial Supplies and Materials	1.75	0.053	1.4
Other	0.51	0.036	4.2
Total merchandise exports	6.34	1.724	2.7

Column (1) and (2) report the sample mean and variance of $(X_j/GNP)*100$, using quarterly data from 1967:1 through 1990:4. Column (3) reports the least squares estimate of ß from $\ln(X_j/GNP)=\alpha+\beta(trend)+e$. The trend is defined to increment by 0.25 each quarter, so ß is an estimate of the annual growth rate.

Table 2

Regressions of U.S. exports on world investment and consumption: simple aggregates.

Dependent Variable: $\ln(X_t)$

	Initial model		Simplified model	
VARIABLE	Coefficient	T Statistic	Coefficient	T Statistic
$\ln(X)_{t-1}$	0.155	0.680	-	-
$\ln(WI)_t$	0.948	6.206	0.944	8.606
$\ln(WI)_{t-1}$	-0.205	-0.886	-	-
$\ln(WC)_t$	0.099	0.130	0.053	0.526
$\ln(WC)_{t-1}$	-0.025	-0.031	-	-
$\ln(P^xE/P^*)_t$	-0.067	-0.514	-	-
$\ln(P^xE/P^*)_{t-1}$	-0.405	-2.814	-0.438	5.306
$\ln(P^xE/P^*)_{t-2}$	-0.179	-0.967	-0.248	3.486
CONSTANT	-7.292	-2.773	-9.536	-11.331
RBAR2		0.996		0.996
SEE		0.024		0.022
DW		n.a.		1.978
N		22		22

Engle-Granger test of no co-integration[1]	
T-Statistic:	-4.761
5 percent critical value:	-4.760
Hausman test that P^x is exogenous[2]	
F-statistic:	1.75
Significance level:	0.21

[1] This test is described in the text. The critical value is from Engle and Yoo (1987), Table 2.
[2] This test uses the U.S. producer price index as an instrument for export prices, P^x.
This table reports least squares estimates, using annual data from 1967 through 1990.

Table 3

Regressions of U.S. exports on world investment and consumption: trade-weighted aggregates.

Dependent Variable: $\ln(X_t)$

	Initial model		Simplified model	
VARIABLE	Coefficient	T Statistic	Coefficient	T Statistic
$\ln(X)_{t-1}$	0.149	0.602	-	-
$\ln(WIB)_t$	1.222	6.166	1.288	8.336
$\ln(WIB)_{t-1}$	-0.059	-0.172	-	-
$\ln(WCB)_t$	-0.682	-0.769	0.013	0.119
$\ln(WCB)_{t-1}$	0.616	0.700	-	-
$\ln(P^xE/P^*)_t$	-0.139	-0.933	-0.083	-0.873
$\ln(P^xE/P^*)_{t-1}$	-0.055	-0.313	-0.086	-0.635
$\ln(P^xE/P^*)_{t-2}$	-0.136	-0.783	-0.229	-2.472
CONSTANT	1.008	0.831	1.155	1.458
RBAR2		0.994		0.995
SEE		0.027		0.026
DW		n.a.		1.724
N		22		22
	Engle-Granger test of no co-integration[1]			
T-Statistic:				-3.897
10 percent critical value:				-4.420
	Hausman test that P^x is exogenous[2]			
F-statistic:				2.47
Significance level:				0.11

[1] This test is described in the text. The critical value is from Engle and Yoo (1987), Table 2.
[2] This test uses the U.S. producer price index as an instrument for export prices, P^x.
This table reports least squares estimates, using annual data from 1967 through 1990.

Table 4

Unit Root Tests

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 \Delta y_{t-1} + e_t$$

$$\Delta^2 y_t = \beta_0 + \beta_1 \Delta y_{t-1} + \beta_2 \Delta^2 y_{t-1} + e_t$$

Variable	T statistic for $\alpha_1=0$	T Statistic for $\beta_1=0$
ln(X)	0.60	-4.80
ln(WI)	-0.62	-6.27
ln(WIB)	-0.64	-3.56
ln(WC)	-0.72	-4.49
ln(WCB)	-3.56	-2.21
$\ln(P^x E/P^*)$	-1.81	-3.11

Significance level	Critical Values[1]
0.01	-3.75
0.05	-3.00
0.10	-2.63

[1] The critical values are for N=25 (Calculated by Dickey, reported in Fuller, Table 8.5.2).
OLS estimates using annual data, 1967-1990.

