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COMPUTERS AND THE TRADE DEFICIT:
THE CASE OF THE FALLING PRICES

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ABSTRACT

This paper investigates two issues related to international trade in computers: measurement and prediction. Because of the rapid technological advancement in the computer industry, the Bureau of Economic Analysis (BEA) measures computer prices using techniques that adjust for quality change. The constructed hedonic index is essentially a domestic price measure, but the BEA uses it for the deflation of international sales and purchases of computers. This paper begins with a review of the theory behind hedonic price indexes, and then proceeds to discuss the concerns that arise when a domestic index is used to deflate international transactions.

If the computer industry is sufficiently different from other industries, separate treatment of computers in empirical models of international trade may be necessary to capture historical developments and predict future outcomes. This paper examines the simulation performance of a conventional aggregate trade model, a modified aggregate trade model, and a model that disaggregates computers. The model with computers disaggregated is shown to out-perform the other models.

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Ellen E. Meade*

1. Introduction

Over the past two decades, technological advances in the computer industry have been enormous. During the 1970s, running a computer program involved a number of cumbersome tasks: typing out computer cards at a keypunch machine, submitting the job by processing the deck of cards through a card reader, and waiting for written output from a printer. Today, the same computer program can be run in a variety of ways, all of which are extremely simple, efficient, and affordable. And, the reduction in the size of computers, from the gigantic mainframe to the portable personal computers, has made international trade in these goods more important. Today, we benefit not only from advances in the domestic computer market, but from technological gains in overseas markets as well.

As economists observing the rapid development in the computer market, a couple of important questions arise. First, how do we measure the advancement in the computer industry in a meaningful way? Ideally, we would like to measure a number of factors: for instance, the availability of new products, the apparent decline in the relative price of computer power, and the resultant increase in our productivity. Second, as computers become an increasingly important product in international markets, how can we best predict future developments? If we think that the recent technological advances in the computer industry may be expected to continue, then we want to treat this industry

separately when formulating predictions, because its behavior differs so much from other industries.

This paper addresses both of these questions. The proper measurement of prices of domestic computers has been the subject of a number of recent studies (including Cartwright 1986, Cole and others 1986, Dulberger 1989, and Gordon 1989). The Bureau of Economic Analysis (BEA) has modified its traditional approach to price measurement with techniques to incorporate adjustment for quality change, in order to capture the developments in the computer market more comprehensively. A hedonic price index was developed to measure prices of domestic computing equipment; the same index is now being used to deflate exports and imports of computers as well. Section 2 gives a detailed discussion of the construction of the BEA index for computer prices, and the potential problems involved in using a domestic index to deflate other categories of spending.

When the BEA index is used to deflate the value of traded computers, the resulting quantity of exported and imported computers shows tremendous growth over the last decade. These data are reviewed in section 3. Empirical trade models have focused on aggregate historical relationships, and have not accounted for developments in the computer industry separately. The paper examines the extent to which separate treatment of computers is warranted, by comparing a conventional trade model with a model that disaggregates exports and imports of computers from other trade flows. The models are outlined in section 4. The comparison of models in section 5 is based on parameter estimates as well as the forecasting ability in and out of sample. Section 6 concludes the paper.

2. Measurement of Computer Prices

Limitations of the Traditional Matched-model Approach

A traditional procedure for the measurement of prices is the "matched-model" approach. A matched-model index records the price for an identical product (produced by identical technology) across two different time periods.¹ Products that are available in the first period but discontinued in the second period, and new products that become available in the second period but are not produced in the first period, are excluded from the sample since prices of these products are not available for both time periods. Generally, this does not present a problem for the construction of the index if the price movements of the products included in the index accurately reflect the movement of prices omitted from the index. In order to form the price index across a number of time periods, these adjacent-year matched-model indexes are linked together multiplicatively in a "chain" index.²

The discontinuation of outdated products and the introduction of new products may pose a problem for price measurement, however, if technological advancement in the industry is particularly rapid. This concept can best be explained by way of example: good x is produced in both the first and second periods; its price is sampled for the matched-model index. Good y, identical in characteristics to x but produced with a newer technology, is introduced in period 2. Because it is produced with a more efficient technology, good y is less expensive than good x. In the long run, both good x and good y should sell for the same price since the products are identical. But in the short run, until equilibrium is established in the market, there will be a price differential. Since the matched-model index only includes the price of

good x, it tends to overstate the level of prices. In some studies, this phenomenon is termed "technologically-induced disequilibrium," since it is the lack of instantaneous adjustment to a new equilibrium that causes the traditional matched-model index to mis-state true price changes³ (see Cole and others 1986, Triplett 1986, and Dulberger 1989, for further discussion of the need for hedonic methods). Obviously, the more rapid is the technological advancement in an industry (implying frequent reductions in price and many new products), the greater is the concern about using the matched-model approach to capture price change.

The Hedonic Approach

Advances in the computer market since the early 1970s have generated incredible gains in efficiency and a broad array of newly available products. The concern about "technologically-induced disequilibrium" has prompted the BEA to augment the traditional matched-model approach to the measurement of computer prices with techniques that adjust for improvement in quality. In essence, these techniques generate estimates for missing prices (in the above example, the price of good y in the first period), so that the matched-model index is formulated over a complete sample of prices. The method used to generate the missing prices is a hedonic regression that relates the behavior of product prices (the dependent variable) to a time dummy, important product characteristics, and a measure of technology (the explanatory variables).⁴ A number of authors have investigated the appropriate specification of hedonic regressions for computer processors and parts, including the choice of functional form, product characteristics included, and estimation restrictions (see Cole and others 1986, Dulberger 1989, and Gordon 1989).

Product Coverage and Construction of the Hedonic Index

Underlying the hedonic approach is the assumption that the price of a product reflects the characteristics bundled in that product. If the hedonic regression adequately controls for changes in the embodied characteristics, then residual price change is the result of technological improvement. Implementation of hedonic techniques for computers requires an appropriate definition of both the product and the product characteristics. The BEA defines the computer in terms of individual pieces of equipment, and constructs price indexes for each component separately.⁵ While the running of a job on a computer may require several pieces of computer equipment acting in sequence, the individual pieces possess different characteristics. Furthermore, although most computer purchases are of a system of components, only the individual prices are observed (and discounting is common for a system purchase). For these reasons, hedonic techniques are applied to the individual computer components rather than to the computer system as a whole. The components measured in the BEA index include computer processors, disk drives, printers, general purpose displays (terminals), and personal computers.⁶

In addition, adequate coverage of the characteristics that determine the value of each component is critical to the success of the hedonic technique. In the development of the hedonic regressions for computers, IBM selected the relevant characteristics for four of the components: for computer processors -- speed of execution of a set of instructions and memory capacity; for disk drives -- memory capacity and the speed of transfer between the drive and the main memory; for printers -- speed, resolution of print, and the number of fonts available; and,

for terminals -- screen capacity, resolution, the number of screen colors, and the number of programmable function keys.⁷

An augmented matched-model index is constructed for each of the four components, using predictions from the hedonic regressions to fill in missing prices. That is, the hedonic regression predicts what the price of the component would have been, given its characteristics and technology, if had it been available at a particular date. The price measure for personal computers does not involve hedonics; it is a traditional matched-model index covering price changes for IBM products and PCs from several other manufacturers. The aggregate index for computers is a weighted average of the augmented matched-model indexes for computer processors, disk drives, printers, and displays, and the unaugmented matched-model index for personal computers. The weights used to construct the index are shares of each component in the shipments of domestic manufacturers.

Caveats

Several comments are in order regarding the construction and the usefulness of the BEA price index for computers. First, if the technological development in the personal computer market has been as rapid as in the market for other computer products, then the estimation of PC prices from a traditional matched-model index will bias the price upward.⁸ Second, for all of the components in the BEA index, the data on prices was for list prices rather than for the actual transactions price. Discounting is a common practice in the computer industry, especially for the purchase of a system of components. To the extent that different components are discounted by different margins, this adds an additional source of bias.

Third, several recent studies have investigated the role of this computer price index in the measurement of productivity (see Bailey and Gordon 1988, and Denison 1989). These studies consider whether the use of this computer deflator in the GNP accounts has biased measures of productivity and output, and perhaps misattributed the gain in computer power (for the BEA opinion on this subject, see Young 1989). While this line of research is timely and important, it is beyond the scope of the study here.

Fourth, very few countries currently employ hedonic techniques for the measurement of computer prices. Based on the author's survey, only Canada and Australia use a hedonic price index. Both of these countries obtain the component price indexes from the BEA, adjust for bilateral exchange rate changes vis a vis the dollar, and use own-country weights to form the aggregate index. Japan measures prices of domestic and traded computers with a unit value index, derived from value and quantity data. While economists with the Economic Planning Agency in Japan acknowledge the need for hedonic techniques, they feel that these techniques are too complicated to pursue. The U.K. follows a traditional matched-model procedure.⁹ Clearly, indicators of international price competitiveness may be biased by the lack of standardization in the measurement of computer prices.

A final concern involves the broad use of this computer price index in the GNP accounts. The components in the index reflect prices for the domestic market, as well as exported and imported computers; the aggregate index is formed using weights in domestic shipments. While the index is a hybrid, it seems most appropriate for the deflation of the computer portion of producers' durable equipment. However, the price is

also used to deflate exports and imports of computers.^{10 11} Using this index to deflate exports and imports of computers will be unbiased only under the conditions that (1) export and import prices for the individual computer components are identical to domestic prices,¹² and (2) the mix of each of the components in exports and imports is identical to that in domestic shipments.

To test the first of these two conditions, the research staff at IBM has gathered information on the prices of the individual components. These data reveal that, with the exception of printers, prices of domestic components do not differ systematically from the prices of traded components. Imported printers, however, exhibit systematic price differentials relative to domestic printers. This is because the United States has tended to produce and export system printers whose prices have fallen less rapidly than the prices of imported PC printers. Regarding the second condition, data for 1988 suggest that the component mix of exports is similar to that of domestic shipments. Imports, on the other hand, appear to have a lower share of computer processors and a higher share of printers and other peripheral equipment than found in domestic shipments.¹³ Evidence on the above two conditions suggests that: first, the domestic computer price index may be a relatively unbiased measure of the prices of exported computers, but be an inappropriate measure of the prices of imported computers; second, if the prices of imported computer components and the mix of the components in imports were adequately measured, the prices of imported computers would likely have fallen more rapidly than the prices of domestic and exported computers.

