Intangibles and the Gap between Export and Domestic Prices: Implications for Measures of Growth and Productivity

by

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Abstract

We present evidence on the gap between output and export prices for goods and services produced in the U.S. Regardless of the underlying reason for the pricing differences, accounting consistency implies that any gap between the output price and the export price is mirrored by an unmeasured gap between the output price and the price paid by U.S. domestic purchasers. Based on measured exports and the measured price gap, we infer the unmeasured purchase prices for goods produced domestically and used by businesses in the U.S. We then trace through the implication of these inferred prices to measures of industry growth and productivity. The basic issue is similar in nature to the large literature on the role of import prices in productivity estimates. To our knowledge, this is the first study to recognize and incorporate the accounting relationship between export prices, output prices, and domestic purchase prices.

We find that industries with a higher share of intangible capital generally have a larger difference between foreign and domestic prices. Furthermore, the gap is especially large for industries with a large gap between import prices and output prices. We speculate that this is because price discrimination is usually lower for commodities, and higher for specialized items or items with few close substitutes. Furthermore, a large gap between import prices and output prices creates an economic incentive to price discriminate. In other words, firms exporting intangible intensive products may have more power to price discriminate than other exporters and they have more opportunity to price discriminate if global prices diverge from domestic prices. Based on the observed relationship between intangibles, the import-domestic price gap and the export-domestic price gap for selected goods, we estimate the gap between foreign and domestic prices for industries without official export price data. We incorporate this set of estimated export prices to calculate domestic purchase prices, industry value added, and productivity.

[1] The views expressed in this paper are solely those of the authors and not necessarily those of the U.S. Bureau of Economic Analysis or the U.S. Department of Commerce.

1. Introduction

The recent slowdown in U.S. productivity growth has been labeled the "productivity puzzle," but this is by no means the first productivity puzzle facing students of economic growth. One could argue that these puzzles are a semi-regular reemergence of a long standing puzzle on productivity growth in the U.S. For the 10 years after (Solow, 1957) argued that technical change accounted for the preponderance of U.S. growth, there was no explanation for productivity change. By exploiting additional implications of producer theory (Jorgenson & Griliches, 1967) argued that "the explanation of productivity change" must include consistent measurement of input prices. In their words, "If the economic theory underlying the measurement of real product and real factor input is properly exploited, the role to be assigned to growth in total factor productivity is small." In other words, once input and output prices were measured to be consistent with the additional theoretical implications, the large majority of growth was accounted for by the accumulation of more and higher quality inputs, thus solving one of the first productivity puzzles. In the middle of the 1990's, the computer productivity paradox emerged. By the late 1990's, economists understood that by integrating information technology (IT) output and input prices consistently, a clear picture of the productivity boom emerged, shedding light a second productivity puzzle. A defining feature of these "explanations" for earlier puzzles is a clean theoretical link between economic theory, economic accounting, price measurement, and productivity measures.

In the aftermath of the Great Recession, a new productivity puzzle has emerged: why has productivity growth in the U.S. slowed down markedly compared to the late 1990's and early 2000's. A broad set of theories have been floated to try to explain the most recent productivity puzzle, and while none of these theories have proven to solve the latest productivity puzzle, a consensus has emerged that increased globalization is making the economy harder to measure and capturing the impact of these measurement challenges on productivity is difficult. In this paper, we explore the link between globalization and input prices. In particular, we highlight the conceptual link between trade prices and input prices and demonstrate that this link has implications for how purchase prices are estimated in the framework of the national accounts. It is these purchase prices that are used in the estimates of productivity growth.

Furthermore, because purchase prices for intermediate inputs are required to estimate GDP by industry, our framework has implications for measures of real value added by industry.

A common theme in the literature on challenges in measuring productivity and puzzles in productivity growth is that input prices are not directly measured. The intuition for the need to pin down input prices is that productivity growth is defined as the growth of real output less the growth of real inputs used in production. Since input prices are not measured, typical approaches use output prices to proxy for input prices for intermediate input, wages and benefits as a proxy for labor input costs; and, there is a large literature estimating prices for capital services input and relating those prices to investment output prices and other factors. This paper focuses on the assumption that output prices are a good proxy for intermediate input prices by using an economic accounting relationship to translate output prices to purchase prices.

The core relationship in our framework is a simple accounting identity between total production and the uses of that production. The economic intuition for the accounting identity that we exploit is just as simple: if prices charged on the international market differ from the output price of a commodity, the gap between the two reflects the unmeasured purchase price paid by U.S. purchasers. For example, consider a pharmaceutical that is produced in the U.S. for $100 a pill (with no trade margins or transportation costs). If we observe that drug being sold in Africa for $5 a pill, that same drug must be selling for more than $100 a pill in the U.S. market. It is the purchase price for U.S. businesses that is relevant for estimating real value-added by industry and productivity by industry..

We are not the first to recognize the potential for a gap between foreign and domestic prices for the same commodity. (Lipsey & Kravis, 1977) document a price gap between export prices and domestic products for closely related products and discuss some of the implications for macro modelling and policy. We provide a similar data analysis to cover the commodities used in the estimates of BEA's industry accounts. To our knowledge, this is the first study to recognize and incorporate the accounting relationship between export prices, output prices, and domestic purchase prices to estimate the importance of this gap for estimates for growth and productivity.

The basic idea in this paper is similar in nature to the recent work by (Houseman, Kurz, Lengermann, & Mandel, 2011) on the link between import prices and measures of growth and productivity. In their work, they argue that switching to new import providers is not captured in prices paid for intermediate goods, leading to an overestimate in real industry value added growth, concentrated in manufacturing.

The approach that we develop in this paper focuses on export prices and is even more basic. We argue that (unlike import prices) the gap between export and domestic production prices is not built into the current approaches used by the BEA to measure input and purchase prices. In our empirical exercise, we estimate the bias from ignoring prices differences across purchasers.

The second objective of the paper is to examine the relationship between intangibles and trade prices. The data-driven motivation for this part of the paper is that trade prices are only available for a subset of the commodities that are traded internationally. The economic motivation is driven by the idea that companies that produce commodities like wheat or petroleum have very little pricing power, thus likely charge similar prices to domestic and foreign buyers. Similarly, companies have little incentive to charge different prices to foreign and domestic purchases **if** the two markets have similar prices. On the other hand, intangible capital like R&D is generally protected by law and close substitutes are forbidden. This gives intangible intensive companies pricing power. Furthermore, companies which face different competitive environments in the United States and abroad have a strong incentive to tailor their prices in each market to match the competition. We use the observed relation between export prices, intangibles and import prices to impute missing export prices.

The remainder of the paper describes the framework in more detail and works through the implications for measures of growth and productivity in the U.S. In section 2, we detail our accounting framework and the relationship between trade prices and input prices. In section 3, we describe how we construct our trade-adjusted intermediate input prices using the official price data, while in section 4, we use the relationship between intangibles and prices to impute export prices for commodities without official data. Section 5 contains a brief description of the data sources used to analyze the impact on measured productivity of our experimental prices. Section 6 presents the effect of our price adjustments on measured TFP growth by industry and for the economy as a whole, and section 7 concludes.

2. Accounting Framework

Our first objective is to establish the role of purchase prices in estimating industry growth and productivity. Our second objective is to establish the accounting link between producer prices, trade prices, and purchaser prices and exploit this to back out the unmeasured purchase prices. The starting point is nominal industry output and industry intermediate input and our focus is on the accounting consistencies in measuring the intermediate input prices. First, intermediate input prices are necessary to compute real intermediate usage and real value added growth by industry j via the following formula[2]:

$$\Delta \ln Q_j = \overline{w_{Vj}} \Delta \ln V_j + \overline{w_{Xj}} \Delta \ln Q_{Xj} \tag{1}$$

where Q_j is real industry output; $\overline{w_{Vj}}$ is the share of value added in industry output; Q_{Xj} is real intermediate input; $\overline{w_{Xj}}$ is the nominal share of intermediate input in industry gross output. Real industry value added growth is V_j and is not directly observable because it is a function of the growth of primary inputs and TFP growth. Thus, equation (1) is used to back out real value added growth by industry. This is typically referred to as "double deflation" because it accounts for both output prices (in deflating nominal industry output) and intermediate input prices (in deflating nominal intermediate input). The starting point for our argument is that producer theory dictates that intermediate input should be deflated by the price paid by the producer to purchase intermediate input. For business purchases, this price is not directly measured by the U.S. statistical system. To fill in these prices in the BEA industry accounts, mostly PPI's (i.e. output prices) are used as a proxy. (Alterman, 2015) describes a proposal for measuring input prices directly, but the funding to conduct the relevant surveys does not appear to be forthcoming.