X	Merchandise exports from the United States. Billions of 1982 dollars.
WI	World investment, excluding the United States, un-weighted average.
WC	World consumption, excluding the United States, un-weighted average.
WIB	World investment, excluding the United States, weighted average (bilateral export weights).
WCB	World consumption, excluding the United States, weighted average (bilateral export weights).
P^x	Price index for U.S. merchandise exports in dollars, 1982=100.
P^*	18 country CPI index, multilateral export weights, 1982=100.
E	18 country nominal exchange rate index, multilateral export weights.

Table 5

Regressions in First Differences: simple aggregates.

Dependent Variable: $\Delta\ln(X_t)$

VARIABLE	Coefficient	T Statistic
$\Delta\ln(WI)_t$	0.841	4.874
$\Delta\ln(WC)_t$	-0.316	-0.395
$\Delta\ln(P^{x}E/P^{*})_t$	-0.169	-1.394
$\Delta\ln(P^{x}E/P^{*})_{t-1}$	-0.424	-3.919
$\Delta\ln(P^{x}E/P^{*})_{t-2}$	-0.245	-2.509
CONSTANT	0.015	0.502
RBAR2		0.842
SEE		0.030
DW		2.295
N		21

Table 6

Regressions in First Differences: trade-weighted aggregates.

Dependent Variable: $\Delta\ln(X_t)$

VARIABLE	Coefficient	T Statistic
$\Delta\ln(WIB)_t$	1.005	5.813
$\Delta\ln(WCB)_t$	-0.831	-1.384
$\Delta\ln(P^xE/P^*)_t$	-0.265	-2.801
$\Delta\ln(P^xE/P^*)_{t-1}$	-0.141	-1.155
$\Delta\ln(P^xE/P^*)_{t-2}$	-0.316	-3.491
CONSTANT	0.034	1.566
RBAR2		0.869
SEE		0.028
DW		2.565
N		21

Table 7

Estimated Forecasting Equations and Tests of Structural Stability

Dependent Variable: $\ln(X)_t$

	Model with investment		Model with GNP	
VARIABLE	Coefficient	T statistic	Coefficient	T statistic
$\ln(WI)_t$	0.994	10.82	-	-
$\ln(WGNP)_t$	-	-	0.789	9.71
$\ln(P^xE/P^*)_t$	0.027	0.23	-0.069	-0.55
$\ln(P^xE/P^*)_{t-1}$	-0.442	-2.55	-0.820	-4.39
$\ln(P^xE/P^*)_{t-2}$	-0.252	-2.21	0.050	0.36
CONSTANT	-2.470	-1.64	4.937	5.28
RBAR2	0.995		0.994	
SE	0.0259		0.0286	
DW	1.88		2.23	
N	16		16	

Chow Test of Structural Stability

Let the subscripts "s" and "f" refer to the sample (1967-1984) and forecast (1985-1990) periods, and let RSS_s stand and RSS_f for the sum of squared residuals and the sum of squared forecast errors, respectively. The null hypothesis is no structural change between the sample and the forecast period: $\beta_S=\beta_F$; $\sigma^2_S=\sigma^2_F$. The Chow test statistic is:

$$\frac{RSS_f - RSS_s}{RSS_s}\left(\frac{N_s-K+1}{N_f}\right) \sim F(N_s-K+1,N_f)$$

	Model with Investment	Model with GNP
F Statistic	0.220	2.950
Significance Level	0.961	0.057

Table 8

Accounting for the 1985-1990 Export Boom

Variable	Change[1]	Model with Investment: Coefficient[2]	Model with Investment: Product	Model with GNP: Coefficient[2]	Model with GNP: Product
	(1)	(2)	(1)*(2)	(3)	(1)*(3)
$\ln(WI)_t$	0.324	0.994	0.322	-	-
$\ln(WGNP)_t$	0.251	-	-	0.789	0.198
$\ln(P^xE/P^*)_t$	-0.496	0.027	-0.013	-0.069	0.034
$\ln(P^xE/P^*)_{t-1}$	-0.403	-0.442	0.178	-0.820	0.330
$\ln(P^xE/P^*)_{t-2}$	-0.362	-0.252	0.091	0.050	-0.018

SUMMARY

	Model with Investment	Model with GNP
Total change in ln(X)	0.604	0.604
Part due to world investment increase	0.322	-
Part due to world GNP increase	-	0.198
Part due to dollar depreciation[3]	0.256	0.346
Unexplained part	0.026	0.060

This table reports simulations of the form: change in dependent variable = change in independent variable times estimated coefficient.

