Measuring the Substitution Effect in Producer Price Index Goods Data: 202-1016 November 2019

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Abstract

The Bureau of Labor Statistics calculates the US Producer Price Index using a modified Laspeyres formula that employs fixed quantities as weights but allows prices to vary over time. Having fixed quantities as weights imposes a restriction on substitution in response to relative price change. This paper examines the effects of the substitution restriction by re-estimating select Final Demand-Intermediate Demand (FD-ID) PPIs from 2002 through 2016 on an annual basis using fixed-based Fisher and Tornqvist formulas, both of which allow for substitution. These experimental FD-ID indexes are calculated from annual average values of commodity indexes with weights updated annually. Subsequently, the experimental indexes are compared to the same indexes calculated using the fixed-based Laspeyres formula. The paper will demonstrate that, in general, the experimental FD-ID indexes calculated using formulas that allow for substitution result in lower in index values than those calculated using the Laspeyres formula, implying substitution toward relatively less expensive products.

Key Words: Producer Price indexes, index bias, substitution effect

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1. Introduction

Producer Price Indexes (PPIs) measure the average change in prices received by domestic producers for their marketed output. The principal PPIs used for analyzing high-level inflation, and the focus of this study, are the Final Demand-Intermediate Demand (FD-ID) prices indexes. Final Demand PPIs measure price change for outputs sold as personal consumption, as capital investment, to government, and as exports. Intermediate Demand PPIs measure price change for outputs sold to businesses as inputs to production, excluding capital investment.

PPIs are calculated using a modified Laspeyres formula. The modified Laspeyres formula employs fixed quantities (over a five-year period) as weights but allows prices to vary monthly. Having fixed quantities as weights imposes a restriction on substitution in response to relative price change, causing PPI data not to reflect the substitution effect. The substitution effect is the effect on price measurement of shifts in production and purchase patterns in response to relative price changes. This paper examines the substitution effect in PPI data by re-estimating select FD-ID PPIs from 2002 through 2016 *on* an annual basis using fixed-base Paasche, Fisher, and Tornqvist formulas. To measure the substitution effect, the indexes calculated using Fisher and Tornqvist formulas (both of which allow for substitution) are compared to comparable indexes calculated using a Laspeyres formula. Importantly, there are no clear expectations as to the direction of the substitution effect. In theory, purchasers tend to shift towards relatively less expensive

products in an effort to reduce costs or increase utility, whereas producers tend to shift towards relatively higher priced products to maximize profits. The substitutions actually observed in the market are the net result of producer and purchaser responses to price change that, again, in theory, work in opposite directions.

There have been a number of studies that analyze the substitution effect using consumer price data. These studies typically find that the dominant effect is consumers substituting towards relatively cheaper products. For example, Braithwiat (1980) measures the substitution effect by comparing a Laspeyres index to a cost of living index from 1958 through 1973. Using annual price and quantity data Braithwiat found that, over the entire fifteen-year period, the Laspeyres index overstated inflation by approximately 1.5 percent as compared to the cost of living index (about 0.1 percent per year). By examining detailed product categories within personal consumption, Braithwait also found that the substitution effect varies by class of product. The substitution effect for recreation and entertainment products, for example, was approximately 3.9 percent from 1958 through 1973, whereas the effect was only 0.1 percent for housing and utilities over the same period. Manser and McDonald (1988) examine the substitution effect by constructing and comparing fixed-base Laspeyres and Paasche indexes to Tornqvist and Fisher indexes using personal consumption data for 101 commodities from 1959 through 1985. They find that, over the entire period, the Laspeyres index overstated inflation approximately 15.7 percent as compared to the Tornqvist index, which is approximately 0.19 percent per year. Aizcorbe and Jackman (1993) measure the substitution effect in the CPI by calculating fixed-base and chained Laspeyres indexes from 1982 through 1991 and comparing those values to fixed-base and chained Tornqvist and Fisher indexes. The indexes are calculated using weights based on annual consumer expenditure data for 207 product categories. The authors estimate the Laspeyres index exceeds the Tornqvist index by 3.4 percent from 1982 through 1991, which is approximately 0.2 percent per year.

In contrast to consumer price data, very little work exists examining the substitution effect in using producer price data. Waehrer (2000) cites a working paper by Galvin and Stewart (1998) in which the authors calculate high-level PPI commodity indexes from 1987 to 1992 using both Laspeyres and Paasche formulas. For thirteen of the fifteen commodity groupings examined, the Laspeyres index increased more than the Paasche index, indicating substitution into relatively cheaper products. Like Galvin and Stewart, this study examines the substitution effect using producer price data. Examining the substitution effect using producer price data, as opposed to consumer price data, is important because doing so allows for analysis of substitution patterns at an earlier point in the supply chain. The paper demonstrates that the experimental FD-ID indexes calculated using formulas that allow for substitution generally result in lower index values than those calculated using the Laspeyres formula, implying the effect of substitution toward relatively less expensive products dominates the effect of substitution towards more expensive products.

2. Methodology

The PPI program's FD-ID indexes are high-level price indexes that measure output price change for products sold to final demand (personal consumption, capital investment, government, and export) or intermediate demand (business inputs). The FD-ID indexes are not constructed directly from price data but are instead calculated by combining detailed PPI commodity indexes. PPI commodity indexes are lower-level price indexes that measure price change for specific products. (For example, beef and veal, processed

poultry, unleaded regular gasoline, hardwood lumber, or automobiles.) Commodity indexes are calculated directly from detailed price data using a modified Laspeyres formula, where weights are derived from data collected from survey respondents. To construct the FD-ID indexes, commodity indexes are aggregated into higher-level price indexes using a modified Laspeyres formula. Aggregation weights are based on value of shipments data from the quinquennial Economic Census and "Use of commodities by industry" data from the Bureau of Economic Analysis. PPI updates the weights used to calculate the FD-ID indexes every five years.