To describe our approach to linking trade prices to purchase prices, it is useful to introduce some additional notation. We model the economy as j industries and i commodities where each industry can produce more than one commodity. This structure follows the input-output accounts produced by BEA. Each industry (potentially) purchases each of the i commodities as an intermediate. The deflator for intermediate input for industry j in equation (1) is a tornqvist index over these i commodity prices where the weights are each commodity's share in total intermediate input purchased by the industry. A basic assumption is that each industry pays the same price for a given commodity, but because the weights differ by industry, the industry-level deflator for intermediate input differs by industry. Finally because

[2] Technically, this is a tornqvist implementation whereas the official BEA NIPA data uses a chained fisher formulation. The BEA/BLS integrated industry level production account employs tornqvist.

each industry can produce more than one commodity, we define the ith commodity price as a tornqvist index over industry output prices using the BEA Make table for weights.[3]

Our approach to measuring input prices paid for intermediate inputs is based on an accounting identity between the total value of commodity production and the total uses of each commodity. Specifically:

$$P_{YCi} Y_i^C = P_{YCDi} Y_i^{CD} + P_{YCXi} Y_i^{CX} \tag{2}$$

Equation (2) states that in nominal values the total production of each commodity Y_i^C must equal total spending on each commodity, which we divide between commodities purchased by foreign purchasers Y_i^{CX} and commodities produced domestically and purchased domestically, Y_i^{CD}. The crux of our approach is that when the prices of domestic production, P_{YCi}, and export price, P_{YCXi}, are observed, then the domestic purchase price for goods produced domestically, P_{YCDi}, can be backed out using equation (2). Note that an underlying assumption of this approach is that all domestic purchasers pay the same price for commodity.[4] Once we have P_{YCDi}, we combine this with existing information on imports used for each commodity and industry based on available BEA data along with their respective prices to arrive at a supply price for each commodity. To clarify, our methodology does not have implications for the treatment of import prices, so we handle the role of imports in intermediate input in the standard way. To analyze the impact of these new prices on productivity growth, we recompute the productivity accounts of (Jorgenson, Ho, & Samuels, 2016)

The accounting relationship between output prices and purchase prices has similar implications for investment prices. A typical simplifying assumption when constructing investment prices is that investment prices reflect commodity output prices. But, exported investment goods may be priced differently than those purchased domestically. Thus, real GDP from the expenditure sides is potentially affected by this accounting exercise as well, as estimates of the capital stock and capital services. Nevertheless, in this paper, we focus on intermediate input and hold the prices of capital fixed. We also note that for industries where input prices are used to proxy for output prices, like the government,

[3] In our empirical exercise, we employ the dataset of (Jorgenson, Ho, & Samuels, 2016) which is based on the methodology of (Jorgenson, Ho, & Stiroh, 2005).

[4] We experimented with differences between PCE prices and industry purchase prices and while there are some discernible differences in prices paid at the commodity level, the aggregate empirical impact on measures of growth and productivity are not worth including in this version of the paper.

non-profits, and R&D output that our adjustment has potential implications for output prices in these sectors. Like capital, we do not pursue this in the current version of the paper.

Finally, it is worth noting one aspect of how our framework relates to the data described below. In our application, we assume that prices are measured with precision, so that the difference between the two prices we measure has the interpretation as the price for domestic purchases. It is possible, however, that export prices are no different than output prices and the gap that we observe is due to measurement error. If this is the case, the industry value added and productivity growth estimates are not biased, but the GDP from the expenditure side would be biased because the current approach makes use of the official export price data.

3. Constructing Purchase Prices for Intermediate Goods

We use data on export prices, domestic output prices, and the export share by commodity to infer the unmeasured price of domestic goods that are used as an intermediate input. This is the main empirical contribution of the paper, although our construction of these prices relies on less than perfect information. We combine the domestic purchase prices with information on imports and import prices by commodity to derive the price of intermediate inputs used in production. The role of import prices in the prices paid for intermediate inputs has garnered significant attention in the literature on economic measurement. A major motivation for this line of literature is that many input prices are unmeasured. We contend that the internally consistent measure of input prices needs to strip out the contribution of export prices to industry output price growth.

To strip out the contribution of export prices to the growth in industry output prices, we construct the export share and corresponding export price for exported goods to implement equation (2). The data source for export prices is the BLS Import and Export Price Indexes and we match these to the 65 commodities used in the BEA industry accounts using the procedures described below.

With data beginning in 2006, BLS has tracked export prices by the same NAICS code that BEA uses in its input-output accounts. Therefore, for 2006 forward, where export prices are available, we concord this data to the 65 commodities used in the published BEA industry accounts. Because there are some export prices that are published at a finer level of detail than the published annual BEA industry accounts, we aggregate the over export prices using 2007 exports from the benchmark IO table as weights. This covers 24 of the 65 commodities that we consider, and most non-services commodities.

Two exceptions are the prices for Textile mills and Apparel and leather products for which BLS doesn't publish NAICS-based prices. For these prices, we used the procedure described below based on "end use categories." For non-goods commodities for which export prices are available, we use the "end use categories" as well. Finally, for Air transportation, we use an equal weight average of the export price of passenger fares and freight from the BLS export price data.

For 1985-2005, we begin with annual average export price for about 122 commodities from the BLS International Price Program "BEA end use export indexes." We then map these 122 commodities to the 65 commodities published in the annual BEA input-output tables. Each row of the BEA use table provides information on the use of intermediate input by industry. The trade prices are on a different classification scheme than the BEA use table. For example, we have export price data on wheat, but need to match this with the farm commodity in the productivity accounts that we use to estimate productivity growth by industry. We concord the two data series with the following procedure:

1) We start with a concordance between harm codes and the commodities in BEA's 2007 benchmark input output accounts. This concordance gives about 20,000 Harmonized System (HS) codes and maps these to about 400 commodities. This concordance includes the value of exports for each of the harm codes.
2) We assign each HS code one of the export price indexes.
3) We use the exports of each HS code as weights to construct weighted prices for each of the commodities in the benchmark IO table
4) We aggregate from commodities in the benchmark IO to the 65 commodities in the input output table using 2007 export shares as weights.

Note that because the export prices cover only goods, this procedure returns export prices for goods only and air transportation. In work describe below, we describe our approach to estimating export prices for all exports. We also highlight that due to measurement challenges in the export prices for IT and other transportation equipment, we experiment with options that include or exclude these prices from our analysis.[5]

[5] This follows the choice in the NIPA accounts to use domestic prices to deflate exports of these goods.

4. Intangibles and Imputed Export Prices

As noted above, the published export price data does not cover the entire range of commodities that are exported. For example, the BLS publishes export price indexes for farmed and manufactured goods, Air transportation, Publishing, and Motion pictures and sound recording, but does not publish export prices for Information and data processing services, Management of companies, Finance, or Legal services.

Our imputed export prices are based on a simple economic model. As we've discussed earlier, we have two fundamental assumptions:

1) Firms with intangible assets like custom software or R&D have more pricing power than firms selling commodities. In contrast, intangible capital like R&D is generally protected by law and close substitutes are forbidden. This gives companies pricing power.

2) U.S. firms adjust their export prices based on the global marketplace.

These two assumptions are not original to us, but rather are based on a vast literature studying export prices changes after exchange rate movements. This literature was pioneered by Paul Krugman in 1986 and has been extended by many other authors. The two consistent results of the literature are: 1) firms generally adjust their export prices based on the exchange rates; 2) the adjustments are larger for firms with more market power. This literature has focused on changes to global prices caused by exchange rate shifts, but the same theory applies to changes in global prices caused by other factors. In this paper, we use import prices as a proxy for global prices and intangible assets as a proxy for market power. Based on those proxies, we can then impute the export price for industries without BLS export price data. We estimate the following regression:

$$\begin{aligned}\Delta \ln PPI_i - \Delta \ln XPI_i &= \alpha + \beta_1(\Delta \ln PPI_i - \Delta \ln IPI_i) + \beta_2(\text{Intangible Share}_i)\\ &+\beta_3(\text{Intangible Share}_i)(\Delta \ln PPI_i - \Delta \ln IPI_i) + \varepsilon_i\end{aligned}$$

To summarize: intangible capital is included because companies selling commodities like wheat or petroleum have very little pricing power. As a result, it is likely that they charge similar prices to domestic and foreign buyers. In contrast, intangible capital like R&D is generally protected by law and close substitutes are forbidden. This gives companies pricing power.