[1] All changes are defined as 1990 values minus 1985 values.

[2] The estimated coefficients are taken from the regressions reported in table 7 which use annual data between 1967 and 1984.

[3] The part due to dollar depreciation is approximated as the sum of the effects of all the export price variables.

Data Appendix

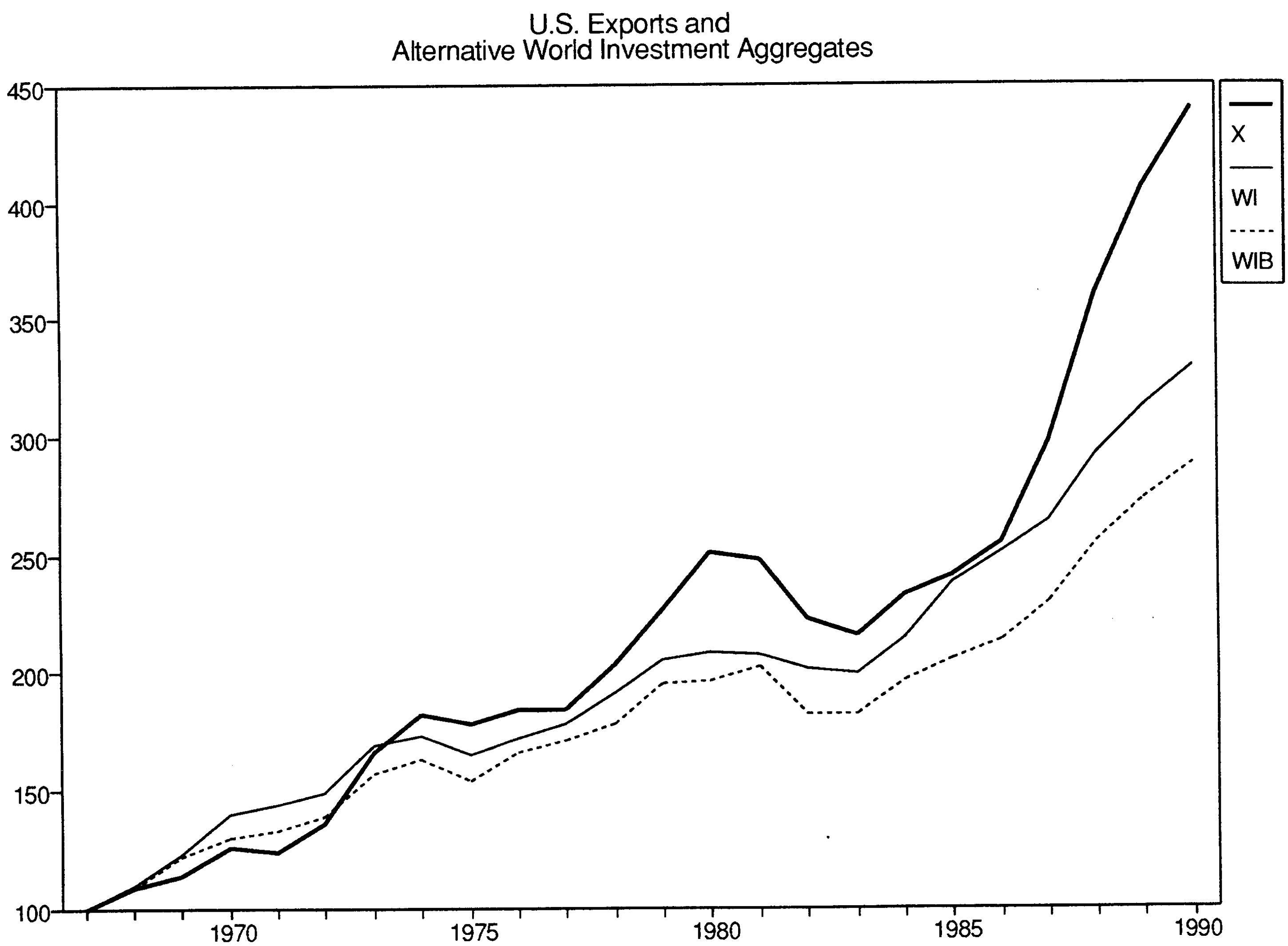
WI	Un-weighted average of investment spending in 31 countries, not including the United States (see equation 3 in the text). The national investment data are public plus private gross fixed investment spending in thousands of 1985 international prices and were obtained from the data set in Heston and Summers [1990]. Using the Heston-Summers naming conventions, investment in the jth country is $RGDPCH_j*POP_j*(ci_j/100)$, where RGDPCH is GDP per capita in 1985 international dollars, POP is population, in thousands, and ci is the percentage share of gross fixed investment in GDP. These data are available between 1962 and 1988 for all 31 countries. The WI variable was obtained by summing and dividing by 31. The 1989 and 1990 values for WI were obtained by applying the growth rates for real investment spending in the non-U.S. OECD to the previous year's level of WI.
WIB	Index of investment spending in 31 countries (equation 4). The weights are the shares of U.S. exports going to a particular country. The index is based on the same investment data used to derive WI.
WC	Un-weighted average of public and private consumption spending in 31 countries. Using the Heston-Summers naming conventions, the calculation for the consumption in the jth country is $RGDPCH_j*POP_j*((cg_j+cc_j)/100)$.
WCB	Index of public and private consumption spending, similarly constructed as WIB, and using the same consumption data that WC uses.
WGNP	Unweighted average of GNP in 31 countries. GNP is calculated as $RGDPCH_j*POP_j*(RGNP_j/100)$, where RGNP is the ratio of GNP to GDP.
X	U.S. merchandise exports in billions of 1982 dollars, on a national income accounts basis.
P^x	Price index for U.S. exports, in dollars, 1982=100.
E	Nominal exchange rate index. Weighted average of 18 countries bilateral exchange rates, using trade shares for weights. Measured as foreign currency per dollar.
P^*	Weighted average of 18 country's consumer price indexes, using trade shares as weights.
P	The U.S. producer price index.
P^{xd}	The implicit deflator for U.S. exports of durable goods, from the national income accounts.
Countries:	The 31 countries, organized by region, are Canada, Mexico, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Peru, Uruguay, Venezuela, China, Hong Kong, India, Indonesia, Japan, S. Korea, Singapore, Taiwan, Thailand, Austria, Belgium, France, Germany, Italy, Netherlands, Spain, Sweden, United Kingdom, Israel, and Australia.