3. Computer Prices and International Trade

The BEA adjusted matched-model (or hedonic) index for computers used in the deflation of exports and imports is shown in figure 1 and table 1 below. According to this index, computer prices have declined more than 14 percent per year on average since 1982 (fourth quarter to fourth quarter), and by the end of last year were almost 70 percent below their 1982 level.¹⁴ These price movements differ markedly from the rate of price change in an alternative measure of computer prices constructed by the Bureau of Labor Statistics. The BLS index for the prices of exported computers has declined modestly since the end of 1984 (the data are not available prior to that time), while the index of import prices has actually increased over the same period. The difference between the BEA price and the alternative BLS measures can be traced to the construction of the indexes -- the BLS prices are traditional matched-model indexes, not adjusted to capture the effects of discontinued models or newly introduced products. It is interesting to note that the BLS price index for exports of computers differs significantly from the index for imports, calling into question the BEA practice of imposing identical prices.

The value of computers and related products in international trade has risen rapidly since the early years of this decade. As a share of nonagricultural exports, the value of computers had almost doubled by 1988 from its 1980 level (see table 2). The share of computers in the value of non-oil imports increased even more over this period, growing in excess of 400 percent. Because the BEA price index for computers has been declining so much over this period, measured trade volumes have increased far more than trade values. While the shares of computers in

the volumes of nonagricultural exports and non-oil imports were small to negligible in 1982, these shares had risen dramatically to 21 and 14 percent respectively, by 1988.

The level and movement of aggregate trade prices has been greatly influenced by the BEA price deflator for computers. Two measures of non-oil import prices, the GNP implicit deflator and the fixed-weight price index, are shown in figure 2. The implicit deflator, which is a variable-quantity-share-weighted index, has risen much less over the recent period than the fixed-weight index, owing to the increasing importance of computers in the variable-weight measure. Exclusion of computers from the implicit deflator (shown as the dotted line in figure 2) results in a measure that moves quite similarly to the fixed-weight index. (Although not shown in figure 2, a similar divergence between the implicit deflator and the fixed-weight price for nonagricultural exports develops over the same period.)

4. A Conventional Trade Model and Two Alternative Specifications

The changes in exports and imports of computers over the past decade or so may well have influenced our ability to explain and predict aggregate trade flows. Conventional empirical models of international trade generally describe nonagricultural exports and non-oil imports, disaggregating agricultural exports and oil imports from other products. Agricultural exports and oil imports are modelled separately, owing to the relative importance of these products in trade combined with the "special" circumstances in these markets -- government subsidies and trade restrictions for agriculture, and the influence of the OPEC cartel on the determination of oil prices and production.¹⁵ Separate empirical

treatment of exports and imports of computers may be warranted as well, given the construction of the price index, the rapid decline in that index, and the increasing importance of these products in trade. This section outlines a framework for evaluating this question by examining a conventional trade model, and investigating whether simple modification of this model can account for recent developments, or whether computer trade should be disaggregated altogether.

The conventional trade model examined here is the part of the Helkie-Hooper (HH) model, a partial-equilibrium model of the U.S. current account used for analysis and forecasting by the staff of the Federal Reserve Board (see Helkie and Hooper 1988, Helkie and Stekler 1987, and Meade 1988).¹⁶ The HH equations describe traded goods and services, and capital flows; policy variables, as well as incomes, prices, and exchange rates are predetermined.¹⁷ The key equations for merchandise trade are the volumes and prices of nonagricultural exports and non-oil imports -- the determinants of the partial trade balance.

Quantities of traded goods depend on real income and relative prices, while prices of traded goods depend on input prices, exchange rates, and the prices of competing products. In general, the form for the determinants of the partial trade balance in the HH model can be written as follows:

$$(1) \quad X = f[Y_f, (P_x \cdot E/P_f)]$$

$$(2) \quad M = f[Y, (TR \cdot P_m/P)]$$

$$(3) \quad P_x = f[P_w, (P_f/E)]$$

$$(4) \quad P_m = f[P_f, E, P_{cmd}]$$

$$(5) \quad PTB = X \cdot P_x - M \cdot P_m$$

where

- X = nonagricultural export quantity
- M = non-oil import quantity
- E = exchange rate (units of foreign currency per dollar)
- P (P_f) = domestic (foreign) prices
- P_w = producer price for nonagricultural exports
- P_x (P_m) = implicit deflator for nonagricultural exports (non-oil imports)
- P_{cmd} = price of non-oil commodities
- Y = U.S. real GNP
- Y_f = index of weighted average rest of world real GNP
- TR = index of tariff rates
- PTB = partial trade balance

In the HH model, several other variables augment the equations. A dummy variable to measure dock strikes appears in both trade volume equations (see Isard 1975). In the equation for non-oil import volume, a variable measuring capacity utilization abroad relative to capacity utilization in the United States captures cyclical variation (a cyclical measure in the export volume equation was dropped due to statistical insignificance). A relative secular supply variable (the ratio of measures of U.S. capital stock to foreign capital stock) appears in both trade volume equations to proxy supply-induced shifts in production (see Helkie-Hooper 1988, p. 20).

The HH formulation measures the prices of traded products with implicit deflators. As discussed above, price indexes in which the share of computers is variable have behaved quite differently over the recent period than indexes in which the weight given to computers is fixed. Because of the rapidly changing role of computers between the estimation period and the post-sample period, equations explaining the implicit

deflator have predicted poorly out of sample. A proposed improvement to the conventional specification is to base the price equations on fixed-weight measures. In a modified HH formulation (termed the HHFW model), the behavioral price equations (3) and (4) are reestimated with fixed-weight price indexes in place of the deflators; bridge equations are then used to relate the fixed-weight price indexes to the implicit deflators, as follows:¹⁸

$$(3') \quad P_{Fx} = f[P_w, (P_f/E)]$$

$$(4') \quad P_{Fm} = f[P_f, E, P_{cmd}]$$

$$(6) \quad P_x = f[Ll(P_x), \Delta P_{Fx}]$$

$$(7) \quad P_m = f[Ll(P_m), \Delta P_{Fm}]$$

where

P_{Fx} (P_{Fm}) = fixed-weight price index for nonagricultural exports
(non-oil imports)

$Ll(\cdot)$ defines the first-order lag operator

Equations (1), (2), and (5) which determine the quantities of nonagricultural exports, non-oil imports, and the partial trade balance, respectively, remain unchanged.

A second, more fundamental, alternative to the original HH specification involves disaggregating computers from the other elements of the partial trade balance, and determining trade in computers separately. In this formulation, equations (1), (2), (3), and (4) represent the volumes and prices of nonagricultural exports and non-oil imports excluding computers.¹⁹ The computer (HHC) model is closed by adding three equations to determine the volume and price of computer

exports and imports.²⁰ The initial specification tested for the quantity of computer exports and imports included an income term, as well as two relative price measures. The first relative price term captures shifts in aggregate trade prices versus domestic prices; the second relative price term measures the shift of prices within nonagricultural exports and non-oil imports between computers and other products:

$$(8) \quad X_c = f[Y_f, (P_x \cdot E/P_f), RP_{xc}]$$

$$(9) \quad M_c = f[Y, (TR \cdot P_m/P), RP_{mc}]$$

where

X_c = computer export quantity

M_c = computer import quantity

RP_{xc} (RP_{mc}) = the price of computers relative to the implicit deflator for nonagricultural exports (non-oil imports) excluding computers

The equation for computer prices differed from the other behavioral price equations. Because the BEA index for computer prices essentially tracks price conditions in the domestic market, and is adjusted further to account for changes in quality, computer prices were modelled as a time series augmented by a linear trend term to capture technological progress:

$$(10) \quad P_c = f[L1(P_c), TREND]$$

where

P_c = implicit deflator for computer exports and imports

TREND = linear time trend

L1(·) defines the first-order lag operator

5. Empirical Results

The proper treatment of computers in empirical trade models is evaluated by the comparison of the original Helkie-Hooper (HH) model with the two alternative specifications -- the fixed-weight aggregate model (HHFW) and the model with computers disaggregated (HHC). First, we examine key parameter estimates in the HH, HHFW, and HHC models. The parameters of particular interest include the income and relative price elasticities in the trade volume equations, and the sensitivity of import prices to exchange rates (the "pass-through" coefficient). Second, we compare the forecasting ability of the components of the partial trade balance both in and out of sample using a summary error statistic (root mean square percent error). Finally, we examine the errors in the projection of the partial trade balance for each of the models.

Parameter Estimates

The structural equations of the three models were estimated in double-log functional form, using quarterly data through the end of 1986. Most of the equations were estimated beginning in 1970:Q1. However, the equation for export prices in all of the models was estimated beginning in 1973:Q1 due to limitations in the availability of data. In the HHC model, the equations for the volumes and price of computers were estimated beginning in 1978:Q1, since computers were relatively unimportant in international trade prior to this date. Tables 3-6 give the parameter estimates for the primary structural equations in each model.²¹ Estimates for the computer sector of the HHC model are shown on table 7.

In general, parameter estimates in the equations for trade prices are fairly similar across models, despite the different measures

for prices used as the dependent variable (see tables 3 and 4). While the dependent variable in the HH and the HHC specifications is an implicit deflator, the dependent variable in the HHC model more closely resembles the fixed-weight price in the HHFW model (see figure 1). Because of this, it would not be surprising to find that the estimated parameters in the price equations of the HHC and HHFW models were more similar to each other than to the estimates of the HH model. This is not the case, however. On the whole, the key parameter estimates in the price equations are not terribly sensitive to the alternative price variables that are employed.