We include import prices because both importers and exporters are competing in a global marketplace. Their prices are often influenced by the same world factors. In contrast, firms which produce and sell within the US are less affected by world factors. Lastly, the interaction of these variables captures firms which have both the motive and the opportunity to price discriminate.

We were only able to match BLS export prices for 25 out of the 65 commodity categories. We use information from (Jorgenson, Ho, & Samuels, 2016) to construct the intangible share in total input. Specifically, we define the intangible share as the sum of the 2007 shares of software, R&D, and Entertainment originals capital services in total input, less an estimate of the income share of prepackaged software. In running the model, we use average annual growth rates over the 1984-2012 period as a whole, 20 we have a total of 25 observations in our first specification.

Because of the limited data, it is extremely difficult to run sophisticated robustness checks. The limited robustness checks we were able to run suggest that our coefficients are similar for weighted and unweighted regressions, and the coefficients are not driven by a single outlier industry. However, more sophisticated robustness checks require more observations than we have.

In order to get more observations, we have also explored splitting the 65 industry categories into the 389 industry subcategories available in the benchmark IO table. Unfortunately, BLS only tracks 122 export price indexes and many of these export price indexes have a short history. Because there are so few usable export price indexes, many of the 389 industry subcategories share a BLS export price index. As a result, splitting the 65 industry categories further adds noise without giving much more power to the regression.

The results for four specifications appear in following table. Our preferred specification is (1). This includes all of the commodities for which we have export price data. Specification (3) drops the prices of Computers and other transportation equipment. As a robustness check, we estimated weighted regressions (export values as weights) corresponding to specifications (1) and (3) in specifications (2) and (4). While the weighting does not have a major impact on the results, whether or not Computers and Other Transportation equipment is included does influence the individual coefficients for B1, B2, and B3. Because we do not have actual information on reason for the pricing differences for these commodities, we default to using the officially published data and the results in specification (1).

Nevertheless, as is evident from the sensitivity analysis and obvious from the limited number of observations, these results should be treated with caution. We note that while the coefficient estimates and their level of significance does depend on the specification, the final imputations do not differ much across specifications. The results presented below should be seen as a starting point for discussion rather than precise estimates.

Regression results:				
VARIABLES	(1)	(2)	(3)	(4)
intangibleshare	0.0877***	0.0998***	0.0349	0.0659*
	(0.0301)	(0.0252)	(0.0400)	(0.0315)
commoditypiipi	0.117	0.208*	0.106	0.261*
	(0.125)	(0.111)	(0.163)	(0.128)
commodityipiintangible	9.748***	4.075	9.594***	2.073
	(2.885)	(3.581)	(2.384)	(3.231)
Constant	-0.00643**	-0.00510**	-0.00561	-0.00274
	(0.00243)	(0.00205)	(0.00374)	(0.00280)
Observations	25	23	24	22
R-squared	0.594	0.632	0.662	0.565

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. Production Account Data

The export price data described above provides one piece of the industry-level production account required to implement the sources of growth model. We combine the price data described above with data on industry output, capital, and intermediate inputs provided by Dale Jorgenson and used in a recent analysis of U.S. economic growth by Jorgenson, Ho and Samuels (2015). This is consistent with the BEA/BLS industry-level production account data, but includes a longer time series. The data for labor and capital inputs are constructed in an analogous way to the measure of intermediate inputs: capital service flows and labor inputs are weighted by their nominal cost shares to construct an input measure that captures substitution towards more productive inputs over time. Unfortunately, the data provided by Jorgenson ends in 2012.

6. Results

We divide our results into two sections. First we analyze the impact of our adjustment to purchase prices. Second, we examine the results on industry productivity.

Figure 1 shows the adjustments to input prices implied by the consistent accounting. This figure includes the Computers and the Other transportation commodities. Like Computers, Other Transportation has an export price that does not closely resemble the domestic price. Because of this, BEA uses the domestic price to deflate exports in the NIPA accounts. To allocate prices to usage category, we weight each price index by the usage share given in BEA's IO table. Many commodities go to multiple usage categories so that one price change could affect multiple usage categories. The figure shows that that the largest adjustments occur on commodities that are purchased as investment goods. Some intuition for this is that the computer commodity prices, for example, fell by about 5% per year between 1985 and 2012, while the export price fell by about 1.5% per year. Since some computers were exported, this implies that the domestic price purchase fell by more than 5% per year. Over the sample we consider, investment prices fell by 12% more using the export-adjusted price indexes, while Government purchase prices were about 4% lower. For intermediate prices, we estimate that purchase prices were 2% lower than current methods estimate and PCE prices about 3% lower.

We reiterate that in this paper we hold final output prices fixed. As a result, our adjusted input prices for personal consumption, investment and government consumption do not affect measured GDP. We have left the effect on measured GDP from the expenditure as future work.

The overall price results, however, are strongly influenced by the prices for Computers and Other transportation. Figure 2 shows our adjustments to input prices excluding these two commodities. Without these, overall prices by final user are not significantly different under our adjustment. Intermediate prices grew faster by about 1% over the entire period, while PCE prices grew slower by about 1%.

Unfortunately, we do not have data to help us determine which scenario (include the adjustment for Computers and Other transportation equipment) or exclude these two commodities. Because of the differences between the trade prices and the output prices for these commodities, BEA uses the output deflator to deflate exports. But, if the differences between the two prices are real and occurs for any economic reason then these two prices should be included in adjustment. For example, if the price difference reflects the composition of the type of commodities that are being exported versus sold domestically, or if the gap indicates a true pricing difference, then accounting consistency requires that we include these prices in our analysis. In the end, we don't take a stance and provide alternative estimates of growth and productivity under the two cases.

The impact of our imputations on purchase prices by user is also small. Figure 3 shows the impact on PCE prices and intermediate prices was similar: prices changed by about 1% more using the trade adjusted prices. Government prices changed by less than half a percent over the sample, while investment prices by about 0.3%. On balance, the prices paid by end user for the commodities for which we impute the price gap all grew more slowly after adjusting for the gap between export and domestic output prices. Equivalently, this indicates that the commodities for which there is no official data are exported at higher prices than those sold on the domestic market on balance, if our simple model is informative. Like the case with actual export price data, our model cannot distinguish between pricing differences due to composition mix, or pricing differences due to pricing to market even though we motivated our model with pricing power. For example, we estimate that export prices for Securities, commodity contracts, and, investments grew by faster than the domestic price by about 1% per year. We cannot determine, unfortunately, whether this is because the exported service was a different mix than that sold domestically, or if producers were pricing to foreign markets. The difference between the two cases may have implications for modeling the macro economy and for economic policy, but does not have implications for how to measure the price deflators; in either case domestic purchases should be deflated with a conceptually correct price index.

Figure 4 provides the underlying detail on the gaps in price growth between 1984 and 2012. We show the BLS published prices in blue and our imputed prices in gray. The first thing to note is that not all price gaps changed in the same direction. For about 20% of the commodity groupings, domestic price growth exceeded export price growth. These dynamics are consistent with lower price change to build market share and brand awareness, but again, our data does not allow us to test this hypothesis.[6] On the other side of the price distribution, export prices for Computers and Forestry and fishing products grew faster than the domestic price. This could be catch up from a relatively low price in the beginning of the sample, reflect a higher price charged for the same good, or reflect the composition of the type of computers that are exported versus sold domestically.[7]

[6] Note that our data cannot tell us about relative price levels, only about relative inflation.
[7] Domestic production of computers fell from $41B in 1997 to $33 billion in 2014.The export share of computers increased slightly from about 30% to 33% of commodity output.