To analyze the substitution effect in PPI data, experimental FD-ID goods indexes are estimated on an annual basis from 2002-2016 using fixed-base Laspeyres, Paasche, Fisher, and Tornqvist formulas. (This study focuses on goods because an annual weight source is more readily available than for other portions of the economy.) The experimental FD-ID indexes are estimated from annual average values of 662 component PPI commodity indexes. The component commodity indexes are those calculated by PPI using their standard modified Laspeyres index formula. The FD-ID index calculation formulas can be written as follows:

$$(1) \quad I_L^t = \sum_{i=1}^{n} RI_i^0 \left(\frac{P_i^t}{P_i^0}\right)$$

$$(2) \quad I_P^t = 1/\sum_{i=1}^{n} RI_i^t \left(\frac{P_i^0}{P_i^t}\right)$$

$$(3) \quad I_F^t = (I_L^t + I_P^t)^{1/2}$$

$$(4) \quad I_T^t = \prod_i \left(\frac{P_i^t}{P_i^0}\right)^{w,t}$$

where the subscript i denotes each of the n component commodities included the index calculation, I_L^t is the Laspeyrers index at time t, I_P^t is the Paasche index at time t, I_F^t is the Fisher index at time t, I_T^t is the Tornqvist index at time t, $RI_i^0$is the relative importance of component index i in the base period, RI_i^t is the relative importance of component index i in period t, P_i^t is the component index value in period t, and $P_i^0$is the component index value in the base period, and $w,t = \frac{1}{2}(RI_i^0) + \frac{1}{2}(RI_i^t)$. The relative importance for component i in period t is calculated as:

$$(5) \quad RI_i^t = \frac{VOS_i^t}{\sum_{i=1}^{n} VOS^t}$$

where VOS_i^t is the value of shipments for commodity i in period t.

Statistical agencies, including the US Bureau of Labor Statistics, often use Laspeyres indexes to measure price change because doing so only requires base period value of shipment data for weighting. (Current period value of shipments data is typically not available in a timely manner.) As noted earlier, however, using base period weight data imposes a restriction on substitution in response to relative price change. In contrast, the Fisher and Tornqvist indexes use current period value of shipments data for weighting. By also using current period value of shipment data for weights, the Fisher and Tornqvist indexes relax the substitution restriction imposed by the Laspeyres index. The Fisher and Tornqvist indexes are superlative indexes and are generally considered better approximations of the theoretical indexes that PPIs are based on. Assuming that a superlative index (such as the Fisher or Tornqvist) is a better measure of producer price

change than a non-superlative index, a measure of the substitution effect can be obtained by comparing the superlative to the non-superlative Laspeyres index.

To construct the indexes in equations 1 through 4, it is first necessary to develop annual weights for the component indexes. Value of shipments data from the annual Census of manufacturing are used to develop weights for the manufacturing sector commodities. Weights for agricultural products are developed from annual Census of Agriculture, and finfish and shell fish weights are constructed using data from the National Oceanic Atmospheric Administration Fisheries of the United States report. An annual weight source for mining and utilities weights is not available. To overcome this problem, Census data are used when available (every five years) and the missing years are estimated by multiplying the Census data by the appropriate annual changes in the Federal Reserve's indexes for industrial production (to account for quantity changes) and then by the annual change in PPIs (to account for price change). The Census, industrial production, and PPI data are all available in a form classified according to the NAICS. Missing Census values are therefore estimated using the closest matching NAICS-based indexes for industrial production and producer prices. Subsequent to developing weights, the FD-ID indexes are estimated using formulas 1 through 4. In cases where a component index value is missing, the missing index is estimated using the closest available substitute index.

It is important to note that the design of this study only allows for the estimation of the substitution effect based on substitution across PPI commodity categories and not within commodity categories. When calculating the experimental superlative FD-ID indexes, the formulas used to aggregate commodity indexes allow for substitution, thereby enabling the examination of the substitution effect across commodities. The component commodity indexes, however, are calculated using a Laspeyres formula, which restricts substitution in response to relative price change. This study therefore only examines substitution effect of responses to relative price change across commodities.

3. Results

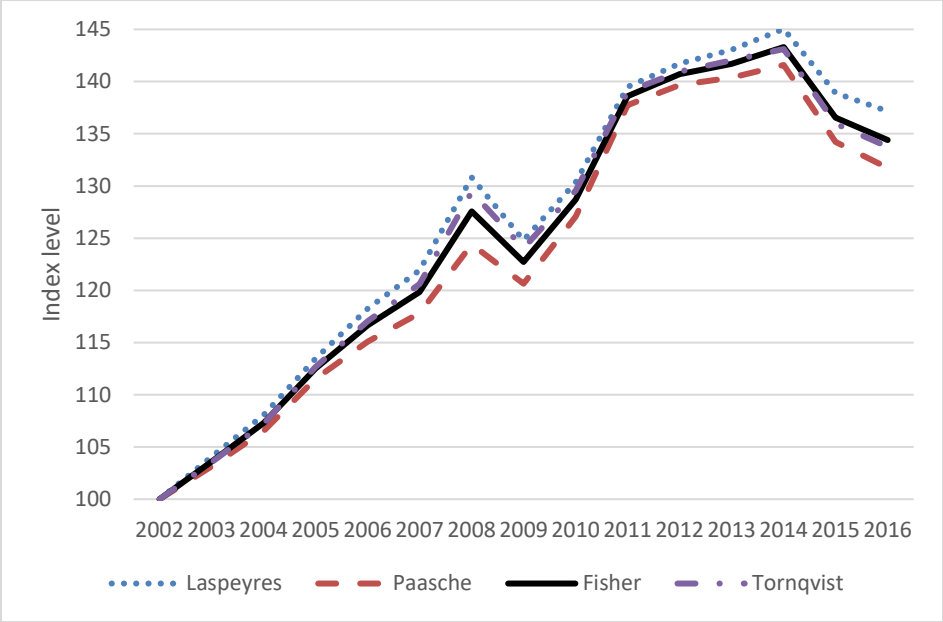
To analyze the substitution effect, both long tem index trends and short term index movements are examined.