YEAR	X	WI	WIB	WC	WCB	WGNP
1967	96.5000	31.9166	55.0000	112.776	52.0000	142.3485
1968	104.900	34.9051	60.0000	116.759	55.0000	149.4085
1969	110.000	39.3214	67.0000	125.427	59.0000	162.2087
1970	120.700	44.7407	71.0000	133.737	62.0000	175.4460
1971	119.300	45.9525	73.0000	139.929	65.0000	183.0106
1972	131.300	47.4821	76.0000	147.292	68.0000	191.4804
1973	160.600	53.7929	86.0000	155.951	72.0000	204.5505
1974	175.900	54.9815	90.0000	160.409	74.0000	211.4390
1975	171.500	52.4355	85.0000	167.063	78.0000	216.2021
1976	177.500	54.9302	91.0000	172.065	81.0000	223.6999
1977	178.100	56.8186	94.0000	179.936	86.0000	234.1234
1978	196.200	61.0347	98.0000	188.449	89.0000	246.6362
1979	218.200	65.4111	107.000	197.142	93.0000	258.0213
1980	241.800	66.4181	108.000	205.599	96.0000	267.7062
1981	238.500	66.0435	111.000	211.528	99.0000	274.0071
1982	214.000	64.2667	100.000	216.358	100.000	277.1112
1983	207.600	63.5560	100.000	223.498	103.000	285.6467
1984	223.800	68.4822	108.000	230.956	106.000	299.3784
1985	231.600	75.8841	113.000	239.791	109.000	312.6978
1986	245.900	79.8325	117.000	256.852	114.000	337.7313
1987	286.500	83.9714	126.000	268.530	118.000	352.8127
1988	347.300	93.0292	140.000	280.261	122.000	374.3262
1989	390.800	99.7270	150.000	287.743	125.000	388.5506
1990	423.900	104.913	158.000	296.002	129.000	402.1499