The alternative purchase prices that we estimate have little impact on aggregate TFP growth for the period as a whole. Figure 5 shows the impact on aggregate TFP estimates based on four alternatives: 1) using all of the actual BLS export prices to back out the domestic purchase price, 2) using the actual BLS export prices, but excluding the export prices for Computers and Other transportation equipment, 3) using the BLS export price data and our imputed export prices, and 4) using the BLS export prices and imputed export prices, but excluding the export prices of Computers and Other transportation equipment.[8] For the period as a whole, before the adjustments, (Jorgenson, Ho, & Samuels, 2016) estimate that TFP growth was 0.47% per year. Thus, relative to aggregate TFP, the adjusted prices have a relatively small impact. Under each of the price adjustments, the contribution to aggregate TFP growth from the Manufacturing sectors was slightly lower, while that from the Services sectors was slightly higher. Changes to TFP growth estimates in the other sectors were even smaller. There does not appear to be compelling differences in the time series dynamics of adjustments. The adjustments do not change the basic story about aggregate productivity growth over the different sub-periods in the sample: TFP growth based on the alternatives ranged from 0.88%-0.92% per year from 1995-2000, 0.44%-0.47% from 2000-2007, and 0.13%-0.15% from 2007-2012.

Figures6-9 show that the adjustments were skewed towards a subset of industries. The imputed prices do not substantively change the effects across industries. When the BLS export price data is used, the Chemical products industry, Computer and electronic products, and Other transportation equipment industries were impacted disproportionately. The results for the Chemicals industry reflects the lower inflation rates for exported drugs, while the results for Computers and Other transportation reflect large gaps between the export and PPI prices noted earlier. The results are similar when we incorporate the imputed prices. Once we drop those two prices, the largest impacts were on the Chemicals, Broadcasting, Food and beverage, and Metals industries. By construction, the largest impacts are on industries that purchase the output of industries that export goods at prices that are different than the measured output price.

7. Conclusions

[8] In this scenario, the imputed prices are based on a regression that excludes the two controversial industries.

As economic measurement and analysis moves from the national to the global level, it is imperative that the conceptual framework captures the impacts of increasing globalization and important to impose consistency in the basic economic accounting. If goods are exported at a price that is different than the total production price, this necessarily implies that domestic purchasers pay a different price as well. Because domestic purchase prices are not measured directly, applying this accounting identity helps pin down the actual prices that are being paid in the U.S. At first pass, there are some substantial differences between prices paid in the U.S. versus abroad. These price gaps appear to be related to intangibles, and we speculate that this is due to the relationship between intangibles and pricing power. But, these price differences do not translate to substantively different measures of TFP growth at the aggregate level. There are some minor differences at the industry level, including sectors like Chemicals which we suspect is related to drug pricing overseas. While the empirical impact is minimal, the accounting framework that we develop ensures that, going forward, these prices gaps would be captured in measured productivity. Finally, the link between export prices, output prices, and purchase prices reinforces the need to measure export prices as accurately as possible.

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Figure 1: Adjustments to Purchase Prices

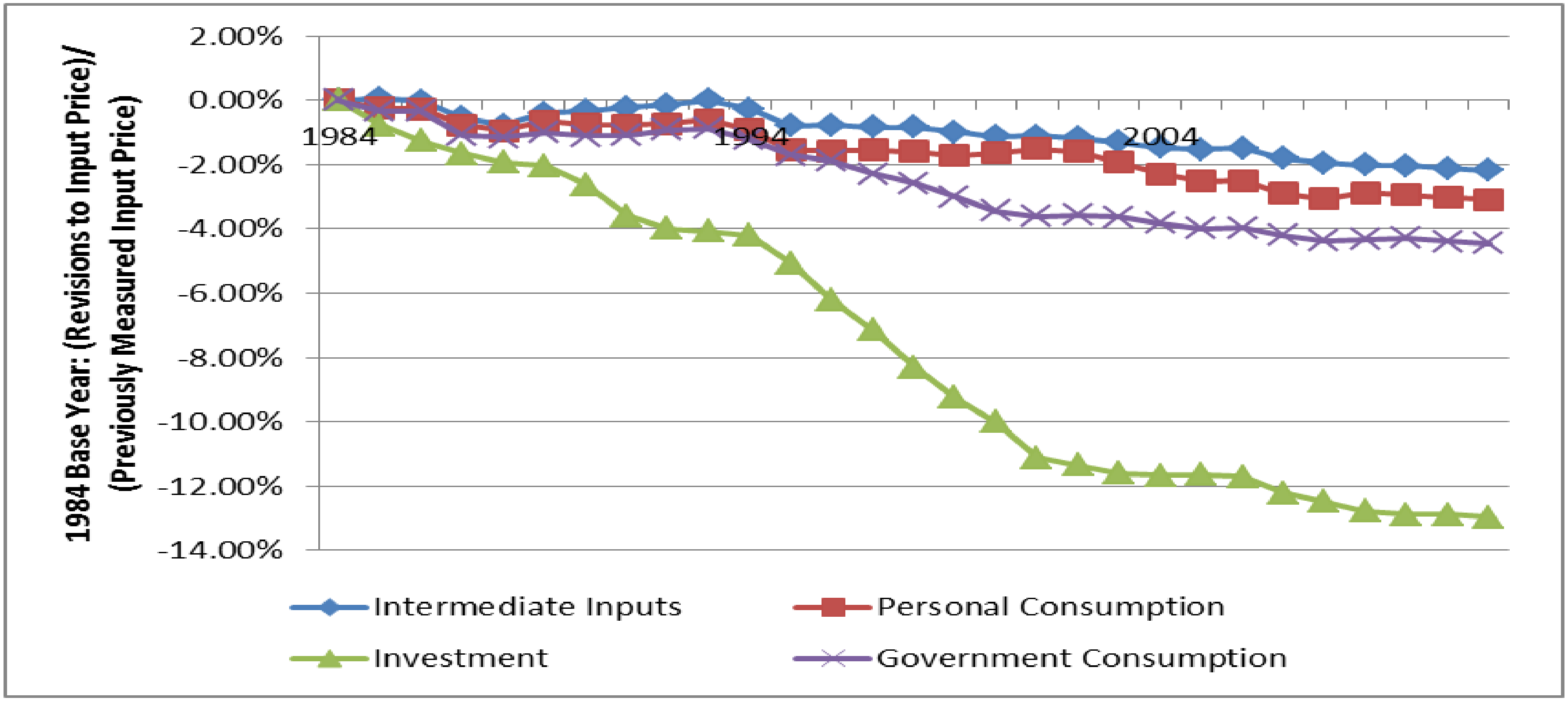


Figure 2: Adjustments to Purchase Prices Excluding Computers and 'Other Transportation'