3.1 Long Term Analysis

Figure 1 presents the index for final demand goods from 2002 through 2016 calculated using Laspeyres, Paasche, Fisher, and Tornqvist formulas. For final demand goods, the Laspeyres index is higher than the Paasche index over the entire 14-year period and the Fisher and Tornqvist are very close to each other, falling between the Laspeyres and Paasche indexes. The gap between the Laspeyres and Paasche indexes is generally growing throughout the sample, but does narrow during the 2009 to 2011 period. Over the entire time period, the Laspeyres index rose 37.1 percent while the Paasche index increased 31.7 percent. Both the Fisher and Tornqvist indexes rose approximately 34 percent. The substitution effect, calculated by subtracting the Tornqvist index from the Laspeyres index, is positive and approximately 3.4 percent over the 14-year period, indicating that the Laspeyres index overstates inflation 0.18 percent per year. These findings for final demand goods are very similar to the findings of Manser and McDonald (1988) and Aizcorbe and Jackman (1993) who estimate the substitution effect to be 0.19 and 0.2 percent annually, respectively, using consumer data. Although the PPI for final demand measures price change based on price producers receive, it measures price change to specific types of

buyers: consumers, government, capital investors, and foreign purchasers of US exports, with sales to consumers being the largest component. In this way, the PPI for final demand is very similar to an index measuring price change from the purchaser's perspective. The positive sign of the substitution effect implies that purchaser substitutions into relatively less expensive products tend to dominate producer substitutions into relatively more expensive products. A possible cause of this observed pattern of substitution would be that supply shifts are occurring more frequently than demand shifts during the sample period.

Figure 1: Final demand goods 2002-2016



The indexes for processed goods for intermediate demand and unprocessed goods for intermediate demand differ from the index for final demand in that they measure price change for goods sold to businesses as inputs to production, as opposed to end users. The processed goods for intermediate demand measures price change for goods that have undergone some level of fabrication and are purchased by businesses as inputs to production. The unprocessed goods for intermediate demand measures price change for business purchases of un-fabricated goods. Figures 2 and 3 present the intermediate demand indexes from 2002 through 2016 calculated using Laspeyres, Paasche, Fisher, and Tornqvist formulas.

For processed goods for intermediate demand, the Laspeyres index is generally higher than the Paasche index, with the exceptions in 2008 and 2009. Likewise, for unprocessed goods for intermediate demand the Laspeyres indexes is higher than the Paasche index except in 2009, 2010, 2013, and 2014. Over the entire 14-year period, the Laspeyres index for processed goods for intermediate demand rose 143.1 percent, while the Tornqvist version increased 141.8 percent. The Laspeyres index therefore overstated inflation an average of 0.07 percent per year relative to the Tornqvist index. The Laspeyres version of the index for unprocessed goods for intermediate demand increased 154.5 percent from 2002 through 2016, while the Tornqvist version moved up 150.8 percent. The Laspeyres index thereby

overstated inflation by 3.7 percent, or 0.18 percent per year, as compared to the Tornqvist index over the full sample.