YEAR	E	P^*	P	P^{xd}	P^x	$(P^x)E/P^*$ [1]
1967	114.680	28.8778	35.9284	31.3200	39.0681	124.858
1968	116.950	29.9215	37.7242	32.4000	40.0836	126.289
1969	117.463	31.1786	39.7706	34.0900	41.7971	126.856
1970	117.117	33.0806	41.9928	36.5100	44.5899	126.889
1971	115.101	35.0996	44.3632	37.8000	46.0780	121.740
1972	107.900	37.2061	46.4344	38.7900	46.7671	109.480
1973	98.7268	40.6721	49.5075	41.5800	48.3119	95.0240
1974	100.885	46.9420	53.9643	49.5500	57.7293	99.8033
1975	99.3394	52.4887	59.2639	56.9100	65.4775	99.9193
1976	106.106	57.3373	63.0004	61.0300	67.6685	101.064
1977	104.703	62.6923	67.2552	64.5400	69.9100	94.6469
1978	95.0024	67.1257	72.1845	69.0700	73.6573	84.7325
1979	92.0166	72.9576	78.5668	77.9700	82.9737	85.0770
1980	93.0902	81.9639	85.6975	87.7400	91.2580	84.4291
1981	108.550	91.4517	93.9152	95.8300	97.8335	93.8647
1982	123.461	99.9528	100.035	100.030	100.054	100.000
1983	135.749	107.663	103.873	98.5900	98.7963	101.510
1984	151.229	115.318	107.758	97.9600	100.422	107.084
1985	159.876	122.610	110.962	94.2300	99.0013	105.165
1986	133.210	127.700	113.846	90.5700	97.7125	84.1176
1987	119.779	133.940	117.418	87.1300	100.338	74.1596
1988	118.361	143.160	121.328	88.0800	104.927	71.6806
1989	128.293	155.178	126.282	89.5600	106.473	72.7511
1990	124.693	172.064	131.426	88.6400	108.534	65.0243

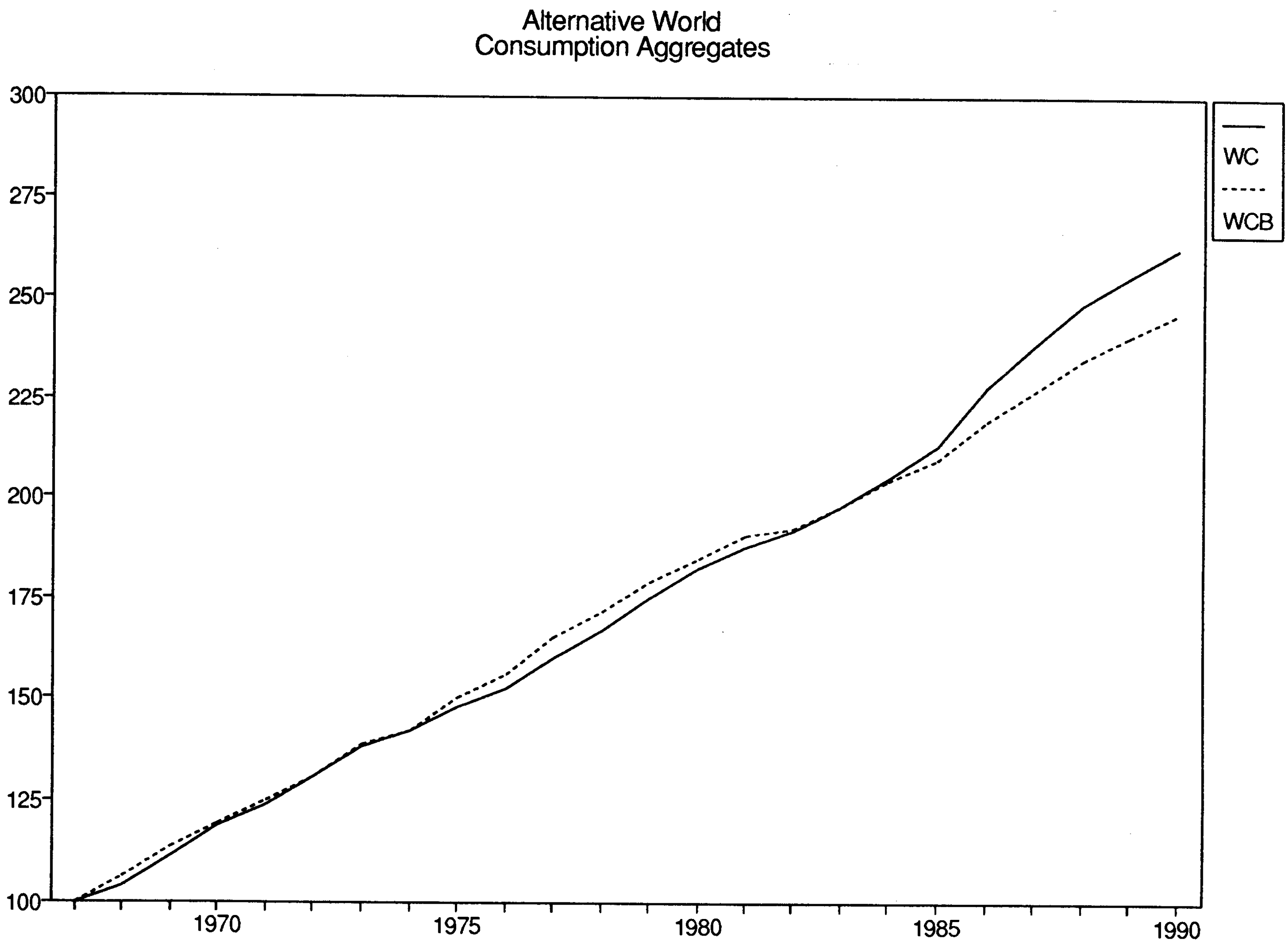
[1] This variable does not quite equal the ratio of the corresponding annual prices reported in this table because the calculation $(P^x)E/P^*$, was done with quarterly data first and then averaged to get the reported annual index.

