THE ROLE OF HEDONIC METHODS IN MEASURING REAL GDP IN THE UNITED STATES

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Abstract

Accurate price indexes are crucial for preparing accurate estimates of real gross domestic product and corresponding productivity measures. The price index must capture price change for a ‘relevant’ market basket goods, while at the same time controlling for changes in characteristics and/or quality of these goods. Traditional price indexes (i.e. ‘matched model’) are well suited to capturing price change for goods that exhibit little or no quality change over time, however, for products whose characteristics and/or quality are changing rapidly (e.g. ICT goods), hedonic methods may be more suitable.

This paper provides a brief history of hedonic methods employed by U.S. statistical agencies and specifically examines the role of hedonic price indexes in the U.S. National Income and Product Accounts. It also attempts to dispel some popular misconceptions about hedonic methods.

[1] The views expressed in this paper are those of the authors and do not represent an official position of the Bureau of Economic Analysis.

1. Introduction

The question is often asked, 'What is the impact of hedonic price indexes on measures of real GDP growth?' However, before one can attempt to answer this question, we must first answer the question, 'What is the impact of hedonic methods on price indexes?' It is often asserted that hedonic methods always result in a lower rate of price change than traditional 'matched model' methods and therefore overstate real GDP growth. However, there have been several studies in which the hedonic index has increased at a higher rate. Hedonic indexes share the same objective as traditional price indexes—to measure the rate of price change excluding (or holding constant) the effects of changes in quality. Both hedonic methods and traditional methods can be appropriate methods, depending on the circumstances. What is important is which method(s) yield the best price index for a given product.

Clearly, traditional matched model price indexes encounter problems when measuring price change for goods with rapidly changing quality and/or characteristics. One such problem is that the price changes observed for the matched models may not accurately reflect price changes for all models. That is, any new models that reflect the newest technology and therefore have different specifications will not be reflected in the matched model simply because they cannot be 'matched' to a model in the period prior to their introduction. For some types of products, particularly information and communication technologies (ICT) products, these models can represent a significant market share. A second problem with the implementation of a traditional matched model approach is that a model may be 'matched' to a model that is not in fact an exact 'match,' leading to a distorted price change. Hedonic methods address these challenges in a relatively systematic and objective way.

In this paper, we will first provide a brief history of hedonic price indexes, followed by a discussion on the hedonic price index basics. Next we'll discuss the impact of hedonic price indexes on measuring real GDP, with a specific focus on computers and peripheral equipment. We also address some common misconceptions about hedonic price indexes and then provide some concluding remarks.

2. A Brief History of Hedonic Price Indexes

The origin of hedonic methods in U.S. official price statistics goes back to the famous article by the late Zvi Griliches (1961) that was published in the report of the Price Statistics Review (Stigler) Committee. Although Waugh (1928), Court (1939) and Stone (1954, 1956) preceded Griliches in developing and applying hedonic techniques,[1] the work of Griliches was original in the following sense defined by Stigler (1955) when he wrote, 'Scientific originality in its important role should be measured against the knowledge of a man's contemporaries. If he opens their eyes to new ideas or to new perspective on old ideas, he is an original economist in the scientifically important sense.' In this sense, the work of Griliches (1961) was surely original—as Lipsey (1990) observed, he took an unconventional method that was then on periphery of price statistics and demonstrated to the economics and statistics community that it could be used to address critical quality adjustment problems that previously had been considered intractable.

[1] It was in fact Court who coined the term 'hedonic pricing method' while developing price measures for automobiles in the late 30's. Court reasoned that using changes in average list prices would not account for the increased 'welfare and happiness' that society as a whole experienced with the rapid improvements in automobiles. His method took this 'welfare and happiness' of society into account by relating model prices to those characteristics that lead to consumer happiness (e.g. power, speed, interior room) and therefore became known as the 'hedonic pricing method.'