Figure 2: Processed goods for intermediate demand 2002-2016

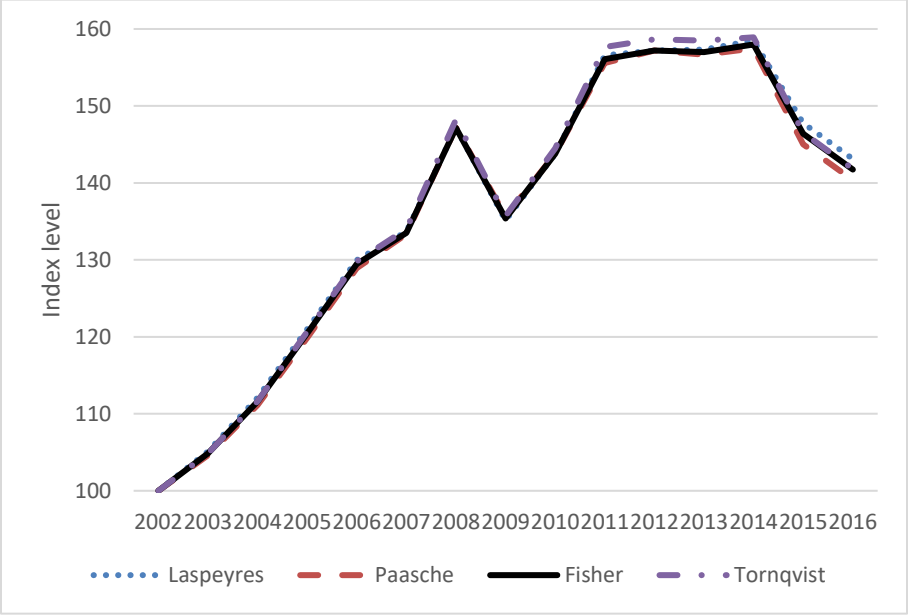
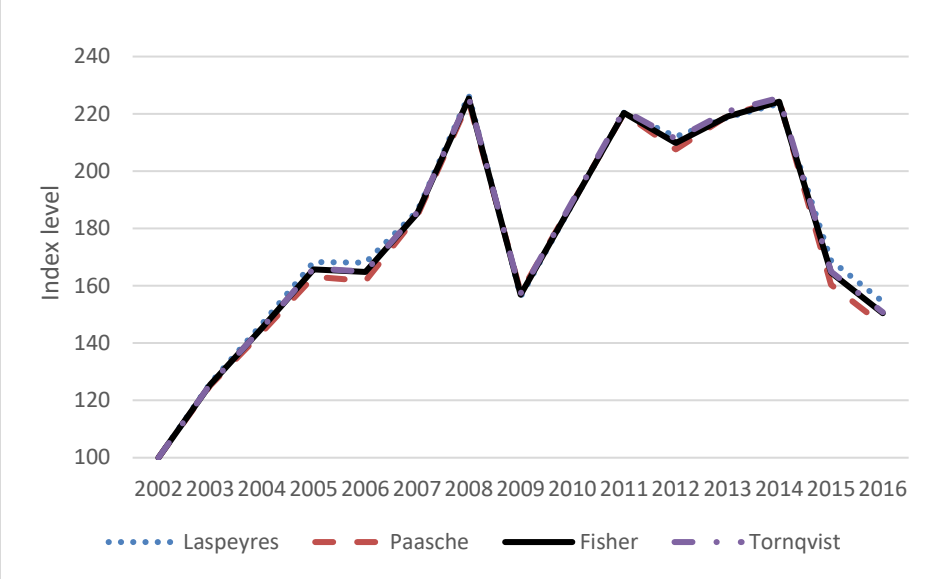


Figure 3: Unprocessed goods for intermediate demand 2002-2016



As evidenced by both the index for final demand and intermediate demand indexes, the substitution effect seems to differ during the Great Recession and subsequent recovery period from the rest of the sample. (The Great Recession began at the end of 2007 continued through mid-2009, but the economy continued to slowly return to a more normal state for a number of years after the recession, with unemployment not falling below 5

percent until late in 2015.) For final demand, the Tornqvist index is always lower than the Laspeyres index, but the two indexes became closer during the Great Recession. The Tornqvist version of the index for processed goods for intermediate demand actually exceeds the Laspeyres version from 2007 through 2014. In all years prior to the Great Recession, and after 2014, the Laspeyres version of the index for processed good for intermediate demand exceeds the Tornqvist version. A similar effect is found in the index for unprocessed goods for intermediate demand. Shoemaker (2013) also notes this effect when comparing the chained CPI-U (calculated using a Tornqvist formula above the elementary level) to the regular CPI-U (calculated using a modified Laspeyres formula above the elementary level), observing that during 2008 the annual rate of change in chained CPI-U was higher than the regular CPI-U. An area of possible further research would be to examine how the substitution effect changes during recessions.

Long-term analysis of the substitution effect shows clear evidence of substitution towards relatively less expensive products in final demand and some evidence of the same effect in intermediate demand (although not during the Great Recession and recovery period). In general, the substitution effect seems stronger in final demand than intermediate demand, which may imply that it is easier for final demand purchasers to shift their purchases across commodities than for businesses to shift their inputs across commodities.

3.1 Short Term Analysis

The previous section examined the substitution effect over the long term. PPI data, however, is often analyzed over mush shorter periods. For that reason, this section examines the substitution effect on an annual basis. Aizcorbe and Jackman (1993) note that, when conducting short-term index analysis, measurement of short term change using the ratio method (by forming ratios of the index in the two periods of interest) is valid for Laspeyres indexes but not for many other formulas, such as the Fisher or Paasche. Instead, the true method for measuring change must be calculated from the correct formula, using the earlier comparison period as the base. For example, the following formula would be used to calculate a percent change between periods t and t+k, using a Paasche index:

$$(6)\quad PCI_P^{t,t+k} = 1/\sum_{i=1}^{n} RI_i^t \left(\frac{P_i^{t+k}}{P_i^t}\right)$$

where $PCI_P^{t,t+k}$ is the percent change in the Paasche index from t to t+k.

Table 1 presents annual changes in FD-ID goods indexes calculated from the Laspeyres, Paasche, and Tornqvist indexes. The table includes percent changes calculated using both the ratio and true methods for the Laspeyres indexes. The true percent change is calculated from the Laspeyres formula (where the earlier comparison period is the base period) and the ratio version is calculated by forming ratios of the index in the two periods of interest. Table 2 presents estimates of the substitution effect, where the substitution effect is estimated by subtracting the annual change in the Tornqvist index from the Laspeyres index. The substitution effect is calculated for both the true and ratio versions of the indexes.[1]

The short-term analysis provides additional evidence that the Laspeyres index is biased upward relative to the Tornqvist index in both final demand and intermediate demand PPI data. In the vast majority of cases, the annual rate of change as measured by the Laspeyres versions of the indexes for final demand, processed goods for intermediate demand, and unprocessed goods for intermediate demand is higher than the rate measured by the

[1] For the full set of changes in indexes calculated using formulas method, see Appendices A though C.