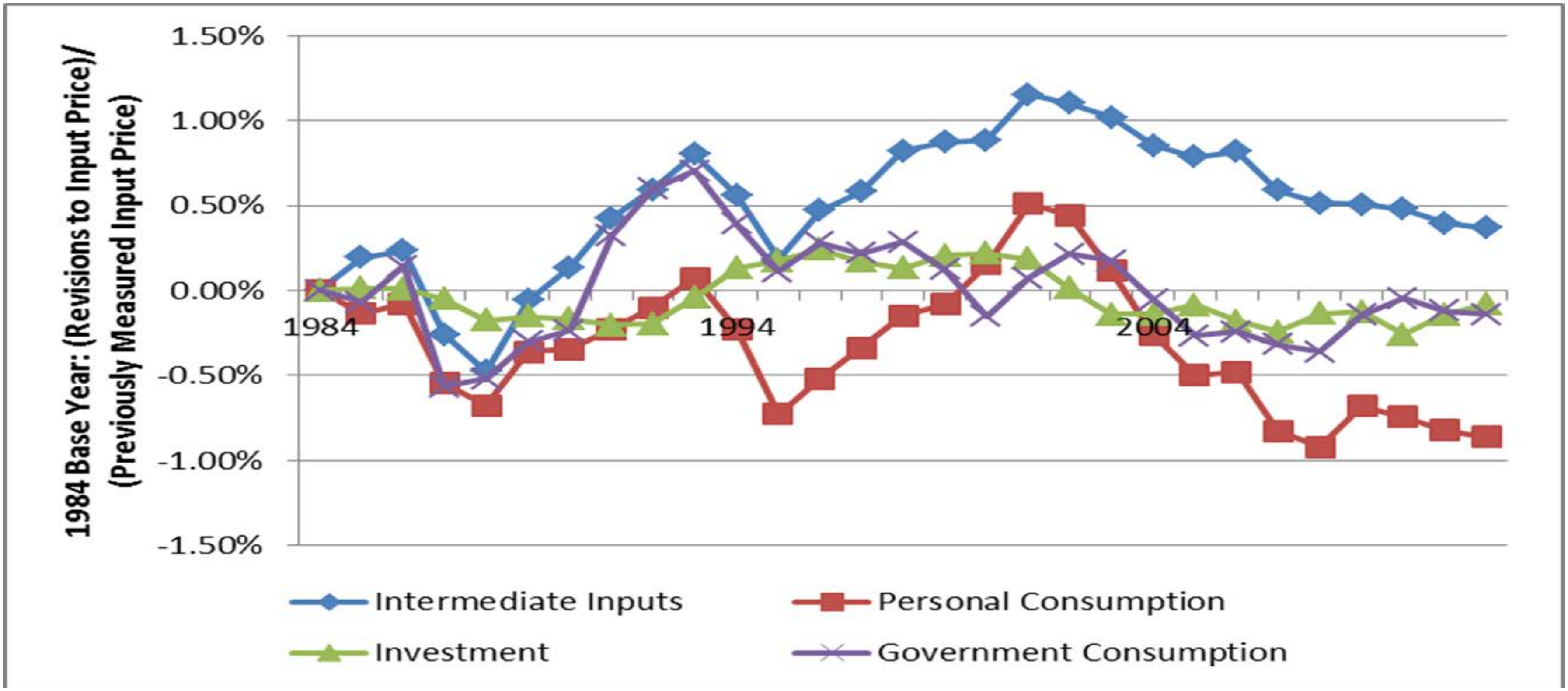
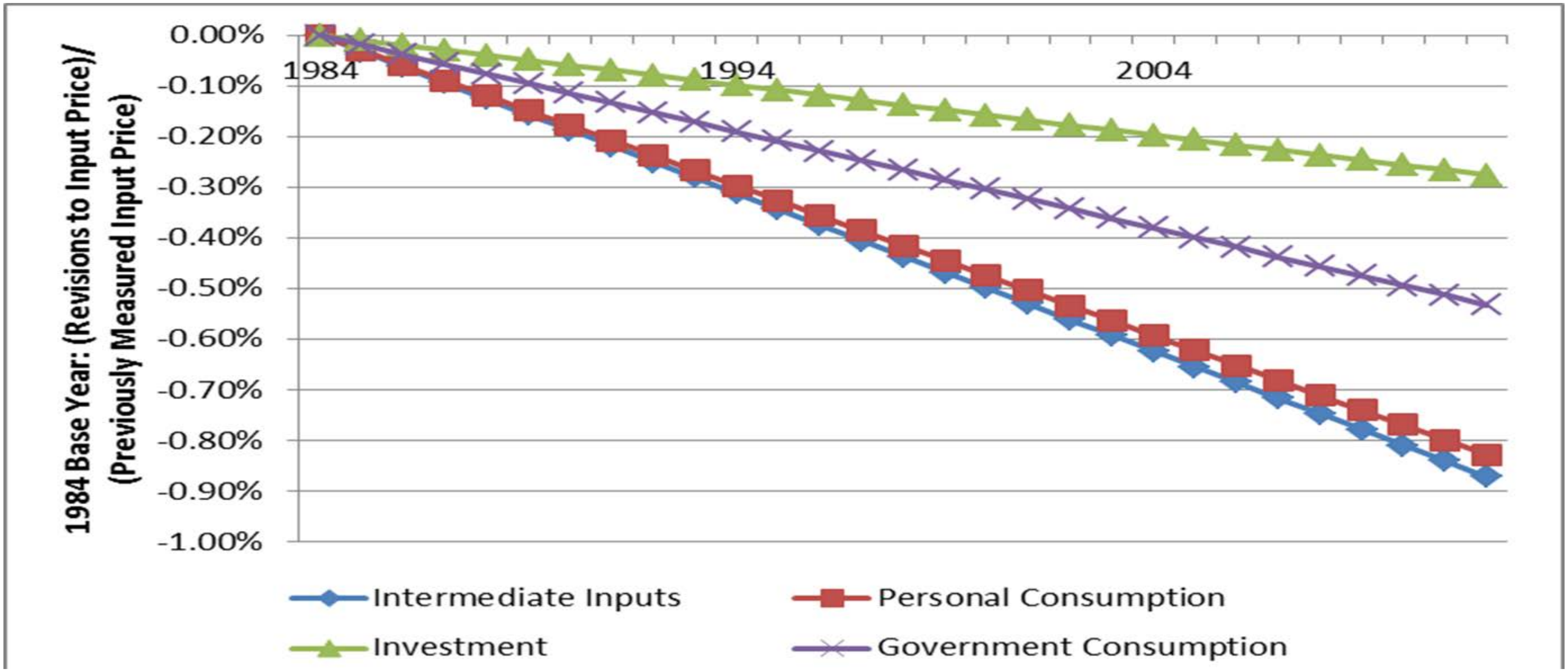