Domestic production costs are a significant determinant of U.S. export prices, but they are less than completely passed through in all three models. Price conditions in destination markets do not appear to influence export prices (contrary to the result in Helkie-Hooper 1988). Movements in foreign prices and exchange rates are the primary factors explaining the behavior of import prices, with some small adjustment for changes in the prices of non-oil commodities. The measure of foreign prices used in the models is a weighted average of consumer prices for the other G-10 and 8 developing countries. This variable acts as a proxy for the cost of production facing foreign suppliers. As discussed in Hooper-Mann (1989), while movements in foreign consumer prices and production costs were quite similar over the 1970s and early 1980s, a large divergence has emerged in recent years. This is an important point to which we will return later in the discussion of simulation results.

Parameter estimates in the volume equations are more sensitive to the definition of the dependent variable. The volume equation for nonagricultural exports and non-oil imports is used in both the HH and

HHFW models; in the HHC model, this same specification is used to explain trade volumes excluding computers. When computers are excluded from nonagricultural exports, the estimated sensitivity to changes in relative prices increases somewhat, and the estimated sensitivity to changes in foreign income is substantially reduced (see table 5). In addition, the effect of changes in relative secular supply becomes statistically insignificant. According to Helkie-Hooper, this variable has traditionally played an important role, measuring the effects of the introduction of new products that are not captured adequately in relative price movements. In the HH model, the relative secular supply variable has tended to reduce the discrepancy in income elasticities between the export and import volume equations. The tendency for the estimated income elasticity of U.S. imports to exceed the income elasticity of U.S. exports (in the absence of adjustment for shifts in supply) is often referred to as the "Houtakker-Magee" result. For non-oil imports, the disaggregation of computers reduces the sensitivity of other imports to changes in relative prices and changes in relative secular supply (see table 6). The estimated sensitivity of imports to U.S. activity, however, is little changed across models. With the income elasticity of exports reduced and that of imports unchanged, the aforementioned discrepancy in income elasticities re-surfaces in the HHC model.

In summary, there are several important points about the alternative model parameters. First, the estimates in the trade price equations are insensitive to the exclusion of computer prices from the implicit deflator (in the HH and HHC models). Second, the relative price elasticities in both trade volume equations are not very sensitive to the exclusion of computers, and generally lie in the neighborhood of unity

whether or not computers are included. Third, estimated income elasticities do appear to be quite sensitive to the treatment of computers, and the discrepancy between income elasticities of U.S. exports and imports (noted in other studies of U.S. trade) re-emerges in the HHC formulation, despite the inclusion of the relative secular supply measure.

Table 7 gives the parameter estimates for the computer sector of the HHC model. Estimation of equation (10) indicates that computer export and import prices are determined primarily by the lagged value of prices, with a small but significant downward trend adjustment. The initial specification for the volume of computer exports postulated in equation (8) did not yield sensible empirical estimates. While the elasticity of computer exports with respect to foreign income was large and highly significant, neither relative price terms was significantly different from zero. (When the homogeneity constraint on the relative price terms was relaxed, only the exchange rate entered the equation with a significant coefficient.) In addition, the relative secular supply variable was negatively correlated with computer exports, a result that runs counter to intuition. After considerable experimentation with alternative formulations, exports of computers were modeled as a ratio to domestic equipment spending on computers. This ratio responds positively to changes in foreign income and declines somewhat with an appreciation of the dollar. When U.S. income increases, domestic spending on computers rises relatively more than exports.

The estimated equation for the volume of computer imports is similar to the specification discussed in equation (9). All of the estimated parameters are statistically significant and of the expected

sign (except for the price of computer imports relative to the price of other non-oil imports, which was dropped from the equation due to statistical insignificance). The activity variable was separated into two terms -- real investment spending on office and computing machinery, and other real GNP -- in order to allow for a differential response of computer imports to these two categories of income. While the estimated sensitivity of computer import volume to the relative secular supply variable and to the price of non-oil imports relative to domestic prices is of the expected sign, both elasticities are larger than expected.

In general, it was difficult to obtain sensible empirical estimates for the computer sector of the HHC model. The estimates are not particularly robust to changes in the range of estimation. Equations using time series or error correction techniques (instead of structural equations with a first-order autoregressive process) would likely do better at capturing the dynamics inherent in the data.

Simulation Performance

Simulation results for the estimation period and for the out of sample period (1987:Q1 - 1989:Q2) were produced for the three models. These results are presented in figures 3 through 7. In order to facilitate the comparison of results across models, the analysis is presented in terms of the components of the partial trade balance. Prediction errors for the HH model equal the difference between the individual equation forecast and the actual data. For the HHFW and HHC models, the prediction errors are an aggregate of individual equation errors. For example, in the HHFW model, the prediction error for the non-oil import deflator is obtained from both the error in the structural equation explaining fixed-weight prices, and the translation equation for

the deflator. In the HHC model, the procedure to obtain the import deflator is even more complicated, as computer prices are predicted separately. In sum, reported prediction errors for the various components of the partial trade balance shown in figures 3 through 7 are a mix of individual equation and multiple equation errors. For the three models, the simulation errors are evaluated on the basis of root mean square percent errors²².

The HHC model tracks the deflators for nonagricultural exports and non-oil imports quite well over the estimation period, and is more accurate than either the HH or the HHFW formulations (see figures 3 and 4). Beyond the sample period, all of the models over-predict prices. The over-predictions are largest for the HH model; compared with the HHC model, over-prediction errors in the HH model are about double the magnitude for export prices, and about 50 percent larger for import prices. Despite the relative accuracy of the HHC model, errors in the prediction of the non-oil import deflator remain sizable. Much of this prediction error may result from the use of consumer prices as a proxy for foreign production costs, as discussed earlier.

In tracking the volume of nonagricultural exports, the HHC model out-performs somewhat the other formulations (see figure 5). If actual historical values are used for the explanatory variables, the equation in the HHFW model is identical to that in the HH model (the upper panel of the figure). If, on the other hand, simulated values of import and export prices are used in the relative prices terms in the volume equations, the models differ (the lower panel). This is because the prediction of export and import price deflators in the HH model involves structural equations, whereas the prediction in the HHFW model is based

on structural equations for fixed-weight prices and bridge equations for the deflators.

The simulation results for the volume of non-oil imports (see figure 6) clearly favor the HHC model, which out-performs the other models over the estimation range and out of sample. Use of the simulated values of the explanatory variables leads to sizable under-prediction of import volume. This under-prediction is caused by the significant over-prediction of import prices discussed earlier.

For the partial trade balance, the prediction errors over the estimation range (as judged by the root mean square level error in billions of dollars), are roughly comparable for all three models regardless of whether historical or simulated values are used for the explanatory variables (see figure 7). This finding changes significantly over the out of sample period, however. The magnitude of the out of sample error in the prediction of the partial trade balance depends critically on whether historical or simulated values of prices are used in the volume equations. Using historical data, all three models significantly over-predict the partial trade deficit. The models over-predict both exports and imports, but the latter error is substantially larger. Using simulated values for the right hand side variables not only reduces the prediction errors, but actually reverses their direction. The over-prediction of import prices leads to an under-prediction of import volumes, with the result that imports in value terms are predicted quite accurately. The HHC model tracks the partial trade balance relatively better than the other formulations.

To summarize, the simulation results indicate that the disaggregation of computers from the other components of the partial

trade balance (as in the HHC model) tends to improve simulation performance both in and out of sample. Imports (both prices and volumes) are more difficult to predict than exports, however, regardless of the model used.

6. Conclusion

This paper has investigated two issues related to international trade in computers: measurement and prediction. In general, the approach adopted by the BEA for the measurement of domestic computer prices is appropriate given recent advances in technology. It may be inappropriate, however, to use this domestic price index for the deflation of international sales and purchases of computers. The development of separate price indexes for computer exports and imports is an important question for future research.

Further, the proper treatment of computers in empirical models of international trade is an open question. If the computer industry is sufficiently different from other industries, separate treatment of computers in these models may be necessary to capture historical developments and predict future outcomes. The analysis in this paper suggests that the disaggregation of computers from the other components of the partial trade balance is warranted, and generally leads to more accurate predictions.

Footnotes:

*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. Thanks to NBER conference participants, Robert B. Kahn, David H. Howard, and William R. Melick for detailed comments and suggestions. Lucia Foster provided excellent research assistance and Virginia Carper provided graphical expertise. This paper is forthcoming in an NBER conference volume entitled *International Economic Transactions: Issues in Measurement and Empirical Research*, edited by Peter Hooper and J. David Richardson.

¹ The formula for a price index (I) at time t, with a base period of t-1 is:

$$I_{t,t-1} = \frac{\sum P_{i,t} Q_{i,t}}{\sum P_{i,t-1} Q_{i,t}}$$

where the index is constructed over i types of the product. $P_{i,t}$ represents the price of product i at time t. $Q_{i,t}$ is the quantity of i purchased at time t. The index is used to deflate current dollar figures (a Paasche index).

² Using the notation defined in footnote 1, the index for the entire period can be written as:

$$I_{0,t} = I_{0,1} \times I_{1,2} \times \dots \times I_{t-1,t}$$

³ The difference between the traditional matched-model index and an index that accounts for quality improvement is quite substantial for several components of computers. Cole and others (1986) compare a matched-model index with three different hedonic indexes for four computer components (processors, disk drives, printers, and general purpose displays). For each component, the hedonic indexes declined twice as much or more on average than the matched-model index.

⁴ It is the time dummy that actually captures price movements once characteristics and technology are controlled for.

⁵ The initial research and development of the computer index was provided by the IBM Corporation and is documented in Cole and others (1986). Since that time, the BEA has altered the original index relatively little. The BEA began using this adjusted matched-model index to deflate computer purchases in the GNP accounts in 1985, and has revised the historical data back to 1969 to incorporate this index.

⁶ Tape drives were covered in the index through 1983, but were excluded thereafter reflecting their declining importance. Prices of tape drives are assumed to be represented by the average change in the prices of other components.

⁷ As Gordon (1989) points out, there are a number of critical attributes excluded from hedonic studies on computers. These are: software maintenance, engineering support, and manufacturer's reputation -- characteristics which are virtually impossible to measure.

⁸ In addition to the BEA index for PC prices, another index was described in Gordon (1987). Like the BEA index, the Gordon index was constructed as a traditional matched-model index.

⁹ These survey results are broadly consistent with an OECD survey of 13 member countries in 1985. At that time, only the United States and Canada employed hedonic techniques.