Tornqvist index. This is especially true when comparing the true Laspeyres indexes to the Tornqvist indexes. In fact, in no instances is the annual percent change for final demand or the intermediate demand index calculated from the true Laspeyres index lower than that calculated from the Tornqvist index. In some cases the percent changes are equal, but again, this primarily occurs during the Great Recession or in the recovery years. On average, the annual percent changes in the indexes for final demand goods, processed goods for intermediate demand, and unprocessed goods for intermediate demand are 0.16, 0.12, and 0.46 percent, respectively, higher when calculated using the true Laspeyres index as opposed to the Tornqvist index. The annual change in the ratio Laspeyres indexes for final demand, processed goods for intermediate demand, and unprocessed goods for intermediate demand are 0.27, 0.18, and 0.44 higher than that for the Tornqvist indexes.[2]

The short-term analysis of the substitution effect provides relatively clear evidence of substitution towards cheaper goods for both final and intermediate demand. As was also found in the long-term analysis, the substitution effect in the Great Recession seems to differ from the effect in more normal economic times.

Table 1. Annual price changes 2003-2016

Year	FD goods				Processed goods for ID				Unprocessed goods for ID			
	Laspeyres		Tornqvist	Paasche	Laspeyres		Tornqvist	Paasche	Laspeyres		Tornqvist	Paasche
	True	Ratio			True	Ratio			True	Ratio		
2003	4.1	4.1	3.5	3.1	5.1	5.1	4.9	4.6	25.9	25.9	25.6	25.2
2004	3.6	3.8	3.5	3.4	6.4	6.6	6.4	6.3	16.3	16.5	15.7	15.2
2005	4.7	5.0	4.7	4.7	7.8	8.0	7.8	7.8	15.0	14.7	14.4	13.8
2006	4.3	4.2	4.0	3.7	7.7	7.4	7.4	7.2	-0.5	-0.2	-0.9	-1.2
2007	3.0	3.1	2.9	2.7	2.9	2.8	2.8	2.7	11.4	10.7	11.3	11.2
2008	6.9	7.3	6.8	6.7	10.1	10.1	10.1	10.1	22.1	21.8	21.7	21.4
2009	-4.6	-4.6	-5.2	-5.9	-8.4	-8.2	-8.9	-9.4	-30.1	-31.0	-30.7	-31.2
2010	4.7	4.4	4.6	4.4	6.8	6.4	6.6	6.4	21.9	20.7	21.0	20.3
2011	7.2	7.0	7.1	7.0	9.2	8.9	9.1	9.0	18.2	16.9	17.5	17.0
2012	1.5	1.6	1.5	1.5	0.3	0.4	0.4	0.4	-3.6	-3.8	-4.5	-5.4
2013	0.7	0.9	0.7	0.7	0.0	0.1	0.0	0.0	3.9	3.2	3.9	3.9
2014	1.2	1.4	1.2	1.1	0.5	0.7	0.5	0.5	1.9	2.2	1.4	0.9
2015	-4.6	-4.2	-4.8	-4.9	-7.6	-6.8	-7.7	-7.7	-28.7	-24.5	-29.2	-29.7
2016	-1.5	-1.3	-1.6	-1.7	-3.2	-3.1	-3.3	-3.4	-8.8	-8.5	-8.9	-9.2

[2] See appendices A, B, and C for full set of percent changes as measured by formulas.

Table 2: Substitution effect

Year	FD goods		Processed goods for ID		Unprocessed goods for ID	
	True	Ratio	True	Ratio	True	Ratio
2003	0.5	0.5	0.3	0.3	0.3	0.3
2004	0.1	0.3	0.1	0.3	0.6	0.8
2005	0.0	0.3	0.0	0.1	0.6	0.3
2006	0.3	0.2	0.2	0.0	0.4	0.7
2007	0.1	0.2	0.1	0.0	0.1	-0.6
2008	0.1	0.5	0.0	0.0	0.3	0.0
2009	0.6	0.6	0.5	0.8	0.6	-0.3
2010	0.2	-0.1	0.2	-0.2	0.9	-0.3
2011	0.1	-0.1	0.1	-0.2	0.6	-0.7
2012	0.0	0.1	0.0	0.0	0.8	0.7
2013	0.0	0.2	0.0	0.1	0.0	-0.7
2014	0.0	0.2	0.0	0.2	0.5	0.8
2015	0.2	0.6	0.1	0.9	0.5	4.7
2016	0.1	0.3	0.1	0.2	0.2	0.4

3. Conclusion

This paper examines the substitution effect in PPI final demand and intermediate demand goods data by calculating select FD-ID indexes from 2002 through 2016 *on* an annual basis using a fixed-base Laspeyres, Paasche, Fisher, and Tornqvist formulas. To estimate the substitution effect, experimental superlative indexes are compared to fixed-base Laspeyres indexes. The substitution effect is examined using both long-term and short-term index movements.

Based on long-term analysis, the substitution effect from 2002 through 2016, calculated by subtracting the Tornqvist index from the Laspeyres index, is on average 0.18 percent per year for final demand goods, and 0.07 and 0.18 percent, respectively, for the indexes for processed and unprocessed goods for intermediate demand. Short-term analysis also suggests that the substitution effect in the FD-ID goods toward relatively cheaper products. Based on an annual comparison of the true Laspeyres indexes to the Tornqvist indexes, the rate of change in the Laspeyres indexes for final demand goods, processed goods for intermediate demand, and unprocessed goods for intermediate demand, are found to be upwardly biased, respectively, by 0.16, 0.12, and 0.46 percent per year on average.
Both the long- and short-term analyses indicate that the substitution effect differs in the time surrounding the Great Recession. Again, a possible area of future research would be to analyze how the substitution effect differs during periods of recession, periods of high economic growth, and economically normal times. A second area of possible further research would be to extend this analysis to include the services and construction sectors of the economy. As noted earlier, this study focused on goods indexes primarily due to the availability of annual weight data.