Figure 3: Adjustments to Purchase Prices based on Imputed Data



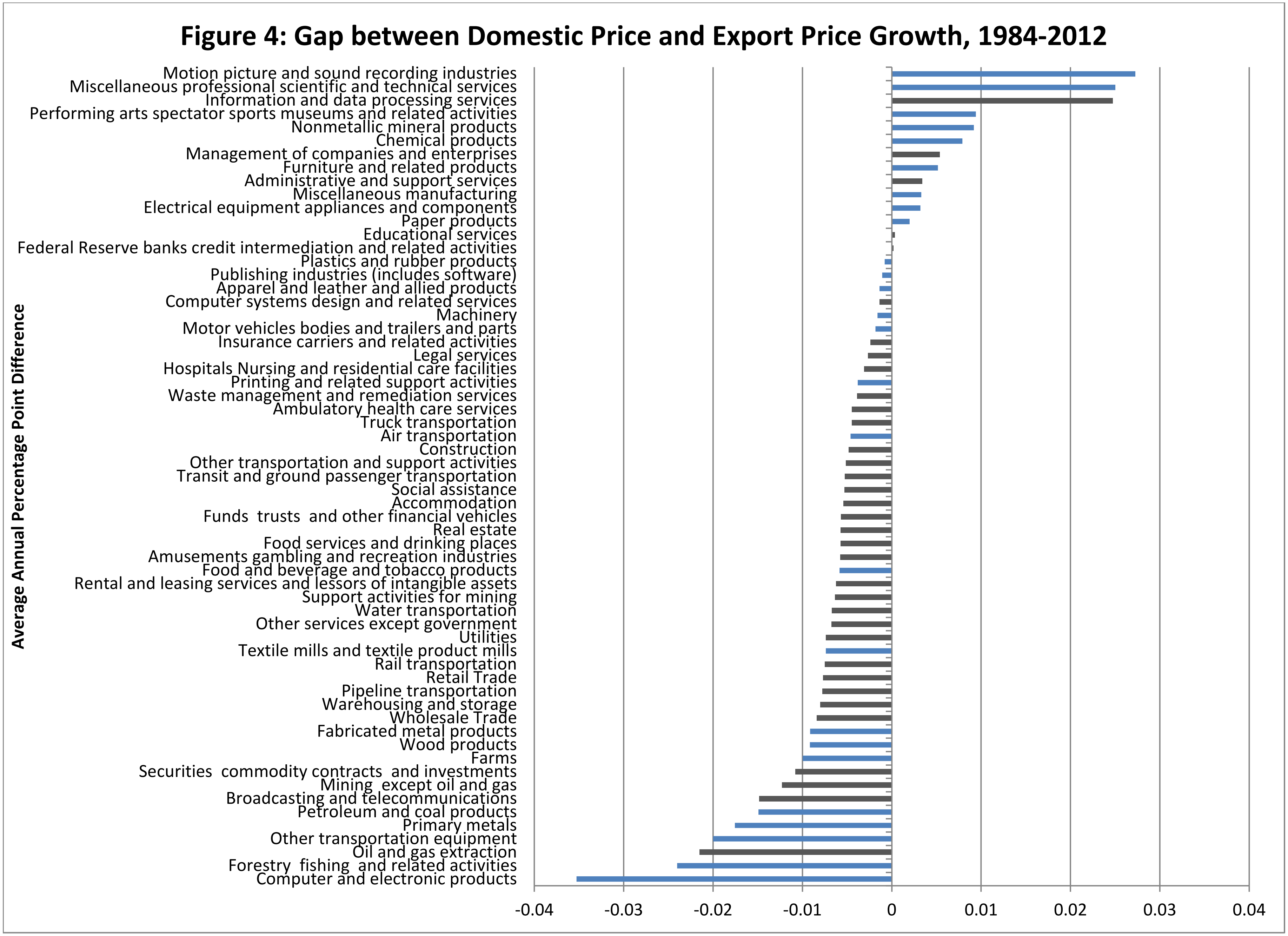


Figure 4: Gap between Domestic Price and Export Price Growth, 1984-2012
Average Annual Percentage Point Difference
Motion picture and sound recording industries
Miscellaneous professional scientific and technical services
Information and data processing services
Performing arts spectator sports museums and related activities
Nonmetallic mineral products
Chemical products
Management of companies and enterprises
Furniture and related products
Administrative and support services
Miscellaneous manufacturing
Electrical equipment appliances and components
Paper products
Educational services
Federal Reserve banks credit intermediation and related activities
Plastics and rubber products
Publishing industries (includes software)
Apparel and leather and allied products
Computer systems design and related services
Machinery
Motor vehicles bodies and trailers and parts
Insurance carriers and related activities
Legal services
Hospitals Nursing and residential care facilities
Printing and related support activities
Waste management and remediation services
Ambulatory health care services
Truck transportation
Air transportation
Construction
Other transportation and support activities
Transit and ground passenger transportation
Social assistance
Accommodation
Funds trusts and other financial vehicles
Real estate
Food services and drinking places
Amusements gambling and recreation industries
Food and beverage and tobacco products
Rental and leasing services and lessors of intangible assets
Support activities for mining
Water transportation
Other services except government
Utilities
Textile mills and textile product mills
Rail transportation
Retail Trade
Pipeline transportation
Warehousing and storage
Wholesale Trade
Fabricated metal products
Wood products
Farms
Securities commodity contracts and investments
Mining except oil and gas
Broadcasting and telecommunications
Petroleum and coal products
Primary metals
Other transportation equipment
Oil and gas extraction
Forestry fishing and related activities
Computer and electronic products
-0.04
-0.03
-0.02
-0.01
0
0.01
0.02
0.03
0.04

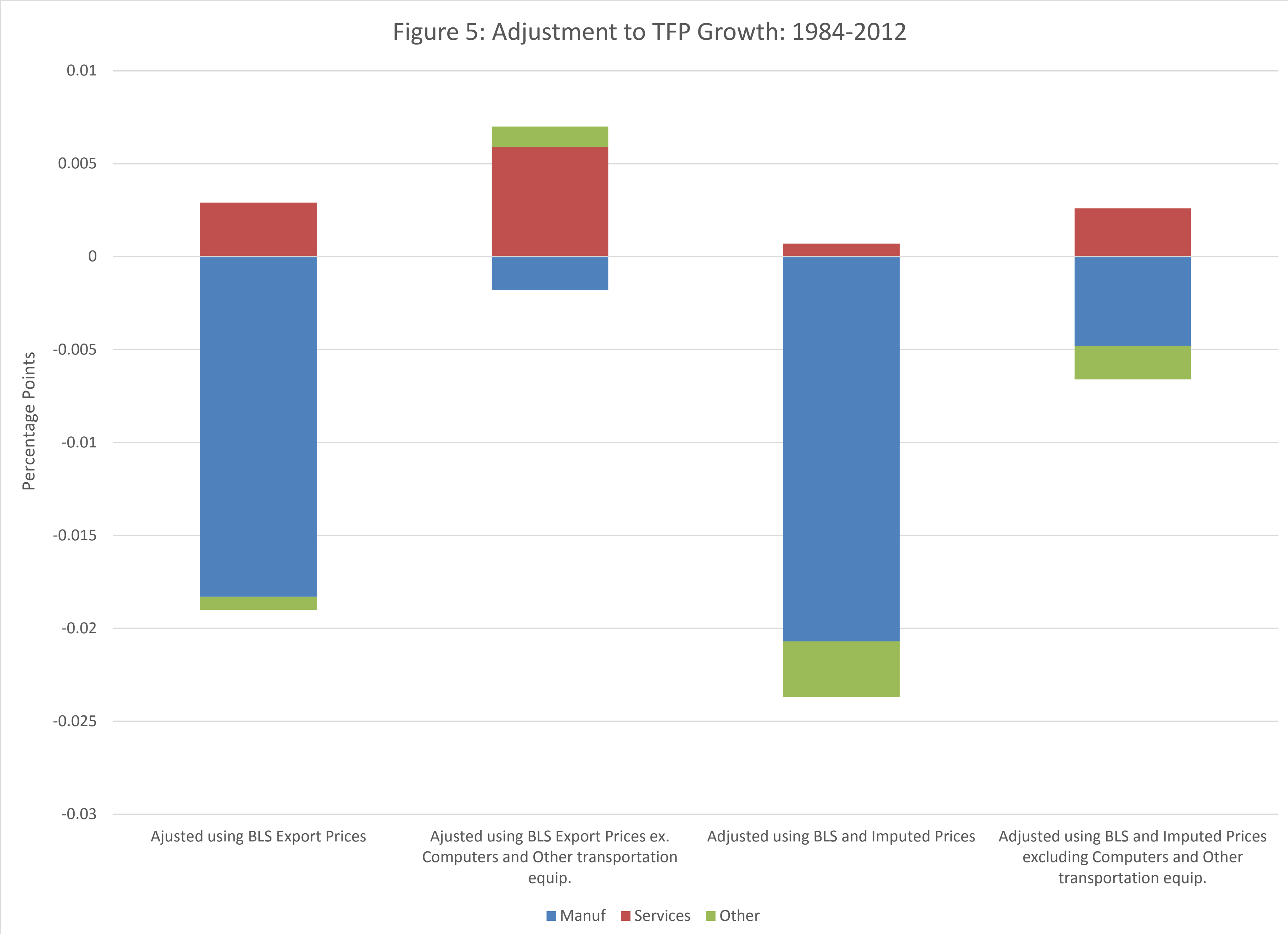


Figure 5: Adjustment to TFP Growth: 1984-2012
Percentage Points
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025
-0.03
Ajusted using BLS Export Prices
Ajusted using BLS Export Prices ex. Computers and Other transportation equip.
Adjusted using BLS and Imputed Prices
Adjusted using BLS and Imputed Prices excluding Computers and Other transportation equip.
Manuf
Services
Other