Figure 1



U.S. Exports and
Alternative World Investment Aggregates
450
400
350
300
250
200
150
100
1970
1975
1980
1985
1990
X
WI
WIB

Figure 2



Alternative World
Consumption Aggregates
300
275
250
225
200
175
150
125
100
1970
1975
1980
1985
1990
WC
WCB

Figure 3

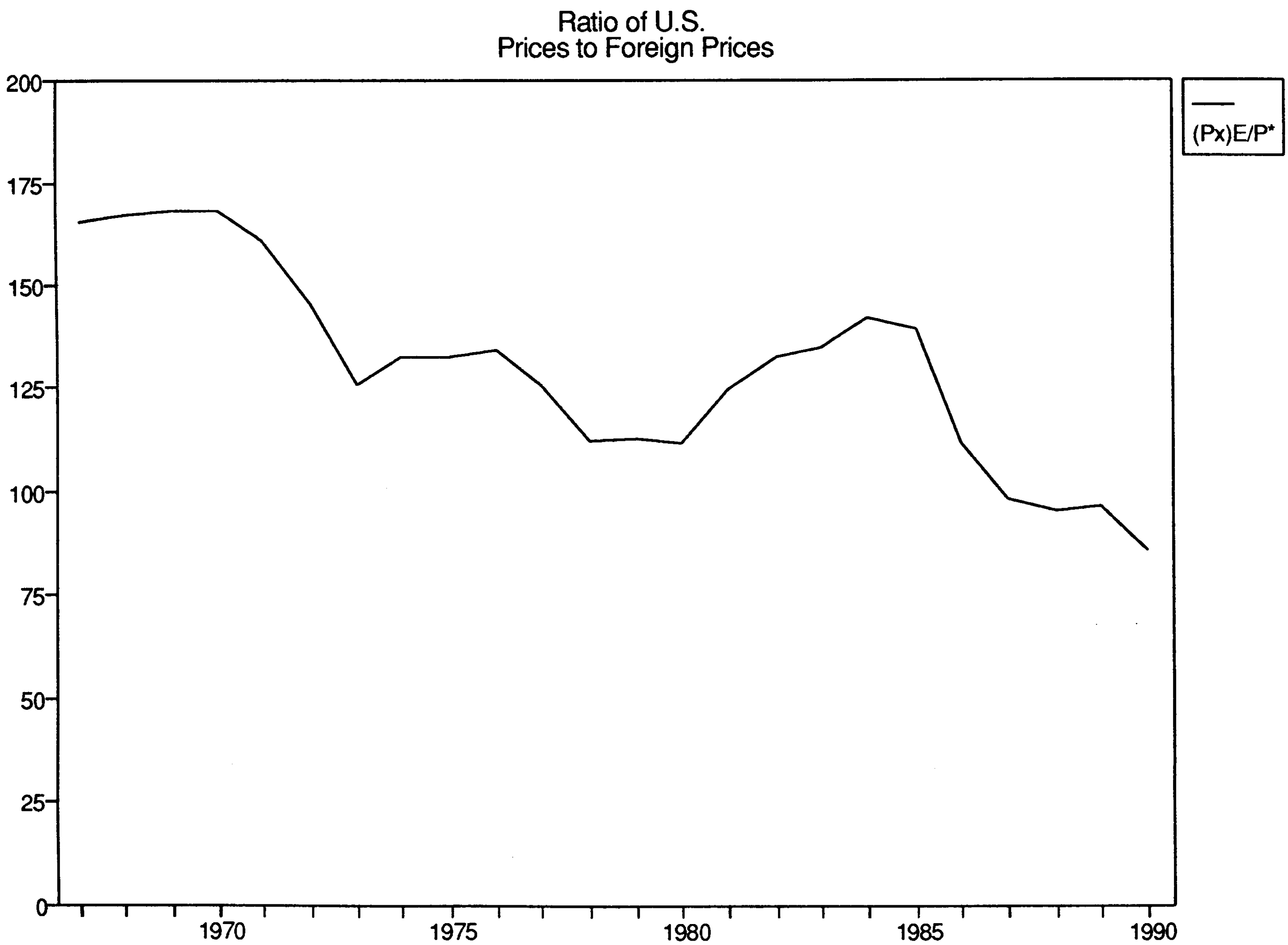