Appendix A: Changes in final demand indexes as measured by formulas

Index	Price change from:	Price change to:														
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Laspeyres	2002	100.00	104.07	108.07	113.48	118.26	121.92	130.82	124.81	130.35	139.48	141.73	143.06	145.04	138.89	137.15
	2003		100.00	103.63	108.47	112.92	116.33	124.47	119.24	124.29	132.61	134.76	136.04	137.99	132.52	131.05
	2004			100.00	104.71	109.15	112.33	120.09	114.95	119.78	127.83	129.87	131.09	132.89	127.55	126.07
	2005				100.00	104.29	107.40	114.98	109.73	114.45	122.35	124.33	125.42	127.01	121.54	120.01
	2006					100.00	103.04	110.21	105.34	109.78	117.27	119.26	120.32	121.89	116.79	115.39
	2007						100.00	106.92	102.15	106.40	113.59	115.47	116.44	117.95	112.99	111.60
	2008							100.00	95.35	99.33	106.05	107.76	108.61	110.06	105.29	103.92
	2009								100.00	104.74	112.57	114.23	115.06	116.50	110.37	108.57
	2010									100.00	107.20	108.83	109.66	111.03	105.56	103.90
	2011										100.00	101.53	102.34	103.68	98.74	97.23
	2012											100.00	100.73	101.97	97.22	95.76
	2013												100.00	101.17	96.20	94.66
	2014													100.00	95.37	93.96
	2015														100.00	98.54
	2016															100.00
Paasche																
	2002	100.00	103.13	106.53	111.55	115.07	117.80	124.41	120.65	127.06	137.73	139.68	140.38	141.59	134.21	131.74
	2003		100.00	103.43	108.34	112.00	114.82	121.74	117.29	123.25	133.15	135.06	135.80	136.97	129.99	127.55
	2004			100.00	104.71	108.33	111.17	118.08	113.24	119.02	128.42	130.17	130.85	132.02	125.27	122.83
	2005				100.00	103.68	106.57	113.44	108.38	113.76	122.33	124.25	124.88	126.14	119.85	117.48
	2006					100.00	102.72	109.46	104.20	109.13	116.95	119.31	119.72	121.29	115.30	113.01
	2007						100.00	106.72	101.17	106.02	113.57	115.62	116.09	117.52	111.74	109.46
	2008							100.00	94.15	98.83	105.95	107.81	108.28	109.61	104.26	101.99
	2009								100.00	104.42	111.62	113.28	114.14	115.27	109.79	107.81
	2010									100.00	106.97	108.61	109.36	110.57	105.17	103.09
	2011										100.00	101.53	102.15	103.38	98.31	96.14
	2012											100.00	100.66	101.85	96.89	94.77
	2013												100.00	101.15	96.25	94.21
	2014													100.00	95.14	93.21
	2015														100.00	98.33
	2016															100.00
Fisher	2002	100.00	103.60	107.29	112.51	116.65	119.84	127.57	122.71	128.70	138.60	140.70	141.71	143.30	136.53	134.41
	2003		100.00	103.53	108.40	112.45	115.57	123.10	118.26	123.77	132.88	134.91	135.92	137.48	131.25	129.29
	2004			100.00	104.71	108.74	111.75	119.08	114.09	119.40	128.12	130.02	130.97	132.46	126.41	124.44
	2005				100.00	103.99	106.98	114.21	109.05	114.10	122.34	124.29	125.15	126.57	120.69	118.74
	2006					100.00	102.88	109.84	104.77	109.46	117.11	119.28	120.02	121.59	116.05	114.19
	2007						100.00	106.82	101.66	106.21	113.58	115.54	116.26	117.74	112.36	110.53
	2008							100.00	94.75	99.08	106.00	107.78	108.45	109.83	104.77	102.95
	2009								100.00	104.58	112.10	113.75	114.60	115.88	110.08	108.19
	2010									100.00	107.09	108.72	109.51	110.80	105.37	103.49
	2011										100.00	101.53	102.25	103.53	98.52	96.68
	2012											100.00	100.70	101.91	97.06	95.27
	2013												100.00	101.16	96.22	94.43
	2014													100.00	95.26	93.58
	2015														100.00	98.44
	2016															100.00
Tornqvist	2002	100.00	103.52	107.25	112.66	117.06	120.61	129.42	124.05	129.56	139.04	140.97	142.02	143.11	135.98	133.76
	2003		100.00	103.53	108.51	112.70	116.04	124.26	119.01	124.22	133.11	135.04	136.03	137.25	130.77	128.73
	2004			100.00	104.74	108.82	111.94	119.71	114.50	119.53	127.99	129.81	130.72	131.98	125.85	123.83
	2005				100.00	103.97	107.04	114.46	109.28	114.15	122.15	124.07	124.88	126.20	120.33	118.30
	2006					100.00	102.89	109.93	104.87	109.49	117.06	119.11	119.83	121.25	115.70	113.77
	2007						100.00	106.84	101.70	106.20	113.51	115.38	116.09	117.50	112.15	110.26
	2008							100.00	94.76	99.08	105.96	107.68	108.34	109.69	104.57	102.64
	2009								100.00	104.57	112.09	113.69	114.55	115.77	109.97	108.03
	2010									100.00	107.09	108.70	109.49	110.77	105.32	103.39
	2011										100.00	101.53	102.25	103.53	98.39	96.46
	2012											100.00	100.70	101.91	96.95	95.09
	2013												100.00	101.16	96.12	94.25
	2014													100.00	95.20	93.49
	2015														100.00	98.43
	2016															100.00