Following Griliches, hedonic methods quickly grew to be a new branch of economic research, which is now far too vast to be easily surveyed. Articles that provide overviews of some of this literature include Griliches (1971, 1990), Triplett (1975, 1987, 2000), Berndt (1983, 1991) and Bartik and Smith (1987). We will leave it to others to comment on this literature, except to note that there have been a number of theoretical and empirical controversies. As Triplett (1990) observed, however, many of these controversies have counterparts in the traditional literature on economic index numbers—issues such as aggregation across individuals in constructing a social cost-of-living index, imperfect competition in constructing an output price index, and problems in separating demand shocks from supply shocks. Our view, which echoes Triplett's, is that all quality adjustment methods are imperfect, but regardless of these imperfections, statistical agencies need to do a better job of quality adjustment, and so these controversies should not prevent agencies from using hedonic methods as one tool in quality adjustment. Many years passed before the economic literature had much impact on the U.S. official price statistics.

2.1. Hedonic Price Index History for BEA

In the mid-1980's BEA collaborated with IBM to develop quality-adjusted price indexes for computers and peripheral equipment. The BEA-IBM price indexes for computer equipment and peripherals were introduced into the national income and product accounts in December 1985 (Cole et al. 1986; Cartwright 1986; Triplett 1986). The original indexes covered five types of computing equipment—computer processors, disk drives, printers, displays (terminals), and tape drives for the period 1972-84. Subsequently, a price index for personal computers was added, and a separate index was created for computer imports. The history and present status of the indexes are documented in U.S. Department of Commerce (2000).

It is interesting to note that the problem BEA addressed in its collaborative effort with IBM was more than just obtaining an improved method of quality adjustment. Prior to 1985, BEA simply had no acceptable price index for computers, so computers had been deflated by an index that was equal to 1 for all periods.

In the early 1990's, BLS began publishing quality-adjusted producer price indexes (PPI's) for computers and peripheral equipment. As these PPI's became available, BEA used them to extrapolate the BEA computer price indexes. Eventually, BLS indexes were used for all of BEA's quality-adjusted computer price indexes.

The BEA computer price indexes show notable declines for all periods; for 1959-2005, the average rate of price change for private fixed investment in computers and peripheral equipment is –16.9 percent per year. Although skeptics have occasionally questioned the rapid price declines, the BEA index has stood the test of time. Scholarly studies have generally found similar rates of price decline (for example, see Berndt, Dulberger, and Rappaport 2000; Aizcorbe, Corrado, and Doms 2000). Several other countries now regularly use the BEA computer price indexes to deflate the computer components of computer imports and capital formation in their own national accounts.

BEA's next hedonic index was the price index for multifamily residential structures (de Leeuw, 1993). The issues for multifamily housing were the same as those for single family housing—severe heterogeneity in the characteristics of housing units leading to the use of an inadequate proxy as a deflator. Considerable research was undertaken before an acceptable hedonic function was identified. The Census Bureau has generously assisted BEA in developing and maintaining this index.

After BEA introduced its quality-adjusted computer price index, a frequently mentioned criticism was that use of the index led to inappropriate measures of value added in the construction of computers because the prices of important inputs, such as semiconductors, were not similarly quality adjusted. In January 1996, BEA introduced new quality-adjusted price indexes for semiconductors, based on indexes for several types of memory chips and microprocessors that were developed by Grimm (1998). In the case of memory chips, Grimm used hedonic methods as a guide to constructing a matched model index. In the case of microprocessors, the hedonic function was used with the matched model to form a composite index, as described earlier.

In 1997, BEA introduced a hedonic price index for digital telephone switching equipment (Grimm 1996; Parker and Seskin 1997). The hedonic regression used data from the filings by regional telephone operating companies with the Federal Communications Commission and incorporated characteristics such as the location, type, and capacity of the switch (number of telephone lines).