¹⁰ The price index is also used to deflate government expenditure on computers (federal as well as state and local). Currently, consumer purchases of computers are deflated using the matched-model index for PCs.

¹¹ Actually, the domestic price index for office, computing, and accounting machinery (OCAM) is used to deflate exports and imports of business and office machines through 1984. From 1985 on, exports and imports of computers, peripherals, and parts are deflated using the computer index. The OCAM index is a composite of BEA's computer index, and the PPI for office and accounting machinery (excluding computers).

¹² This bias will contaminate not only the deflation of traded computers, but the deflation of domestic purchases as well.

¹³ This is a preliminary finding of a project to construct component shares for exports and imports, and then use these shares to compute price indexes for computer exports and imports.

¹⁴ Measured from the beginning of the hedonic index in 1969 through 1988, the computer price declined almost 7 percent per year on average.

¹⁵ Oil exports and agricultural imports are not treated separately, however, because these products are relatively unimportant in overall trade.

¹⁶ The HH model also used as the U.S. current account sector of the Federal Reserve Board Multicountry Model (see Edison, Marquez, and Tryon 1987).

¹⁷ A typical criticism of this partial-equilibrium framework is that different policies have different effects on incomes, prices, and exchange rates. In these sorts of models, incomes, prices, and exchange rates are predetermined, and policy has no explicit role. Thus, a particular change in the predetermined variables has an identical effect on trade flows, regardless of the underlying policy. Essentially, the parameter estimates measure the responsiveness of trade flows to changes in predetermined variables, given the average mix of policies that generated the historical data.

¹⁸ It is still necessary to produce an estimate for the implicit deflator, as this measure is used to form the relative price term in

equations (1) and (2), and to compute the partial trade balance in equation (5).

¹⁹ Thus, the endogenous variables X , M , P_x , and P_m must be re-defined to exclude computers.

²⁰ Recall that the same price index is used to deflate the value of exports and imports. Thus, only one price equation is necessary.

²¹ While the equations in the HH model are identical to those discussed by Helkie and Hooper (1988), the parameter estimates differ somewhat due to revisions to the historical data and the extension of the estimation range through the end of 1986.

²² RMS percent error is the root mean square error as a percentage of the sample mean of the variable. The in-sample errors are computed over the estimation range of the equation, or the intersection of the estimation ranges of the component equations. The out-sample errors are computed beginning in 1987 through the second quarter of this year.

Table 1
Measures of Computer Prices

	BEA ¹		BLS - Export		BLS - Import	
	<u>Level</u>	<u>Change²</u>	<u>Level</u>	<u>Change²</u>	<u>Level</u>	<u>Change²</u>
1982:Q4	98.5	-4.6	n.a.		n.a.	
1983:Q4	76.4	-22.4	n.a.		n.a.	
1984:Q4	65.5	-14.3	102.4	n.a.	100.7	n.a.
1985:Q4	46.8	-28.5	99.1	-3.2	102.4	1.7
1986:Q4	41.7	-10.9	98.0	-1.1	104.1	1.7
1987:Q4	35.2	-15.6	95.0	-3.1	112.2	7.8
1988:Q4	34.8	-1.1	95.5	0.5	111.3	-0.8
1989:Q4	31.1	-10.6	93.6	-2.0	110.1	-1.1

¹ The BEA uses the same price index to deflate exports and imports.

² The percentage change is computed on a Q4/Q4 basis.

Table 2
Computers as a Share of Merchandise Trade

	<u>1980</u>	<u>1982</u>	<u>1984</u>	<u>1986</u>	<u>1988</u>
<i>Value:</i>					
Nonagricultural Exports	4.1	5.2	7.4	7.3	8.0
Non-oil Imports	.9	1.4	3.0	3.3	4.5
<i>Volume:</i>					
Nonagricultural Exports	3.3	5.2	10.5	14.9	21.1
Non-oil Imports	.8	1.4	4.2	7.2	14.2

Table 3
Parameter Estimates for Export Price Equations, 1973:Q1-1986:Q4¹

Model:	<u>HH</u> ²	<u>HHFW</u> ³	<u>HHC</u> ⁴
Dependent variable:	P_x	P_{Fx}	P_{xnc}
Explanatory variables:			
Intercept	.49 (1.35)	.93 (3.81)	.45 (1.74)
U.S. producer price (P_w)	.89 (11.69)	.80 (15.59)	.90 (16.63)
Foreign price ⁵ (P_f)	.05 (0.68)	.07 (1.59)	.08 (1.46)
Exchange rate ⁵ (E)	-.05 (0.68)	-.07 (1.59)	-.08 (1.46)
Summary statistics:			
Rho	.83 (23.81)	.77 (11.00)	.80 (18.68)
R ²	.99	.99	.99
S.E.R.	.011	.009	.010

¹Equations estimated in double-log form. T-statistics are in parentheses.

²Dependent variable is the implicit deflator for nonagricultural exports.

³Dependent variable is the fixed-weight price for nonagricultural exports. The bridge equation between the fixed-weight price and the deflator is:

$$\log(P_x) = 0.03 + 0.99 * \log(L1(P_x)) + 1.10 * \Delta \log(P_{Fx})$$

where $L1(\cdot)$ is the first-order lag operator.

R² = .99; S.E.R. = .005; all coefficients are highly significant. The estimation range is 1970:Q1-1986:Q4.

⁴Dependent variable is the deflator for nonagricultural exports excluding computers.

⁵4-quarter polynomial distributed lag.

Table 4
Parameter Estimates for Import Price Equations, 1970:Q1-1936:Q4¹

Model:	<u>HH²</u>	<u>HHFW³</u>	<u>HHC⁴</u>
Dependent variable:	P _m	P _{Fm}	P _{mnc}
<i>Explanatory variables:</i>			
Intercept	4.25 (12.58)	4.63 (17.31)	3.93 (11.89)
Foreign price (P _f)	.84 (20.85)	.77 (24.15)	.85 (21.63)
Exchange rate ⁵ (E)	-.89 (12.42)	-.81 (14.45)	-.84 (11.97)
Commodity price ⁶ (P _{cmd})	.18 (4.39)	.08 (2.35)	.18 (4.54)
<i>Summary statistics:</i>			
Rho	.64 (6.39)	.56 (5.46)	.63 (6.26)
R ²	.99	.99	.99
S.E.R.	.014	.013	.014

¹Equations estimated in double-log form. T-statistics are in parentheses.

²Dependent variable is the implicit deflator for non-oil imports.

³Dependent variable is the fixed-weight price for non-oil imports.

The bridge equation between the fixed-weight price and the deflator is:

$$\text{Log}(P_m) = 0.99 * \text{Log}(L1(P_m)) + 1.12 * \Delta \text{Log}(P_{Fm})$$

where L1(.) is the first-order lag operator.

R² = .99; S.E.R. = .007; all coefficients are highly significant. The estimation range is 1970:Q1-1986:Q4.

⁴Dependent variable is the deflator for non-oil imports excluding computers.

⁵8-quarter polynomial distributed lag.

⁶4-quarter polynomial distributed lag.

Table 5
Parameter Estimates for Export Volume Equations, 1970:Q1-1986:Q4¹

Model:	<u>HH, HHFW</u> ²	<u>HHC</u> ³
Dependent variable:	X	X _{nc}
Explanatory variables:		
Intercept	-4.85 (7.47)	4.12 (5.01)
Foreign income (Y _f)	2.04 (6.86)	1.25 (8.82)
Relative price ⁴	-.86 (7.57)	-.99 (9.46)
Relative supply (RSUP) ⁵	1.12 (2.25)	1.20 (0.20)
Dock strike	.83 (7.01)	.83 (7.01)
Summary statistics:		
Rho	.67 (7.11)	.68 (7.75)
R ²	.99	.98
S.E.R.	.027	.027

¹Equations estimated in double-log form. T-statistics are in parentheses.
²Dependent variable is the volume of nonagricultural exports and is identical in both models.

³Dependent variable is the volume of nonagricultural exports excluding computers.

⁴The relative price in the HH and HHFW models is the nonagricultural export deflator relative to foreign consumer prices in dollar terms; in the HHC model, the relative price is the deflator for nonagricultural exports excluding computers relative to foreign prices in dollars. 8-quarter polynomial distributed lag.

⁵Ratio of the capital stock in the U.S. relative to foreign countries.

Table 6
Parameter Estimates for Import Volume Equations, 1970:Q1-1986:Q4¹

<i>Model:</i>	<u>HH, HHFW</u> ²	<u>HHC</u> ³
<i>Dependent variable:</i>	M	M _{nc}
<i>Explanatory variables:</i>		
Intercept	.11 (4.21)	-1.49 (.29)
U.S. income (Y)	1.97 (2.54)	2.02 (2.64)
Relative price ⁴	-1.11 (9.81)	-1.02 (8.90)
Relative supply (RSUP) ⁵	-.90 (2.14)	-.74 (1.83)
Relative capacity ⁶	-1.28 (1.64)	-1.30 (1.73)
Dock strike	.78 (4.24)	.79 (4.26)
<i>Summary statistics:</i>		
Rho	.48 (4.21)	.47 (4.10)
R ²	.99	.99
S.E.R.	.031	.031

¹Equations estimated in double-log form. T-statistics are in parentheses.

²Dependent variable is the volume of non-oil imports and is identical in both models.

³Dependent variable is the volume of non-oil imports excluding computers.

⁴The relative price in the HH and HHFW models is the non-oil import deflator (adjusted for tariffs) relative to the U.S. GNP deflator; in the HHC model, the relative price is the deflator for non-oil imports excluding computers (adjusted for tariffs) relative to the GNP deflator. 8-quarter polynomial distributed lag.

⁵Ratio of the capital stock in the U.S. relative to foreign countries.

⁶Ratio of manufacturing capacity utilization in the other G-10 countries relative to U.S. capacity utilization.