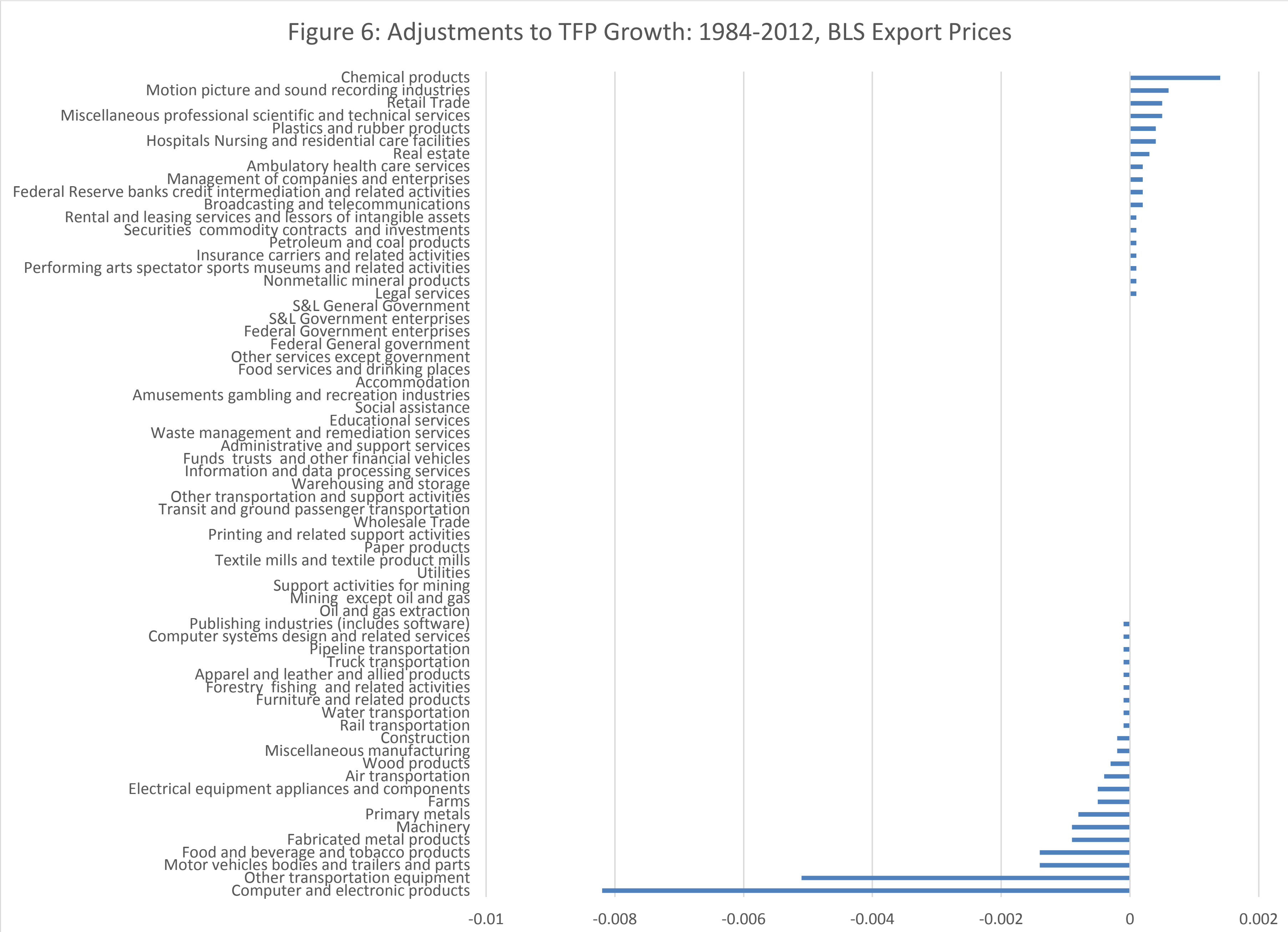


Figure 6: Adjustments to TFP Growth: 1984-2012, BLS Export Prices
Chemical products
Motion picture and sound recording industries
Retail Trade
Miscellaneous professional scientific and technical services
Plastics and rubber products
Hospitals Nursing and residential care facilities
Real estate
Ambulatory health care services
Management of companies and enterprises
Federal Reserve banks credit intermediation and related activities
Broadcasting and telecommunications
Rental and leasing services and lessors of intangible assets
Securities commodity contracts and investments
Petroleum and coal products
Insurance carriers and related activities
Performing arts spectator sports museums and related activities
Nonmetallic mineral products
Legal services
S&L General Government
S&L Government enterprises
Federal Government enterprises
Federal General government
Other services except government
Food services and drinking places
Accommodation
Amusements gambling and recreation industries
Social assistance
Educational services
Waste management and remediation services
Administrative and support services
Funds trusts and other financial vehicles
Information and data processing services
Warehousing and storage
Other transportation and support activities
Transit and ground passenger transportation
Wholesale Trade
Printing and related support activities
Paper products
Textile mills and textile product mills
Utilities
Support activities for mining
Mining except oil and gas
Oil and gas extraction
Publishing industries (includes software)
Computer systems design and related services
Pipeline transportation
Truck transportation
Apparel and leather and allied products
Forestry fishing and related activities
Furniture and related products
Water transportation
Rail transportation
Construction
Miscellaneous manufacturing
Wood products
Air transportation
Electrical equipment appliances and components
Farms
Primary metals
Machinery
Fabricated metal products
Food and beverage and tobacco products
Motor vehicles bodies and trailers and parts
Other transportation equipment
Computer and electronic products
-0.01
-0.008
-0.006
-0.004
-0.002
0
0.002

Figure 7: Adjustments to TFP Growth: 1984-2012, BLS and Imputed Export Prices

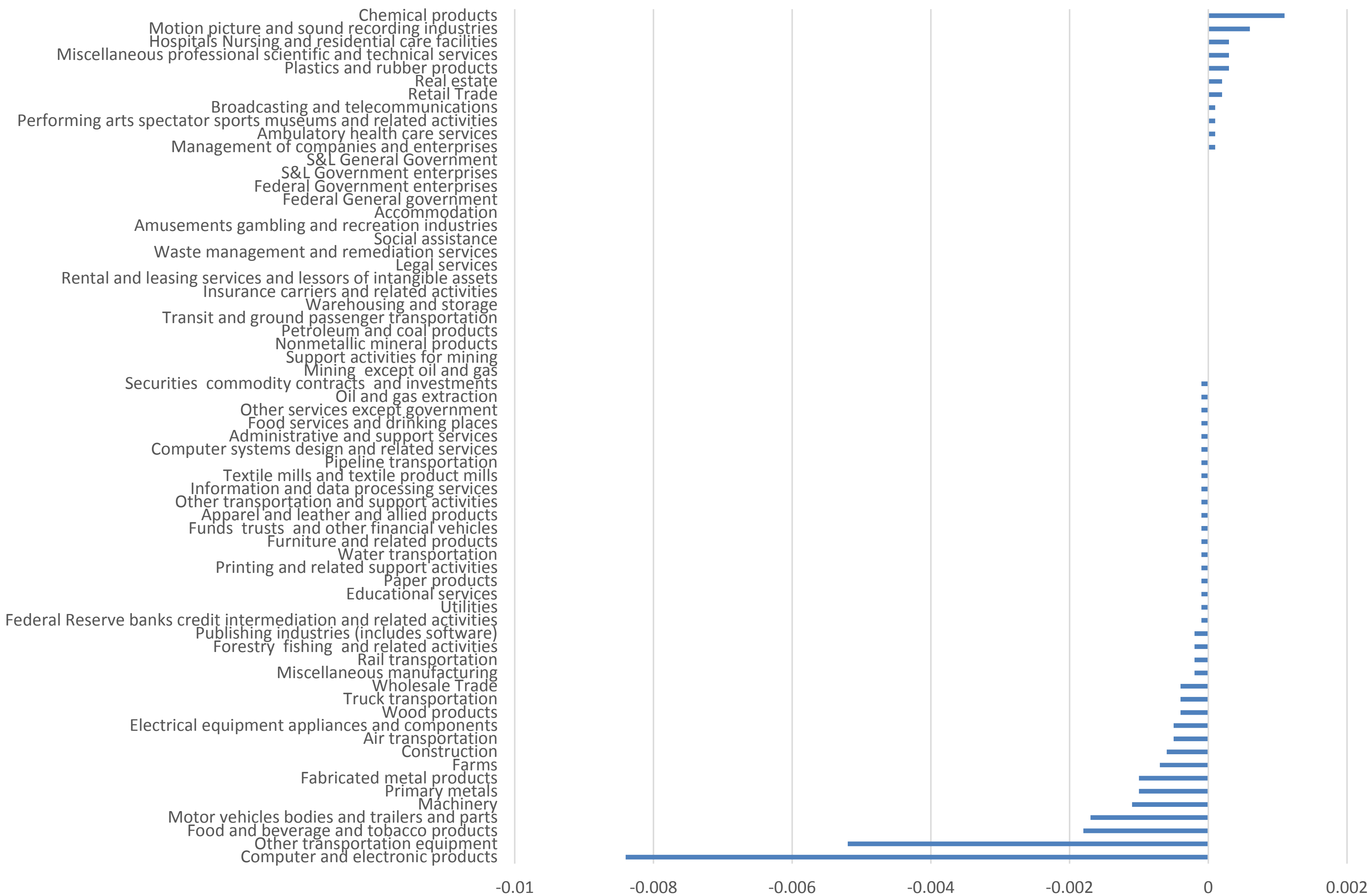
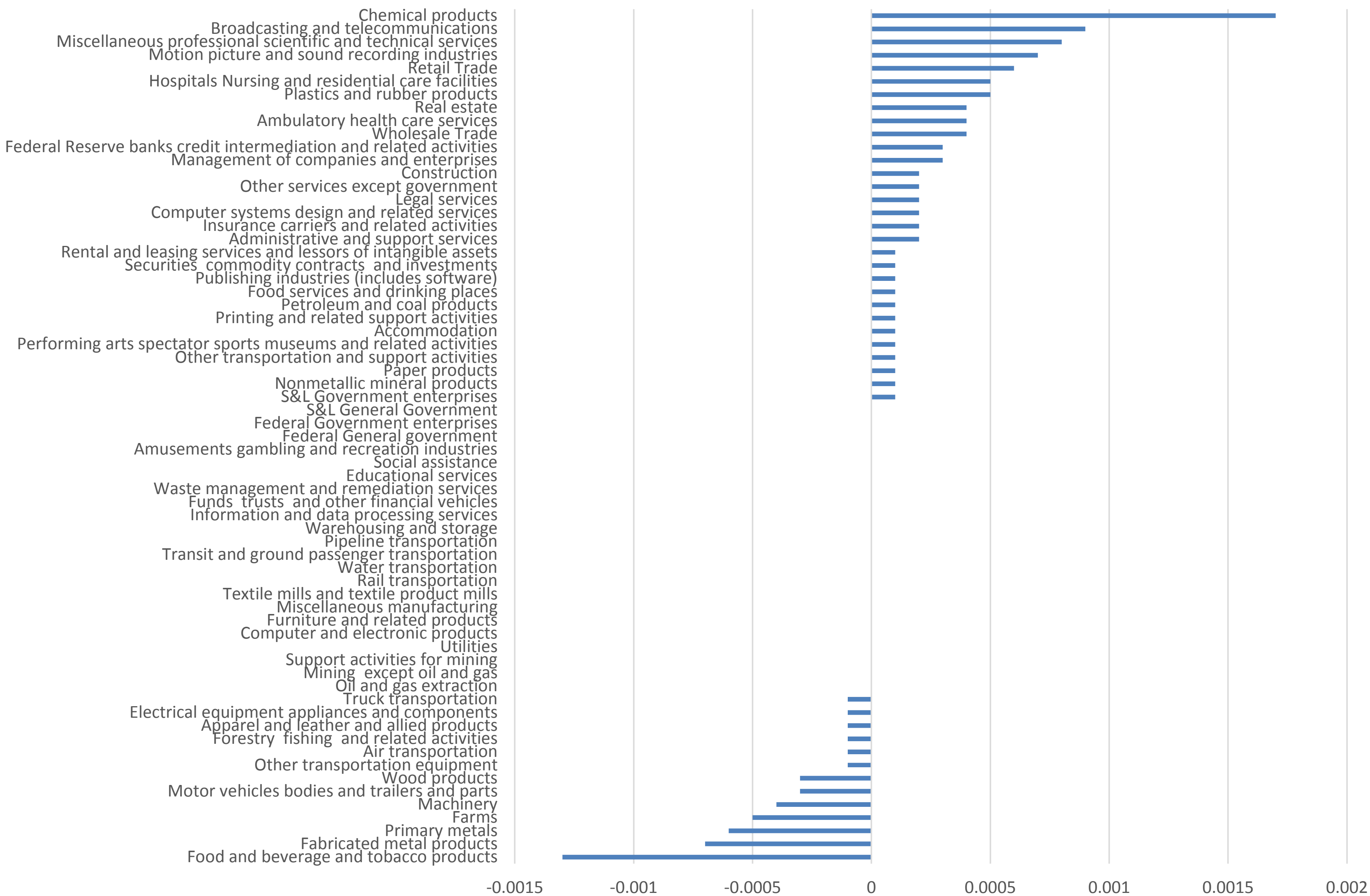