In 1999, BEA expanded its concept of capital in the national accounts to recognize expenditures for software as fixed investment (Moulton, Parker and Seskin 1999). Because quality-adjusted price indexes for software did not then exist, BEA developed hedonic indexes for a portion of pre-packaged software—specifically, for spreadsheets and word processing programs (Parker and Grimm 2000). Because these types of software represent only a portion of pre-packaged software, the hedonic indexes were averaged with matched model indexes to form the pre-packaged software price index. Because data for estimating the hedonic function were available only for 1985-93, bias adjustments were applied to the matched model index for subsequent years.

In 2003, BEA introduced a hedonic price index for photocopying equipment (Wasshausen 2003). The hedonic regressions were biennial (to allow for changes in parameters over time) using data purchased from a trade source and incorporated characteristics such as copy speed, color capability, multi-functionality capability and recommended maximum copy volume.

In 2005, BEA hired a contractor to develop an improved price index for custom software. (The current price index is primarily a cost-based index that assumes roughly zero growth in multifactor productivity.) The contractor developed a number of price indexes for custom software using proprietary data on thousands of custom software projects. Custom software is a good example of a product where traditional matched model methods will simply not work. Custom software, by its nature, cannot be effectively matched from one observation to another. Accordingly, a hedonic price index based on biennial regressions where price was a function of project type and size, software type, software quality and fixed effects of clients was recommended (Goldfarb, Heller, White and Abel 2006). BEA has purchased updated proprietary data that was used in this study and is continuing to analyze whether or not this data may yield an improved custom software price index using hedonic methods.

In addition to developing several hedonic price indexes in-house, BEA uses the consumer, producer, import and export price indexes produced by BLS, the Census construction price indexes, and prices from several other agencies in deflating the national, regional, and industry accounts. In several cases, BEA has also back-cast or made bias adjustments to indexes that have been shown to be biased, thereby maintaining a more consistent time series.

3. Hedonic Price Index: Basics

The term 'hedonic methods' refers to the use in economic measurement of a 'hedonic function,' $h(\ )$,

(1) $p_i = h(c_i)$,

where p is the price of a variety (or model) i of a good and c_i is a vector of characteristics associated with the variety. The hedonic function is then used in one of several ways to adjust for differences in characteristics between varieties of the good in calculating its price index. The hedonic function is usually estimated by regression analysis.

There are basically two techniques for constructing a hedonic price index. The first technique, which we will refer to as the 'regression price index,' uses estimated coefficients on year dummy variables to estimate price change. For example, the hedonic function for photocopying equipment is as follows:

$$\mathrm{P} = \beta_0 + \beta_{MCS} x_{MCS} + \beta_{Color} x_{Color} + \beta_{MF} x_{MF} + \beta_{MV} 1 x_{MV} 1 + \beta_{MV} 2 x_{MV} 2 + \beta_t x_t + \mu$$

Where:

- 'P' is the natural log of price, 'μ' is the error term and 'β_0' is the constant.
- x_{MCS} is the natural log of copy speed.
- x_{Color}, x_{MF}, x_{MV1}, and x_{MV2} are dummy variables capturing the effect of color, multi-functionality and recommended copier volume.
- x_t is a dummy variable that captures the effect of time.

The estimated coefficient on x_t (β_t) represents the percent change of a constant-quality price in period 't'. That is, the change in price that is *not* explained by differences in speed, color, multi-functionality, or recommended copier volume (characteristics believed to account for 'quality') since they are controlled for within the equation.