Table 7
Parameter Estimates for Computer Equations, 1978:Q1-1986:Q4¹

Model: HHC

BEA computer price (P_c):

$$\log(P_c) = .29 + .94*\log[(P_c)_{-1}] - .003*TREND$$

(1.28) (21.50) (2.17)

$R^2 = .99$ S.E.R. = .028

Computer export volume (X_c):²

$$\log(X_c/PDE_{oca}) = -1.97 - 1.92*\log(Y_{-1}) + 4.04*\log(Y_f) - .42*\log(E)$$

(0.51) (2.31) (4.24) (2.89)

$R^2 = .58$ S.E.R. = .062 Rho = .35 (2.08)

Computer import volume (M_c):³

$$\log(M_c) = 72.84 + 2.01*\log(Y-PDE_{oca}) + .36*\log(PDE_{oca})$$

(-2.93) (2.43) (3.53)

$$- 19.90*\log(RSUP) - 2.93*\log(P_m/CPI)$$

(10.31) (6.64)

$R^2 = .99$ S.E.R. = .044 Rho = .25 (1.34)

¹ T-statistics are in parentheses. PDE_{oca} is investment spending on office, computing, and accounting machinery in billions of 1982 dollars. CPI is the U.S. consumer price index.

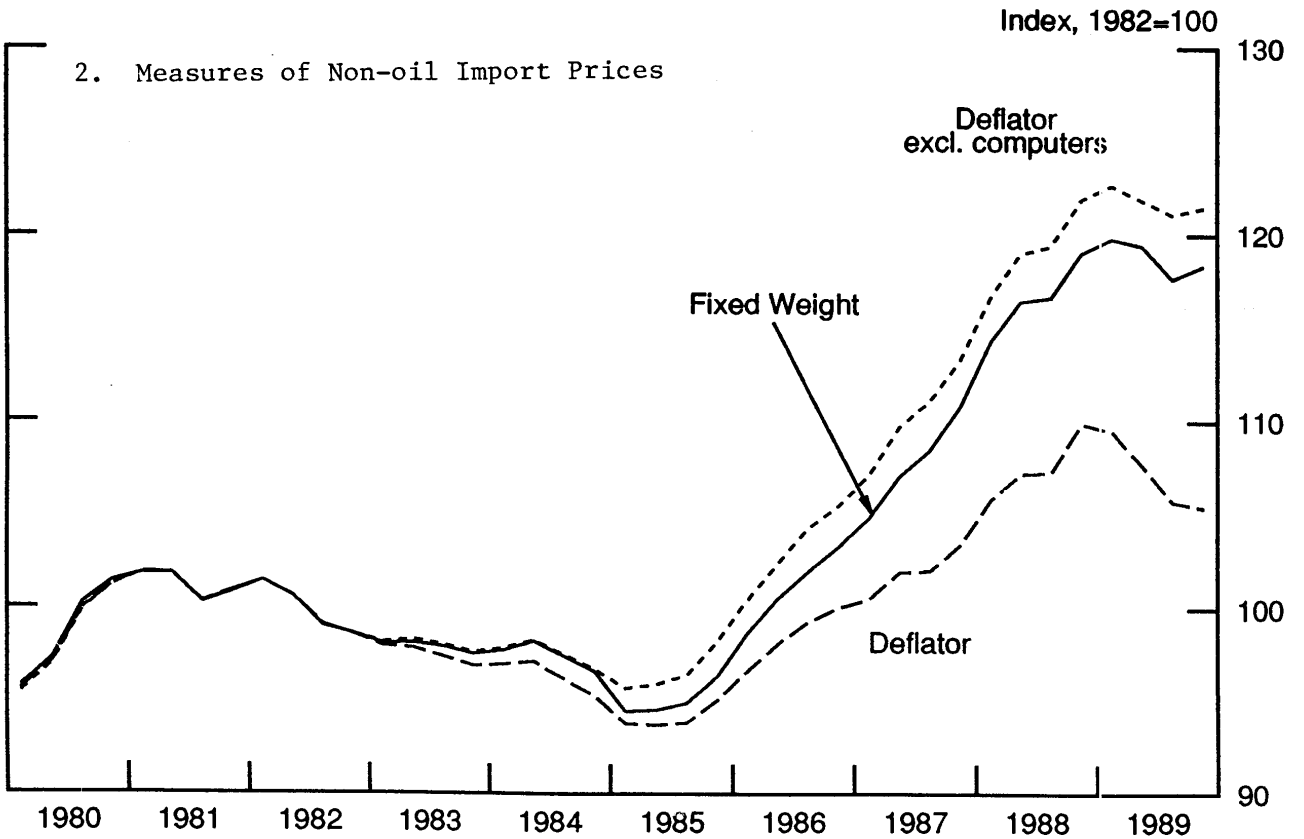
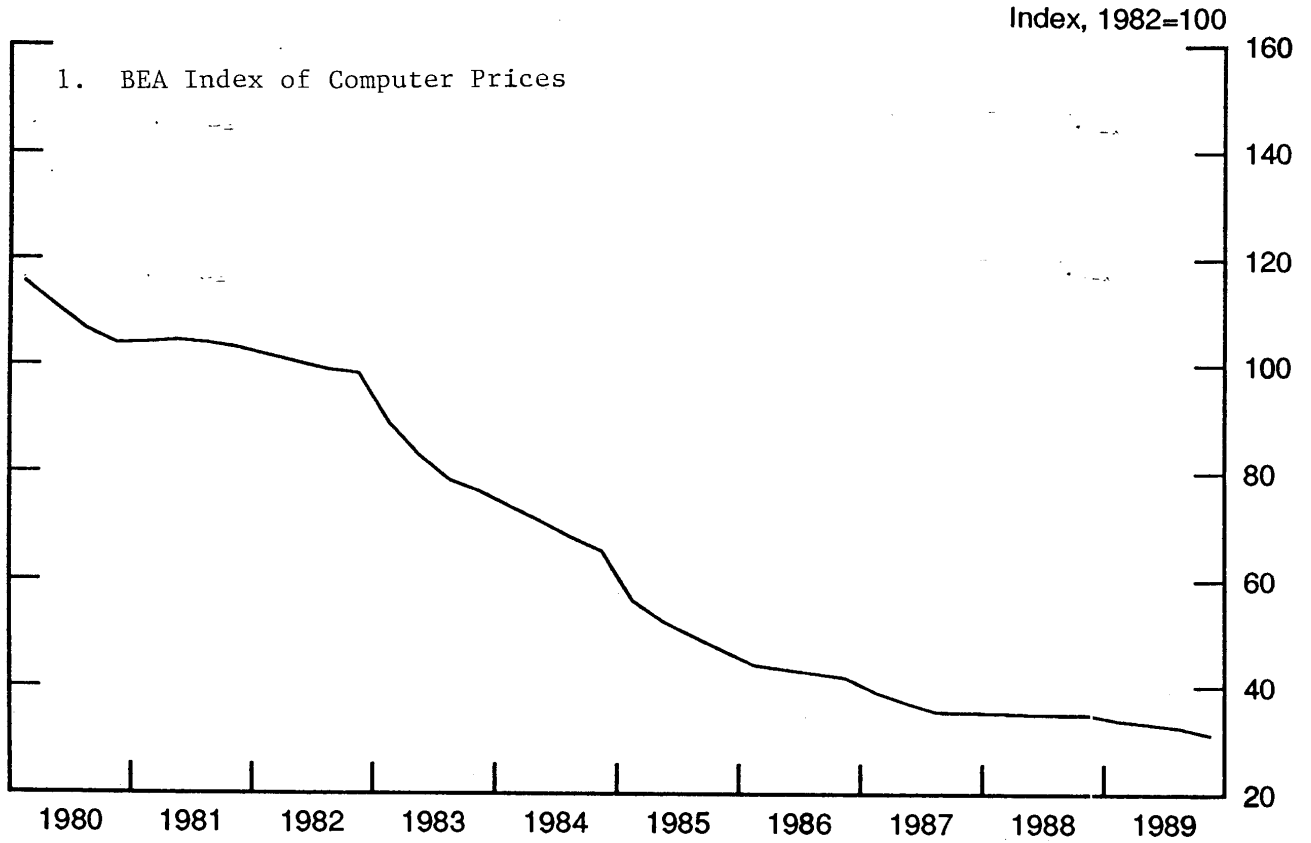
² 4-quarter polynomial distributed lag on the exchange rate (E).