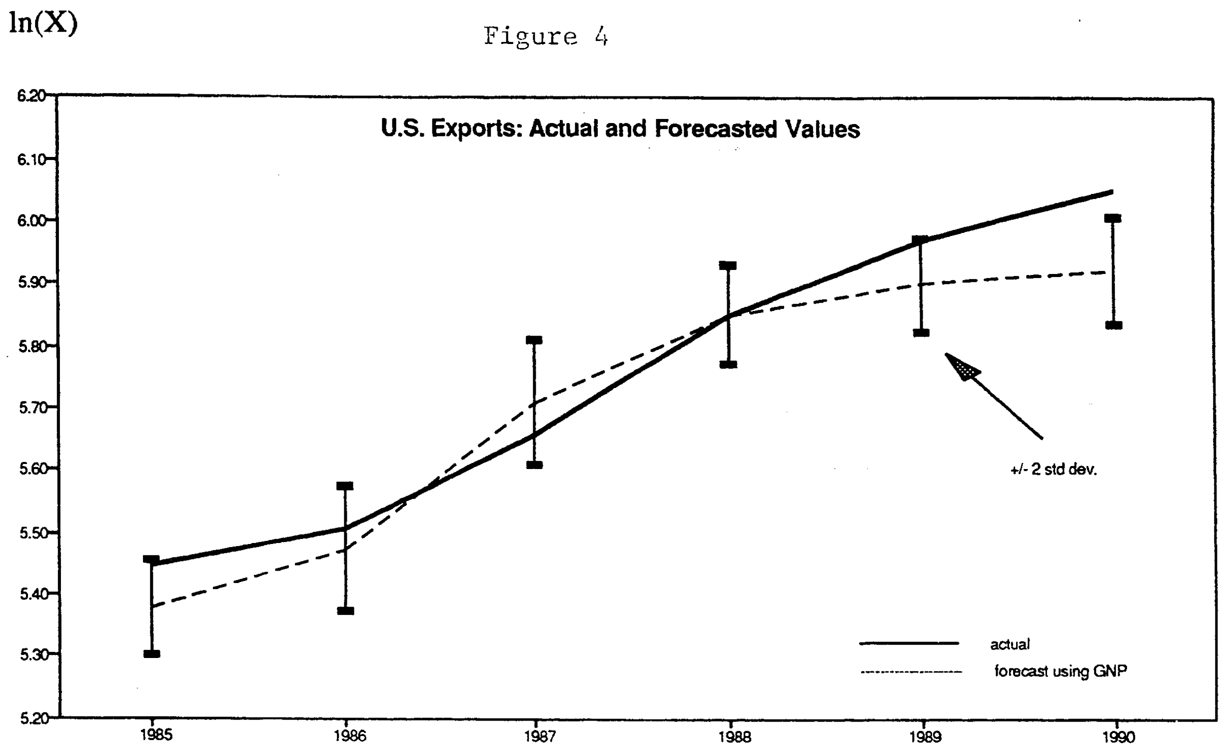
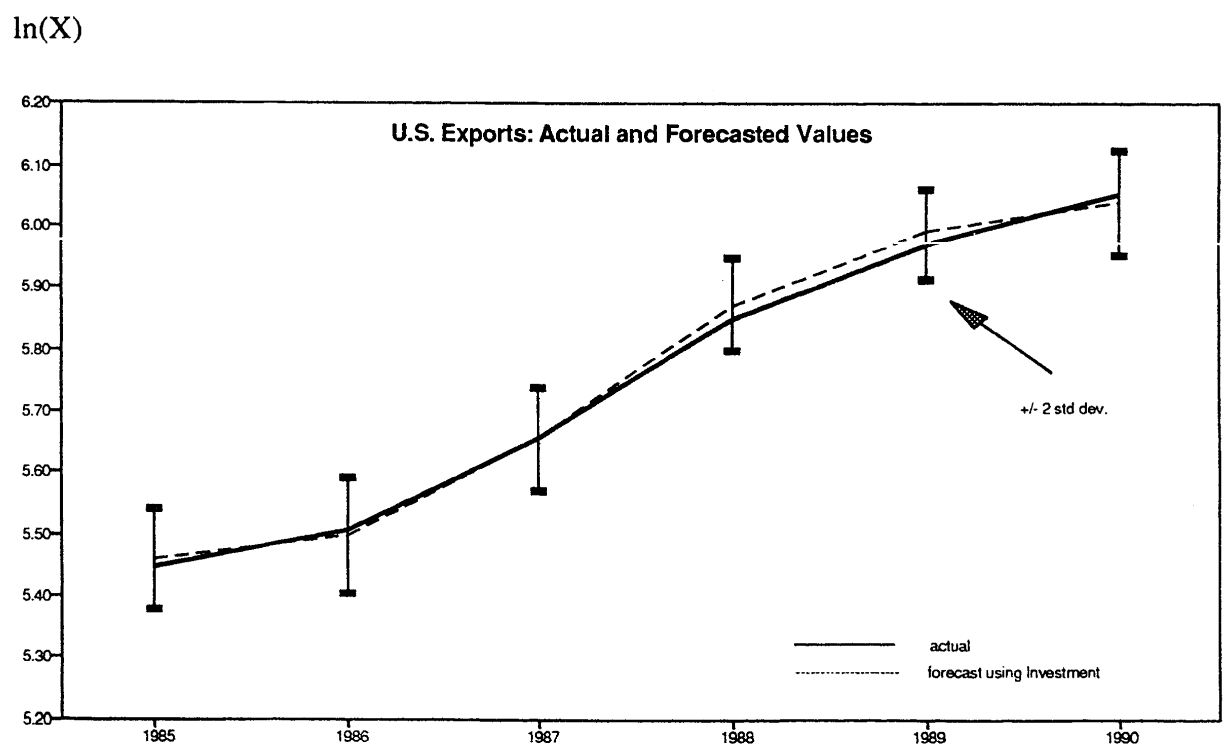

Ratio of U.S.
Prices to Foreign Prices
200
175
150
125
100
75
50
25
0
1970
1975
1980
1985
1990
(Px)E/P*

Figure 4


ln(X)
U.S. Exports: Actual and Forecasted Values
6.20
6.10
6.00
5.90
5.80
5.70
5.60
5.50
5.40
5.30
5.20
1985
1986
1987
1988
1989
1990
+/- 2 std dev.
actual
forecast using GNP


ln(X)
U.S. Exports: Actual and Forecasted Values
6.20
6.10
6.00
5.90
5.80
5.70
5.60
5.50
5.40
5.30
5.20
1985
1986
1987
1988
1989
1990
+/- 2 std dev.
actual
forecast using Investment

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