The second technique for constructing a hedonic price index employs a mix of hedonic and matched model methods. These price indexes are sometimes referred to as 'composite price indexes.' Here, the matched model technique is used as much as possible. Only when a new model is introduced do we need to rely on hedonic methods. The BLS producer price index (PPI) for portable computers is a good example of this technique. Consider the following hypothetical example:

Assume the hedonic function for portable computers is a linear function as follows:

$p_i = h(ps_i,\ hds_i\ \&\ mem_i)$,

where '*p*' is the price, '*ps*' is processor speed, '*hds*' is hard drive size and '*mem*' is the amount of memory. In period '*t-1*' portable computer model *123*, which has an 80 GB hard drive with 512 MB of memory and a processor speed of 2000 MHz, has a reported price of $1000. In period '*t*' model *123* has been replaced with model *123A* and the only differences between the two is that model 123A has an increased processor speed of 2100 MHz and now costs $1200. Assume the estimated coefficient on *ps* is 3.5 ($/MHz), therefore the increase in processor speed can be quantified in dollars as (2100 MHz– 2000 MHz) * 3.5$/MHz = $350. The quality-adjusted (QA) price change is calculated as ($P_{(t)}$ – QA) / $P_{(t-1)}$ or ($1200 – 350) / $1000, or -15 percent.

Table 1 – Portable Computers Example

	Model 123, period 't-1'	Model 123A, period 't'	Estimated coefficient	Quality Adjusted Model 123A, period 't'
Price	$1,000	$1,200	---	$850
Processor speed	2000 MHz	2100 MHz	3.5	$350
Hard disk size	80 Gb	80 Gb	---	---
Memory	512 MB	512 MB	---	---

BLS has other alternatives to using hedonic functions for dealing with changes in quality, however these methods rely on, perhaps, more subjective analysis. For example, one alternative used by BLS is to ask the respondent to provide a dollar estimate of the change in quality embedded in the new product.

There is an additional fundamental difference between these two hedonic techniques which lies in the weighting of the observations. In the 'regression price index,' the individual observations are essentially unweighted while the 'composite price index' reflects a weighted average of observations. Aizcorbe and Pho (2005) examined this issue of aggregating detailed observations for over 60 classes of consumer electronic and IT goods and found that differences in the weights do matter.

4. Impact of Hedonic Price Indexes on Measuring Real GDP

Hedonic price indexes are used to deflate a number of GDP final demand components, accounting for about 20 percent of nominal GDP in recent years. (See appendix A for a table presenting the components of GDP that are deflated with hedonic-type price indexes.) It should be noted that not all of these price indexes reflect hedonic methods for all years. In many cases, source data used to construct the hedonic function are not available for all years and a bias-adjustment is used to account for quality changes that may not be reflected in a traditional matched model price index. For example, the price index for prepackaged software reflects hedonic methods for years 1985-93; years 1994-present reflect a matched model price index with a bias-adjustment.

For many of the 'hedonic components' the difference between the matched model price and the hedonic price index is small and somewhat offsetting. For example, the introduction of hedonic price indexes by BLS slightly raised the rate of price increase for VCR's and for rent but slightly lowered it for televisions.

The main component in which hedonic methods have had a significant impact is computers and peripheral equipment. Focusing on private fixed investment in computers and peripheral equipment, the average annual price decline from 1990-2005 is 16.0 percent, although the rates of decline appear to be slowing down in more recent years (average annual decline for years 2001-2005 is 11.1 percent). Several previous papers and articles have examined the robustness and validity of hedonic computer price indexes, including a comprehensive literature review by Berndt and Rappaport (2000). Berndt and Rappaport's review compared rates of decline for PC's and Mainframes estimated by a dozen or so hedonic price index experts. Naturally there was some variation in reported declines over varying time periods, however, when detailed components are compared over similar periods the results are consistent, including BEA's computer price index.

There is evidence that a 'well constructed' matched model index for rapidly changing high-tech goods could yield a price index that adequately controls for quality differences and that this price index is consistent with a quality-adjusted price index constructed using hedonic methods. Aizcorbe, Corrado, and Doms (2003) constructed price indexes for microprocessors using high frequency disaggregated data on models whose characteristics were constant over time and found that their matched model price indexes were remarkably close to those constructed using hedonic methods (table 2). Similar results were reported in Aizcorbe, Corrado, and Doms (2000) for personal computers. Silver and Heravi (2001, 2002) report similar findings using scanner data for washing machines and televisions. However, given that we often do not have the abundant data necessary to construct such a matched model price index, then the hedonic price index is the practical approach for measuring prices of rapidly changing goods or goods that by nature are heterogeneous (e.g. custom software or homes).