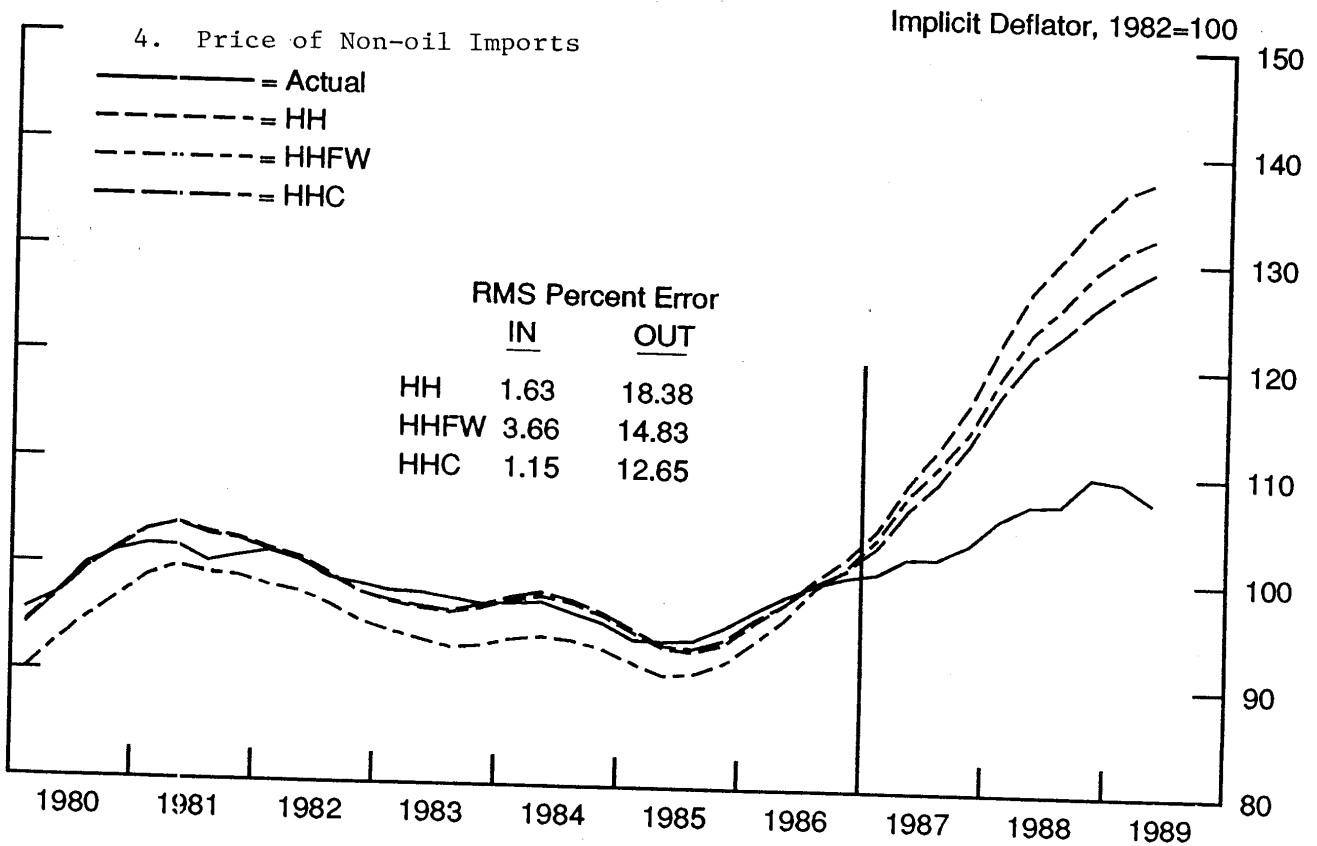
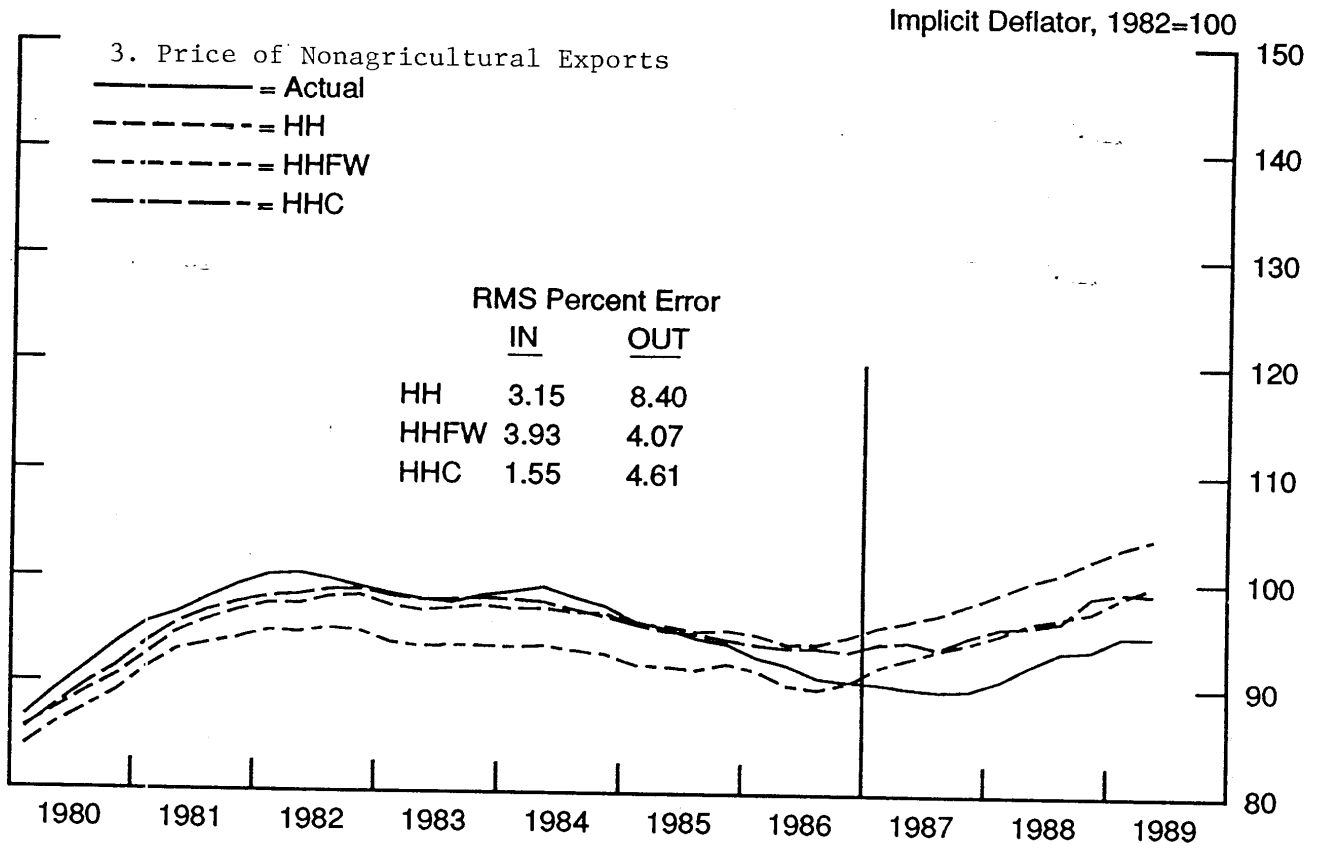
³ 8-quarter polynomial distributed lag on the relative price (P_m/CPI). RSUP is the ratio of the capital stock in the U.S. relative to foreign countries.

References

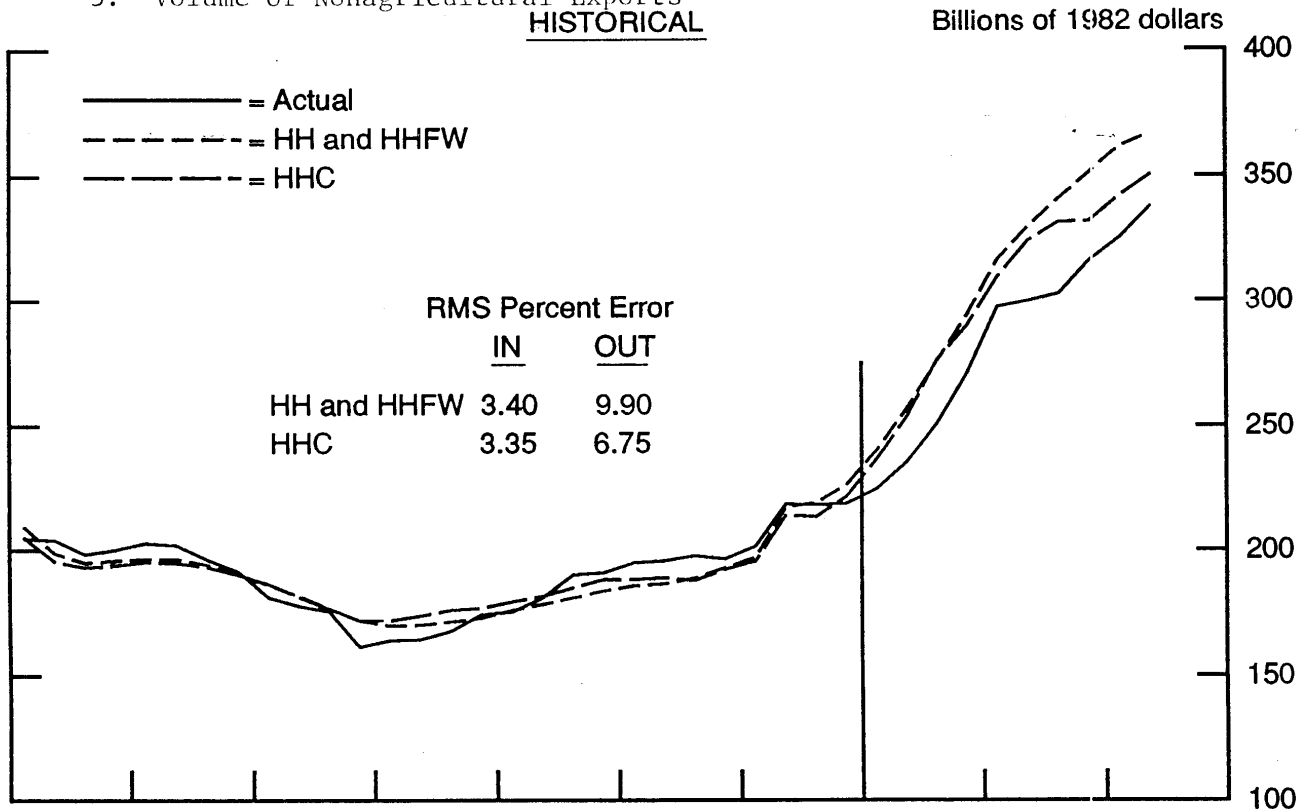
- Baily, Martin Neil and Robert J. Gordon. 1988. The Productivity Slowdown, Measurement Issues, and the Explosion of Computer Power. *Brookings Papers on Economic Activity* 2: 347-420.
- Cartwright, David W. 1986. Improved Deflation of Purchases of Computers. *Survey of Current Business* 66 (March): 7-10.
- _____ and Scott D. Smith. 1988. Deflators for Purchases of Computers in GNP: Revised and Extended Estimates, 1983-88. *Survey of Current Business* 68 (November): 22-23.
- Chow, Gregory C. 1967. Technological Change and the Demand for Computers. *American Economic Review* 57 (December): 1117-30.
- Citrin, Daniel. 1989. The Recent Behavior of U.S. Trade Prices. *IMF Staff Papers* 36 (December): 934-949.
- Cole, Rosanne, Y.C. Chen, Joan A. Barquin-Stolleman, Ellen Dulberger, Nurhan Helvacian, and James H. Hodge. 1986. Quality-Adjusted Price Indexes for Computer Processors and Selected Peripheral Equipment. *Survey of Current Business* 66 (January): 41-50.
- Denison, Edward F. 1989. *Estimates of Productivity Change by Industry: An Evaluation and an Alternative*. Washington, D.C.: Brookings Institution.
- Dion, Richard and Jocelyn Jacob. 1988. The Dynamic Effects of Exchange Rate Changes on Canada's Trade Balance, 1982-1987. Working paper, Bank of Canada.
- Dulberger, Ellen R. 1989. The Application of a Hedonic Model to a Quality-Adjusted Price Index for Computer Processors. In Dale W. Jorgenson and Ralph Landau, eds., *Technology and Capital Formation*. Cambridge, MA: MIT Press.
- Edison, Hali J., Jaime R. Marquez, and Ralph W. Tryon. 1987. The Structure and Properties of the Federal Reserve Board Multicountry Model. *Economic Modelling* 4 (April): 115-315.
- Gordon, Robert J. 1989. The Postwar Evolution of Computer Prices. In Dale W. Jorgenson and Ralph Landau, eds., *Technology and Capital Formation*. Cambridge, MA: MIT Press.
- _____. 1987. The Postwar Evolution of Computer Prices. NBER working paper no. 2227, April.
- Griliches, Zvi. 1964. Notes on the Measurement of Price and Quality Changes." In *Models of Income Determination*. Studies in Income and Wealth no. 28. Princeton, N.J.: Princeton University Press for NBER.