Appendix B: Changes in processed goods for intermediate demand indexes as measured by formulas

Index	Price change from:	Price change to:														
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Laspeyres	2002	100.00	105.13	112.07	121.01	129.97	133.66	147.12	135.12	143.77	156.57	157.21	157.33	158.50	147.77	143.12
	2003		100.00	106.43	114.69	123.32	126.70	139.16	128.49	136.51	148.44	149.04	149.20	150.38	140.66	136.29
	2004			100.00	107.81	116.14	119.27	131.04	120.76	128.53	139.87	140.29	140.36	141.42	132.11	127.91
	2005				100.00	107.69	110.67	121.78	111.92	119.32	130.03	130.44	130.46	131.37	122.42	118.43
	2006					100.00	102.94	113.33	104.18	111.08	121.04	121.48	121.56	122.47	114.19	110.54
	2007						100.00	110.10	101.10	107.81	117.62	118.01	118.07	118.85	110.50	106.93
	2008							100.00	91.61	97.59	106.55	106.98	107.01	107.72	99.97	96.76
	2009								100.00	106.84	116.99	117.42	117.51	118.34	109.07	105.22
	2010									100.00	109.21	109.62	109.70	110.47	101.94	98.47
	2011										100.00	100.35	100.41	101.11	93.37	90.24
	2012											100.00	100.00	100.53	92.79	89.69
	2013												100.00	100.50	92.66	89.55
	2014													100.00	92.41	89.42
	2015														100.00	96.80
	2016															100.00
Paasche																
	2002	100.00	104.62	111.14	119.86	128.94	133.34	147.19	135.66	143.75	155.58	157.18	156.65	157.47	145.03	140.37
	2003		100.00	106.26	114.63	123.14	127.01	140.28	128.34	136.39	147.96	149.76	149.32	149.97	138.17	133.58
	2004			100.00	107.79	115.60	119.21	131.51	120.28	127.90	138.91	140.44	140.05	140.65	129.67	125.30
	2005				100.00	107.22	110.20	121.54	110.81	117.96	128.23	129.85	129.49	130.02	120.00	115.85
	2006					100.00	102.66	113.05	103.20	109.55	118.98	120.82	120.30	121.06	111.78	107.90
	2007						100.00	110.10	100.16	106.48	115.80	117.30	116.85	117.52	108.48	104.68
	2008							100.00	90.56	96.53	105.14	106.16	105.85	106.47	98.41	94.83
	2009								100.00	106.44	115.85	116.92	116.80	117.21	108.23	104.59
	2010									100.00	108.98	109.77	109.67	110.18	101.77	98.14
	2011										100.00	100.42	100.33	100.89	93.21	89.73
	2012											100.00	99.96	100.52	92.82	89.36
	2013												100.00	100.52	92.76	89.30
	2014													100.00	92.28	88.86
	2015														100.00	96.55
	2016															100.00
Fisher	2002	100.00	104.87	111.61	120.43	129.46	133.50	147.16	135.39	143.76	156.07	157.19	156.99	157.99	146.40	141.74
	2003		100.00	106.35	114.66	123.23	126.86	139.72	128.41	136.45	148.20	149.40	149.26	150.18	139.41	134.93
	2004			100.00	107.80	115.87	119.24	131.27	120.52	128.22	139.39	140.37	140.20	141.03	130.88	126.60
	2005				100.00	107.46	110.44	121.66	111.36	118.64	129.13	130.14	129.98	130.69	121.20	117.13
	2006					100.00	102.80	113.19	103.69	110.31	120.01	121.15	120.93	121.76	112.98	109.21
	2007						100.00	110.10	100.63	107.14	116.71	117.65	117.46	118.18	109.49	105.80
	2008							100.00	91.08	97.06	105.84	106.57	106.42	107.10	99.19	95.79
	2009								100.00	106.64	116.42	117.17	117.15	117.78	108.65	104.91
	2010									100.00	109.09	109.70	109.68	110.32	101.85	98.30
	2011										100.00	100.38	100.37	101.00	93.29	89.99
	2012											100.00	99.98	100.53	92.80	89.52
	2013												100.00	100.51	92.71	89.42
	2014													100.00	92.35	89.14
	2015														100.00	96.67
	2016															100.00
Tornqvist	2002	100.00	104.86	111.64	120.65	129.79	134.02	148.21	135.73	144.48	157.66	158.64	158.49	158.92	146.52	141.81
	2003		100.00	106.35	114.75	123.41	127.16	140.40	128.51	136.74	149.03	150.13	150.01	150.57	139.27	134.82
	2004			100.00	107.82	115.91	119.33	131.54	120.50	128.19	139.58	140.56	140.42	141.04	130.62	126.43
	2005				100.00	107.44	110.44	121.68	111.38	118.50	128.98	129.96	129.86	130.49	120.98	117.03
	2006					100.00	102.81	113.24	103.73	110.24	119.95	121.04	120.91	121.63	112.82	109.14
	2007						100.00	110.11	100.65	107.04	116.54	117.47	117.34	118.03	109.37	105.75
	2008							100.00	91.09	97.03	105.77	106.48	106.39	107.06	99.12	95.71
	2009								100.00	106.61	116.39	117.14	117.14	117.73	108.58	104.86
	2010									100.00	109.10	109.68	109.68	110.31	101.81	98.25
	2011										100.00	100.38	100.37	101.00	93.18	89.83
	2012											100.00	99.98	100.52	92.68	89.33
	2013												100.00	100.51	92.61	89.26
	2014													100.00	92.29	89.04
	2015														100.00	96.69
	2016															100.00