Table 2 – Matched Model vs Hedonic Price Indexes

	Percent		
	Matched Model	Hedonic	Difference
Aizcorbe et al.:[1]			
Desktop personal computers, 1993:I to 1998:IV	-30.3	-28.2	2.1
Notebook computers, 1993:I to 1998:IV	-24.9	-22.8	2.1
Microprocessors, 1993:I to 1999:IV	-18.0	-18.2	-0.2

[1] Source for desktop and notebook computers: Aizcorbe et al. 2000. Source for microprocessors: Aizcorbe et al. 2003.

Ideally, in order to measure the impact of hedonic price indexes on real GDP, we would have a second set of traditional matched model price indexes for all goods that are deflated using hedonic price indexes and we would re-compute real GDP using this second set of price indexes and then compare growth rates. Unfortunately this approach is not possible due to resource constraints. Borrowing from an analysis presented by Landefeld and Grimm (2000) we have prepared a shortcut one can take to estimate the affect that the hedonic quality-adjustment process for computers and peripheral has on measuring real GDP. Table 3 below shows that the average annual change in unit value for single-user computers over the years 2001-2005 is -4.9 percent. This estimate, which does not take any changes in quality into account, is derived from shipments data published in the 'Current Industrial Reports' by the U.S. Census Bureau (http://www.census.gov/cir/www/alpha.html). The NIPA private fixed investment quality-adjusted price index for single-user computers (a.k.a. PC's) shows an average rate of decline 16.4 percent over the same years. The difference in the two declines is 11.5 percent, which can be characterized as the affect of quality-adjusting the PC price index. Assuming this estimated 'quality adjustment' difference for PC's is representative of all types of computers and peripheral equipment (or provides an upper bound estimate which is reasonable given that the price index for PC's declines on average more rapidly than any of the other component) we can approximate the impact that hedonic quality adjustment has for all computers and peripheral equipment by multiplying the 11.5 percent 'quality-adjustment' difference by the average nominal share of final sales of computers to GDP (about 0.8 percent). The results of this exercise shows that the estimated impact of the hedonic quality adjustment is less than 0.1 percentage point of average annual real GDP growth over the period.[1] This exercise is not intended to mitigate the role that hedonic methods have in constructing high quality price indexes; rather it is intended to illustrate that one should not attribute periods of robust real GDP growth, at least for the United States, to the use of hedonic methods to estimate quality-adjusted price indexes.

Table 3 – PC Prices: Average Annual Changes, 2001-05

	Percent
Census CIR average unit values	-4.9%
NIPA private fixed investment price index	-16.4%
Estimated quality adjustment	-11.5%

5. Misconceptions about Hedonic Price Indexes

The experience of the U.S. statistical agencies may help dispel several misconceptions about the application of hedonic methods. We list a few misconceptions below, in each case following with a brief discussion of the actual experience of applied hedonic methods.

5.1. Quality-adjusted Price Indexes Are Synonymous with Hedonic Indexes

Virtually all methods used to construct price indexes are designed to measure price change holding quality constant (an exception being unit-value indexes, which are not designed to hold quality constant). Hedonic methods hold quality constant by conditioning on characteristics in a regression analysis. There are other techniques, in addition to hedonic methods, for adjusting for changes in quality. For example, BLS may ask the respondent to provide a dollar estimate of the change in quality embedded in the new product and adjust the reported price for that new product accordingly so that it 'matches' the product reported in the previous period. A potential drawback to this technique is that an increase in price may be wholly attributed to the increase in quality. Alternatively, the reported value of the quality change may be based solely on the cost of incorporating that change, without reflecting the value perceived by the customer.) Another quality-adjustment technique, recently adopted by BLS to construct the CPI for computers, is referred to as 'attribute cost adjustment.' In this technique, monetary values for the attributes that affect price (e.g. processor speed, amount of RAM, storage capacity, etc.) are obtained from original equipment manufacturers (OEM), websites and price compiler sites on the Internet and these values are used as the basis to determine appropriate