- Helkie, William L. and Peter Hooper. 1988. The U.S. External Deficit in the 1980s: An Empirical Analysis. In Ralph C. Bryant, Gerald Holtham, and Peter Hooper, eds., *External Deficits and the Dollar: The Pit and the Pendulum*. Washington, D.C.: Brookings Institution.
- _____, and Lois Stekler. 1987. Modeling Investment Income and Other Services in the U.S. International Transactions Accounts. International Finance Discussion Papers no. 319. Federal Reserve Board. Washington, D.C.
- Hooper, Peter and Catherine L. Mann. 1989. Exchange Rate Pass-through in the 1980s: The Case of U.S. Imports of Manufactures. *Brookings Papers on Economic Activity* 1: 297-337.
- Isard, Peter. 1975. Dock-Strike Adjustment Factors for Major Categories of U.S. Imports and Exports, 1958-74. International Finance Discussion Papers no. 60. Federal Reserve Board. Washington, D.C.
- Meade, Ellen E. 1988. Exchange Rates, Adjustment, and the J-Curve. *Federal Reserve Bulletin* 74 (October): 633-644.
- Rosen, Sherwin. 1974. Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy* 82 (January/February): 34-49.
- Triplett, Jack E. 1986. The Economic Interpretation of Hedonic Models. *Survey of Current Business* 66 (January): 36-40.
- _____. 1989. Price and Technological Change in a Capital Good: A Survey of Research on Computers. In Dale W. Jorgenson and Ralph Landau, eds., *Technology and Capital Formation*. Cambridge, MA: MIT Press.
- Young, Allan H. 1989. BEA's Measurement of Computer Output. *Survey of Current Business* 69 (July): 108-115.

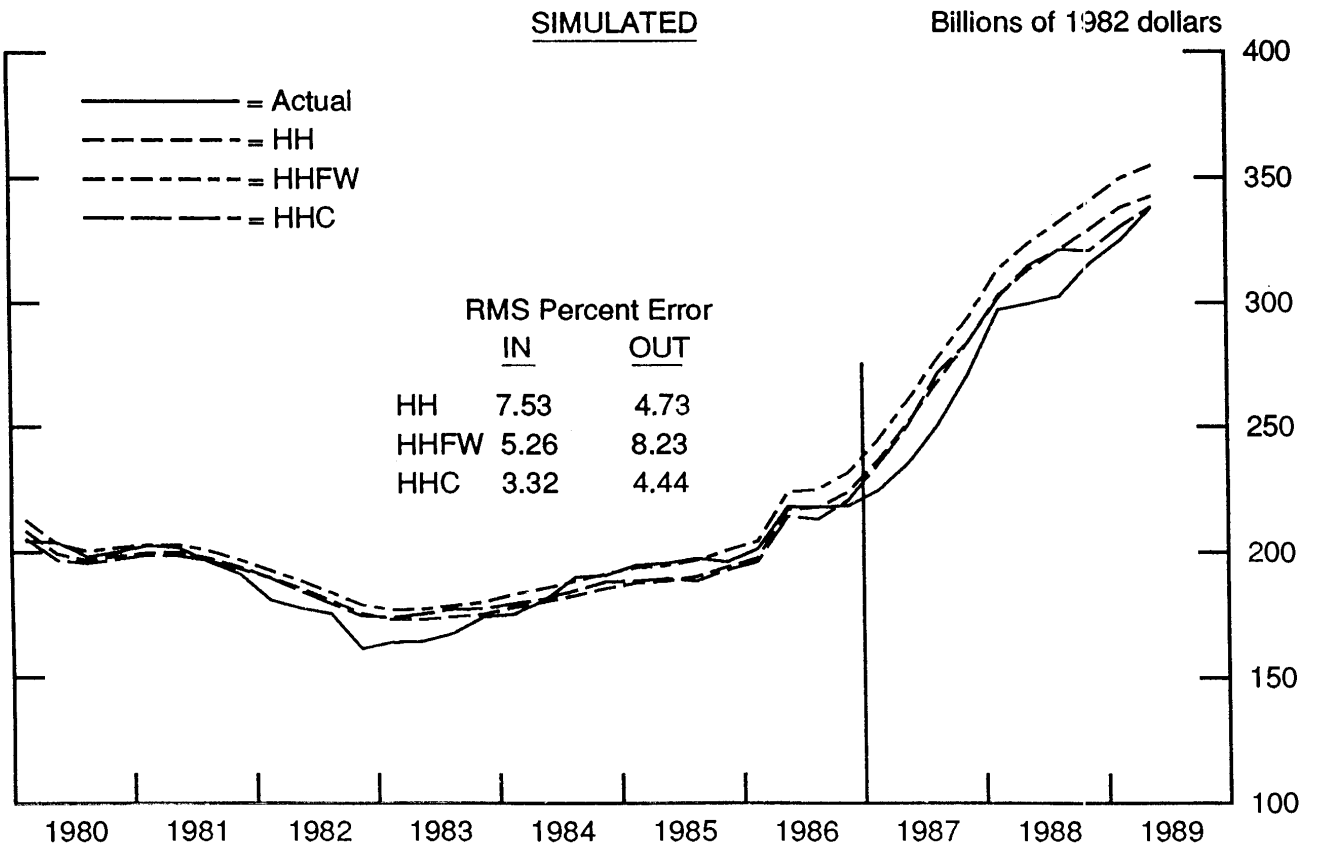




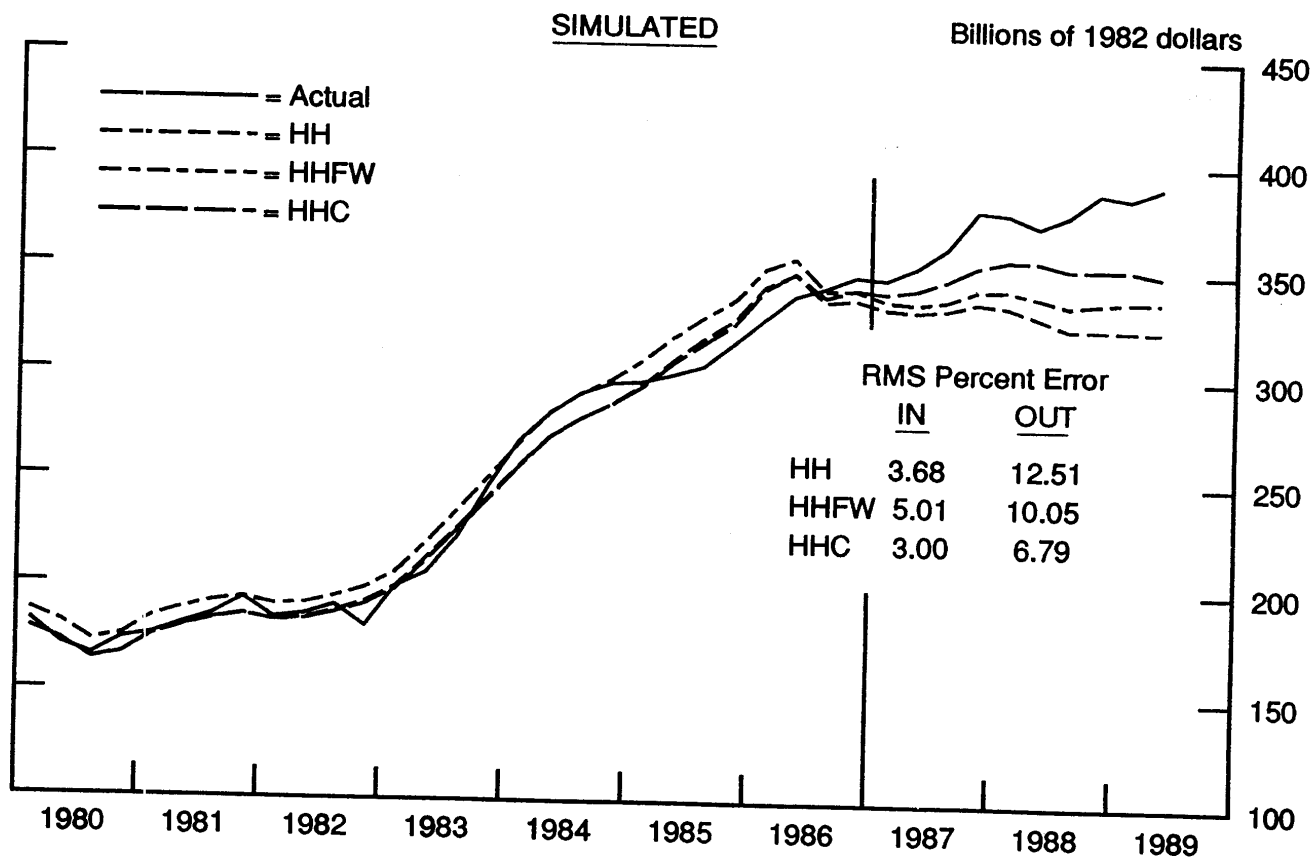
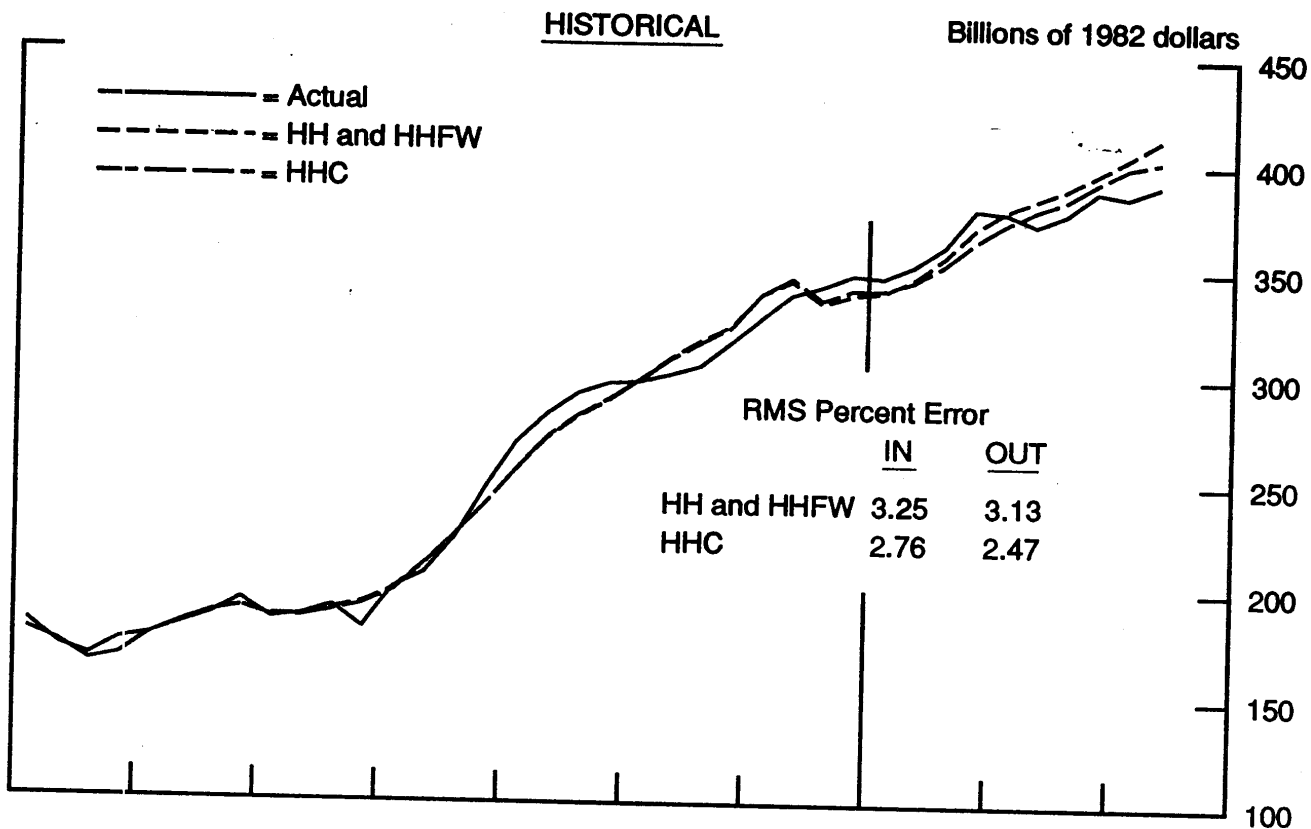
5. Volume of Nonagricultural Exports
HISTORICAL