Appendix C: Changes in unprocessed goods for intermediate demand indexes as measured by formulas

Index	Price change from:	Price change to:														
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Laspeyres	2002	100.00	125.92	146.73	168.31	168.04	185.99	226.44	156.28	188.62	220.45	212.09	218.79	223.59	168.86	154.47
	2003		100.00	116.32	133.54	133.43	147.93	180.10	124.89	150.33	175.86	169.68	174.90	178.14	134.52	123.42
	2004			100.00	115.02	114.49	126.89	153.92	107.71	128.38	150.34	145.51	150.26	153.05	116.86	107.07
	2005				100.00	99.50	110.84	134.62	95.07	112.94	132.69	128.78	132.62	134.64	103.43	94.90
	2006					100.00	111.39	135.07	95.54	113.05	132.40	128.60	132.75	135.18	104.01	95.43
	2007						100.00	122.06	85.63	103.32	121.53	117.66	120.52	122.13	92.73	85.08
	2008							100.00	69.89	84.23	98.83	95.56	98.19	99.71	75.62	69.31
	2009								100.00	121.92	144.12	138.89	141.99	143.17	107.69	98.49
	2010									100.00	118.18	114.42	117.38	118.39	89.17	81.39
	2011										100.00	96.35	99.55	101.31	75.74	69.16
	2012											100.00	103.90	106.12	77.39	70.60
	2013												100.00	101.94	73.54	67.01
	2014													100.00	71.31	64.95
	2015														100.00	91.24
	2016															100.00
Paasche																
	2002	100.00	125.17	143.85	163.17	161.66	184.48	224.30	157.63	188.91	220.22	207.59	219.34	224.81	160.36	146.45
	2003		100.00	115.16	131.09	129.57	149.12	180.94	126.94	151.44	174.92	159.75	168.75	172.66	122.76	111.97
	2004			100.00	113.81	112.52	127.61	155.17	107.96	130.10	150.17	136.20	143.35	146.74	103.25	94.26
	2005				100.00	98.77	112.54	135.75	95.46	114.02	129.89	116.14	121.73	124.03	87.49	80.31
	2006					100.00	111.16	134.70	93.95	113.26	130.09	118.21	123.42	125.33	88.14	80.89
	2007						100.00	121.41	84.16	101.81	117.85	107.67	112.48	114.08	80.23	73.33
	2008							100.00	68.82	83.06	96.45	87.53	91.08	91.69	64.34	58.83
	2009								100.00	120.30	140.82	133.23	139.27	141.34	100.02	91.52
	2010									100.00	116.95	109.62	114.10	115.73	80.99	74.18
	2011										100.00	94.58	98.35	99.11	69.45	63.42
	2012											100.00	103.90	104.61	73.61	67.15
	2013												100.00	100.89	71.03	64.92
	2014													100.00	70.31	64.32
	2015														100.00	90.80
	2016															100.00
Fisher	2002	100.00	125.54	145.28	165.72	164.82	185.23	225.37	156.95	188.76	220.33	209.83	219.07	224.20	164.56	150.41
	2003		100.00	115.74	132.31	131.49	148.53	180.52	125.91	150.89	175.39	164.64	171.80	175.38	128.51	117.55
	2004			100.00	114.41	113.50	127.25	154.55	107.83	129.24	150.25	140.78	146.76	149.86	109.85	100.46
	2005				100.00	99.14	111.68	135.18	95.26	113.48	131.28	122.30	127.06	129.23	95.13	87.30
	2006					100.00	111.27	134.89	94.74	113.15	131.24	123.30	128.00	130.16	95.75	87.86
	2007						100.00	121.73	84.89	102.56	119.67	112.55	116.43	118.04	86.26	78.99
	2008							100.00	69.35	83.64	97.64	91.46	94.57	95.62	69.76	63.85
	2009								100.00	121.11	142.46	136.03	140.62	142.25	103.78	94.94
	2010									100.00	117.56	111.99	115.73	117.05	84.98	77.70
	2011										100.00	95.46	98.95	100.20	72.53	66.23
	2012											100.00	103.90	105.36	75.48	68.85
	2013												100.00	101.42	72.27	65.96
	2014													100.00	70.81	64.63
	2015														100.00	91.02
	2016															100.00
Tornqvist	2002	100.00	125.59	145.23	166.05	164.96	185.63	225.67	157.29	189.46	221.28	211.31	220.85	225.63	164.96	150.77
	2003		100.00	115.70	132.46	131.59	148.94	180.99	125.90	151.22	175.68	165.52	173.25	176.84	128.54	117.55
	2004			100.00	114.45	113.53	127.41	154.75	107.68	129.24	150.15	141.09	147.50	150.62	109.43	99.98
	2005				100.00	99.14	111.68	135.24	94.81	113.13	130.50	122.11	127.09	129.43	94.57	86.77
	2006					100.00	111.27	134.87	94.55	112.93	130.62	122.98	127.83	130.06	95.27	87.38
	2007						100.00	121.72	84.89	102.53	119.66	113.14	116.90	118.39	86.39	78.98
	2008							100.00	69.27	83.55	97.46	91.60	94.69	95.68	69.68	63.63
	2009								100.00	121.04	142.39	136.42	140.87	142.25	104.02	95.13
	2010									100.00	117.54	112.19	115.84	117.08	85.07	77.72
	2011										100.00	95.52	98.98	100.18	72.47	66.07
	2012											100.00	103.89	105.36	75.50	68.80
	2013												100.00	101.44	72.23	65.83
	2014													100.00	70.77	64.55
	2015														100.00	91.05
	2016															100.00

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