[1] This calculation implicitly assumes that adjustments to percent changes in prices are exactly offset by adjustments to percent changes in quantities.

quality adjustment amounts.[1] There is evidence that this technique yields results similar to those obtained using hedonic methods. A third technique is to impute a price change for the product that has experienced a change in quality. For this technique to be valid, the statistical agency must develop an imputation strategy that is consistent with the price-setting behavior of the seller. An example of such a strategy is the class-mean imputation method. The class-mean imputation strategy is often used for products where price change is closely associated with periodic introduction of new lines or models (e.g. motor vehicles) and direct quality adjustment is not feasible. With this method, price change is estimated from the price changes of other observations that are going through similar item replacement at the same time and were either quality adjusted directly or were judged directly comparable.[2]

Traditional matched model methods hold quality constant by carefully specifying each variety in the sample and ensuring that exactly the same variety is resampled each period. There can be problems with matched model methods—the samples may be unrepresentative or out of date, the methods used to handle new or disappearing items may be sensitive to unusual price changes that sometimes occur when an item first appears or disappears, or the decisions made by the statistical agency analyst about how to treat the replacement of items in the sample may be faulty. These problems may lead to either upward or downward biases and hedonic methods are important because they can help address some of these problems. Several researchers—for example, Aizcorbe, Corrado and Doms (2003) & (2000)—have observed that matched model methods using good samples with up-to-date weights may give results similar to, or perhaps better than, hedonic methods.

5.2. Hedonic Methods Are Opposed to Traditional (Matched Model) Methods

In fact, most hedonic research at U.S. statistical agencies has led to the opposite conclusion—hedonic research has often led to improvements in sampling methods that have led to better samples, sample replacement strategies, or other improvements in the matched model indexes. The U.S. statistical agencies have found that hedonic analysis is a useful tool, whether used in the background as a guide to application of the matched model methods, or used directly in making quality adjustments for sample items that are being replaced. The articles by Liegey (1993) and Fixler et al. (1999) on the use of hedonics in the CPI for apparel include a number of examples of how hedonic methods can be used in both ways.

5.3. Hedonic Methods Always Result in a Lower Rate of Price Change

Many people think of the rapid decline of the BEA and BLS computer price indexes as representative of hedonic methods. The recently developed hedonic index for LAN equipment of Doms and Furman is another example of an item for which application of hedonic methods led to a much lower rate of price growth. On the other hand, several of the BLS hedonic CPI's have resulted in higher rates of price change—as described above, the hedonic rent indexes were specifically designed to correct for a downward bias. Also, the apparel indexes and, perhaps more surprisingly, videocassette recorders are examples of items for which hedonic methods led to higher rates of price growth.

[1] For more information on how BLS calculates the CPI for computers, please see http://www.bls.gov/cpi/cpifaccomp.htm.

[2] For more information, please see http://www.bls.gov/opub/hom/pdf/homch17.pdf.

5.4. Hedonic Methods 'Solve' the Quality Adjustment Problem

Hedonic regressions are only as good as the data and modeling efforts that go into them. If an important new characteristic has appeared on the market, but is not included in the hedonic regression equation, there is no hope of using the hedonic function to adjust for the improvement in quality. Similarly, just as matched model methods may be biased if samples are out of date or unrepresentative, so also hedonic methods may be biased if estimated using unrepresentative samples. For both hedonic methods and more traditional methods, the statistical agencies must depend on knowledgeable staff who proactively keep track of new products and other market developments.