SIMULATED

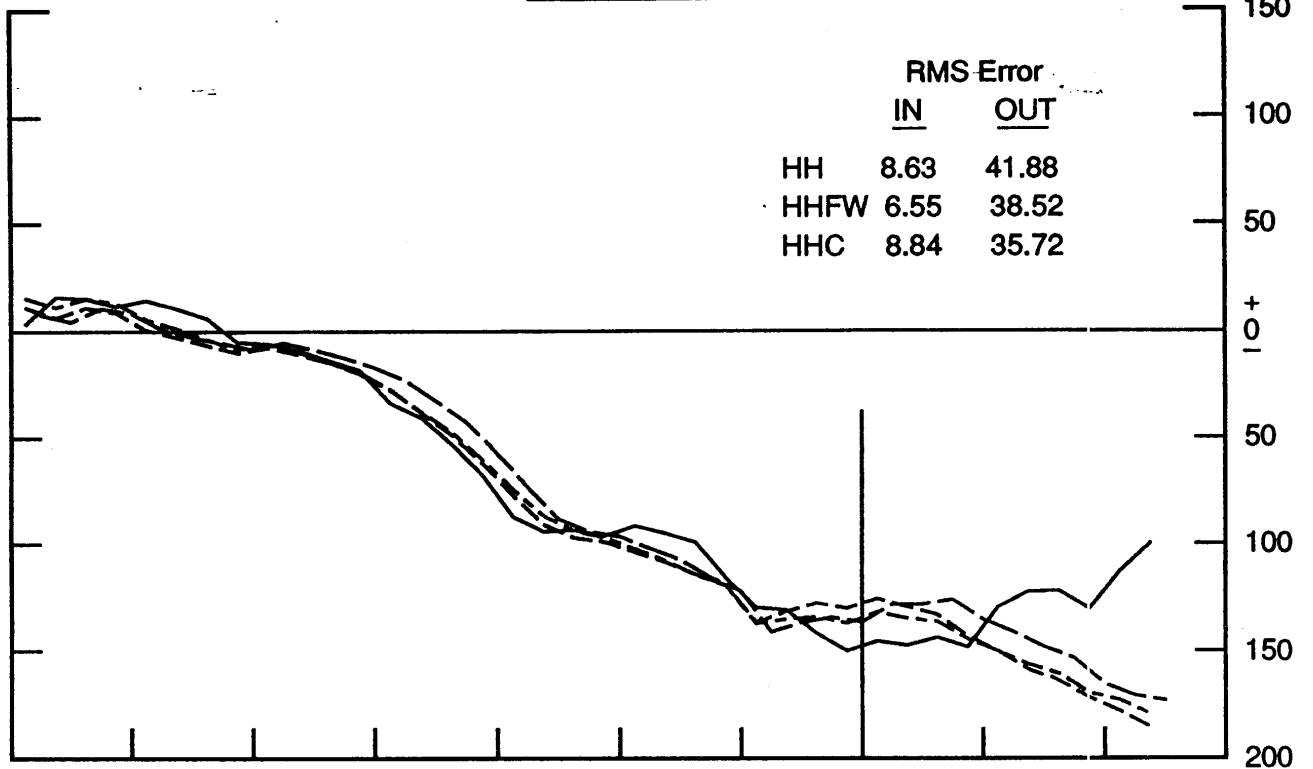


6. Volume of Non-oil Imports



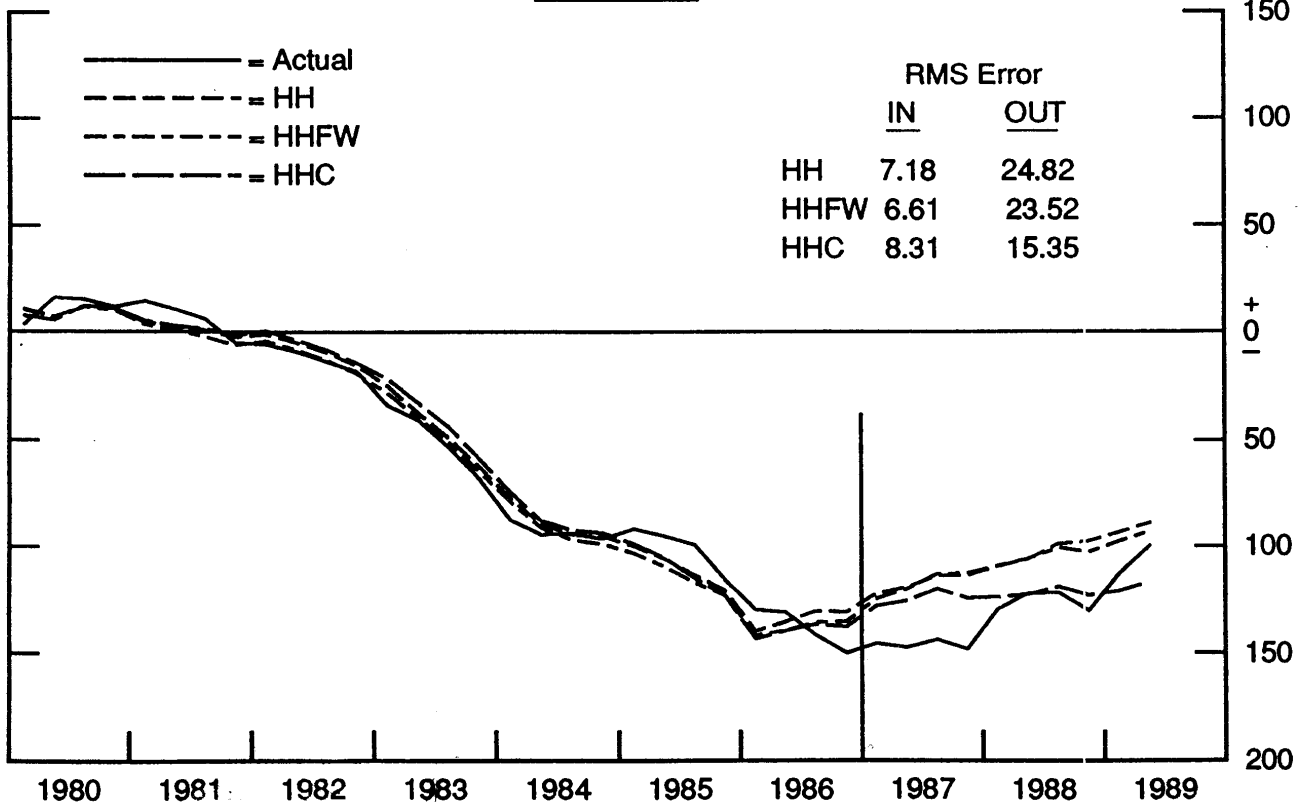
7. Partial Trade Balance HISTORICAL

Billions of dollars



SIMULATED

Billions of dollars



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