Figure 8: Adjustments to TFP Growth: 1984-2012, BLS Export Prices excluding Computers and Other Transporation Equipment



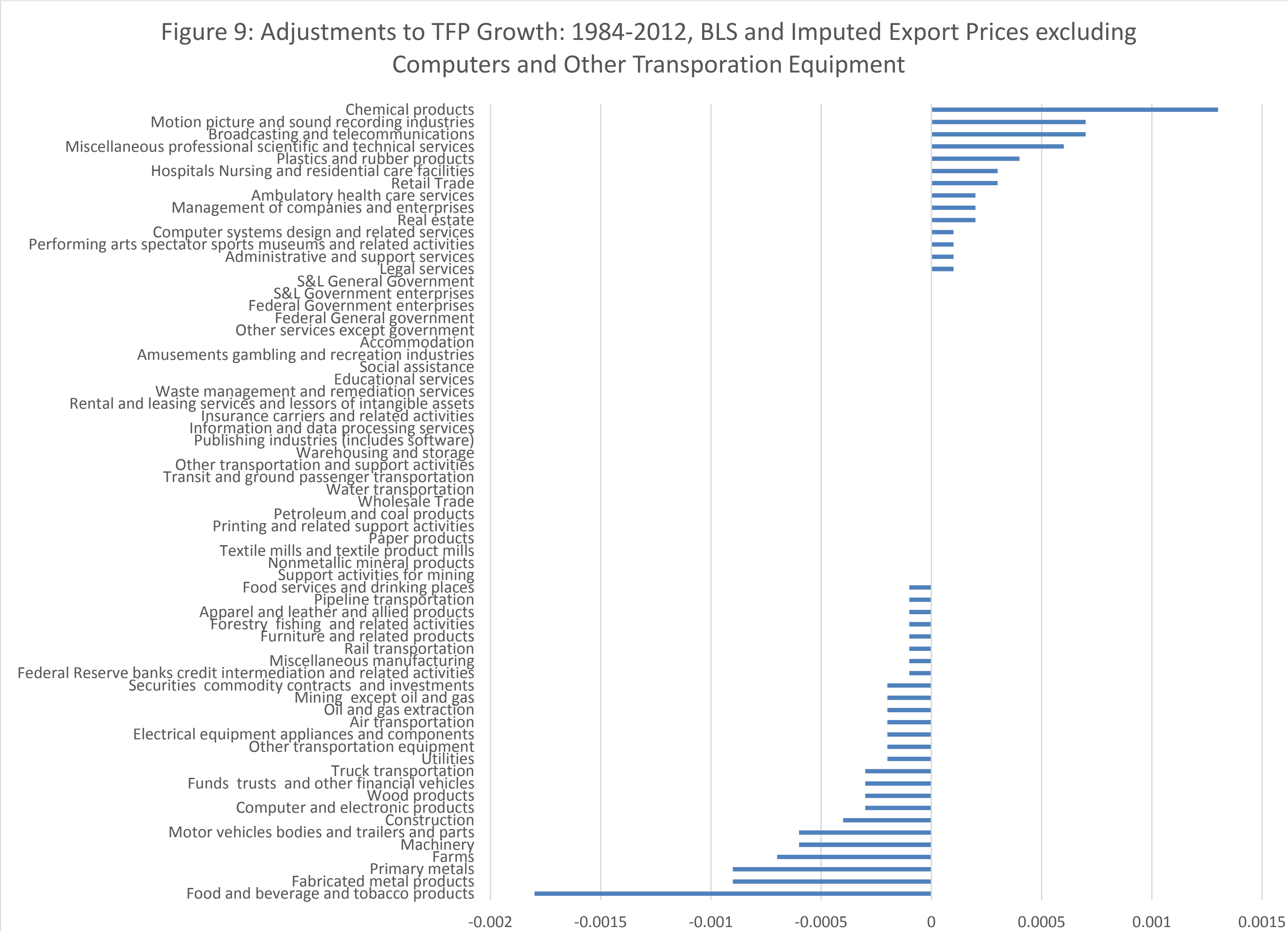


Figure 9: Adjustments to TFP Growth: 1984-2012, BLS and Imputed Export Prices excluding Computers and Other Transporation Equipment
Chemical products
Motion picture and sound recording industries
Broadcasting and telecommunications
Miscellaneous professional scientific and technical services
Plastics and rubber products
Hospitals Nursing and residential care facilities
Retail Trade
Ambulatory health care services
Management of companies and enterprises
Real estate
Computer systems design and related services
Performing arts spectator sports museums and related activities
Administrative and support services
Legal services
S&L General Government
S&L Government enterprises
Federal Government enterprises
Federal General government
Other services except government
Accommodation
Amusements gambling and recreation industries
Social assistance
Educational services
Waste management and remediation services
Rental and leasing services and lessors of intangible assets
Insurance carriers and related activities
Information and data processing services
Publishing industries (includes software)
Warehousing and storage
Other transportation and support activities
Transit and ground passenger transportation
Water transportation
Wholesale Trade
Petroleum and coal products
Printing and related support activities
Paper products
Textile mills and textile product mills
Nonmetallic mineral products
Support activities for mining
Food services and drinking places
Pipeline transportation
Apparel and leather and allied products
Forestry fishing and related activities
Furniture and related products
Rail transportation
Miscellaneous manufacturing
Federal Reserve banks credit intermediation and related activities
Securities commodity contracts and investments
Mining except oil and gas
Oil and gas extraction
Air transportation
Electrical equipment appliances and components
Other transportation equipment
Utilities
Truck transportation
Funds trusts and other financial vehicles
Wood products
Computer and electronic products
Construction
Motor vehicles bodies and trailers and parts
Machinery
Farms
Primary metals
Fabricated metal products
Food and beverage and tobacco products
-0.002
-0.0015
-0.001
-0.0005
0
0.0005
0.001
0.0015