5.5. Hedonic Methods Are Prohibitively Expensive

Our experience has been that hedonic methods do require time and effort. Probably the most significant issue is collecting prices and detailed characteristics for a representative sample of models or varieties. We found that for a number of items—for example, televisions and rental housing—the data already collected by the statistical agency were perfectly adequate for hedonic analysis. For other items, special data collection or purchases of secondary data may be required; as Fixler et al. (1999) describe, the BLS CPI program is now employing both of these approaches specifically for use in the estimation of hedonic regressions. The actual regression analysis itself is often straightforward, and with training should be within the capacity of statistical agency staff in many countries.

6. Conclusion

Accurate price indexes are crucial for preparing accurate estimates of real GDP and corresponding productivity measures. The price index must be representative of the market and control for changes in characteristics and/or quality of these goods. Traditional matched model price indexes are well suited for capturing price change for goods that exhibit little or no quality change over time, however, for products whose characteristics and/or quality are changing rapidly (e.g. ICT goods) or are heterogeneous by nature (e.g. custom software), hedonic methods may be more suitable. Aizcorbe et al. (2000 and 2003) showed that matched model indexes constructed from highly disaggregated, high-frequency data can yield a price index that is remarkably close to a hedonic quality-adjusted price index constructed from the same dataset. However, such abundant datasets are not always readily available and therefore a hedonic price index may be preferable.

The role of hedonic methods in measuring real GDP has certainly been an important one and has grown significantly over the past 25 years. The incorporation of hedonic methods has sometimes led to higher rates of price decline (e.g. computers and semiconductors) than the traditional matched model price index, and has sometimes led to higher rates of price change (e.g. apparel, VCR's and rent). While we are not able to precisely quantify the affect of incorporating improved prices that use hedonic methods, we did approximate the impact that quality-adjusting computer prices (arguably the most prominent hedonic price indexes with the greatest rates of decline) has on measuring real GDP. The results were minimal – on average less than 0.1 percentage point for years 2001-05.

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Appendix A – Components of GDP that are deflated with hedonic-type price indexes

	2002	2003	2004
	(Billions of dollars)		
Gross Domestic Product	**10,469.6**	**10,960.8**	**11,712.5**
Total hedonic components[1]	**2,240.5**	**2,324.8**	**2,527.9**
Percent of GDP	**21.4%**	**21.2%**	**21.6%**
Computers and peripheral equipment	198.4	201.5	221.4
PES	77.2	77.8	82.3
Exports	38.6	39.9	42.8
Imports[1]	75.2	76.5	88.6
Government	7.5	7.2	7.7
Software	90.4	92.5	98.9
PES	80.4	82.3	88.6
Government	10.0	10.2	10.3
Structures	543.4	584.5	673.5
Private residential	297.2	344.0	416.3
Private nonresidential	156.0	148.7	161.1
State and local government	90.2	91.8	96.0
Telecomuications	19.2	15.0	14.6
PES	19.2	14.9	14.5
Photocopiers	2.4	3.0	2.8
PES	0.7	0.7	0.2
Exports	0.5	0.5	0.5
Imports[1]	1.1	1.8	2.0
Audio & Video	52.1	53.1	56.8
PCE			
Private Residential Equipment Investment	0.3	0.3	0.3
Apparel	242.9	247.9	262.4
PCE	242.9	247.9	262.4
Household appliances	32.0	32.8	35.3
PCE	27.0	27.7	29.9
Private Residential Equipment Investment	5.0	5.1	5.5
Rent	1,056.8	1,091.6	1,159.0
PCE			
Education writing equipment	3.0	3.0	3.2
PCE	3.0	3.0	3.2

[1] import are included as a positive since we are identifying the total dollar amount that is deflated with hedonic-type price indexes.
PES – Private fixed investment in equipment and software
PCE – Personal consumption expenditures