Examining industry composition effects in state employment

Using Current Employment Statistics data, this article examines employment for all 50 states and the District from 2007 to 2016 to determine whether an industry composition effect slowed the post-Great Recession recovery of six states—Alabama, Connecticut, Mississippi, New Mexico, West Virginia, and Wyoming. The industry composition of these states was analyzed first at a macrolevel (from goods producing to service providing) and then at a more detailed industry supersector level. Based on industry shares over a decade, the industry composition of the six states that were slower to recover was little different from the composition of the states that did recover. However, the six states had higher rates of employment in goods-producing industries before the recession and higher rates of employment in service-providing industries following the recession.

The Great Recession began in December 2007 and ended in June 2009, as determined by the National Bureau of Economic Research.[1] The effects of the recession were still evident a decade later in the employment levels of six states, although national employment had rebounded. This slow recovery raises some questions:

1. Did these states have a different industry composition that resulted in different recessionary impacts?

2. Did these states shift to a mix of industries that was different from that of other states?

Using data from the Current Employment Statistics (CES) program, this article analyzes industry composition, focusing on how employment was affected by the Great Recession at the state level.[2] In particular, this article looks at the nonrecovered states that did not recover their employment from each of the major industry supersectors.[3] Although the Great Recession officially lasted only 18 months, total private employment (total nonfarm employment less government) at the national level did not recover until early 2014.[4] Forty-three states and the District of Columbia took at least 18 months to recover to their prerecession employment levels. Meanwhile, by December 2016, nonrecovered states had yet to recover all of their prerecession peak employment: Alabama, Connecticut, Mississippi, New Mexico, West Virginia, and Wyoming. (Henceforth, the six states will be referred to as nonrecovered states.) Figure 1 shows the employment of these nonrecovered states, indexed to July 2020.
December 2007, which was the first month of the recession. All states in this group began seeing declines in the early months of 2008.

In December 2016, five of the nonrecovered states were nearly at or above their December 2007 employment levels, if not at their prerecession peak employment. At first, West Virginia and Wyoming rebounded from the effects of the recession, but then West Virginia in July 2013 and Wyoming in January 2015 began to experience further employment declines.

Declines in employment and changes in the industry composition of the American economy are nothing new. Over the last 30 years, goods-producing jobs (mining and logging, construction, and manufacturing industries) have declined overall. (In this article, mining, logging, and construction [MLC] will be considered one industry based on the guaranteed publication criteria under the CES State and Area program.) Conversely, the share of private service-providing jobs in the economy has steadily increased over the same period. (See figure 2.) These jobs include those in trade, transportation, and utilities; information; financial activities; professional and business services; education and health services; leisure and hospitality; and other services sectors (other services is its own industry supersector and includes industries such as repair and maintenance and religious and civic organizations).[6] Following the recessions of 1990–91 and 2001, establishments, particularly goods-producing establishments, were more likely to lay off workers permanently, which led to a structural economic change toward more service-based jobs. In previous recessions, workers were often laid off temporarily and then rehired to the same establishment once economic conditions improved.[7] Each of the two recessions was followed by what was termed a “jobless recovery,” in which gross domestic product growth occurred without a corresponding return or
growth in employment or payroll. This condition was caused by productivity gains resulting from technological change.

**Figure 2. Employment in total private, private service-providing, and goods-producing industries, seasonally adjusted, in thousands, January 1990–December 2016**

Comparing goods-producing jobs with service-providing jobs

Nationally, private service-providing (henceforth referred to as service-providing) jobs increased steadily throughout the 1990s, increased more modestly in the 2000s, and then increased sharply following the end of the Great Recession. The number of goods-producing jobs, however, remained relatively stable throughout the 1990s and 2000s, dropped sharply during the Great Recession, and stabilized, but then slowly increased from mid-2011 to 2016. The proportion of goods-producing employment as a percentage of total private employment fell from 26.3 percent in 1990 to 16.1 percent in 2016.

Most of the shift from goods-producing jobs to service-providing jobs in each state occurred just before and immediately following the Great Recession. From 2007 to 2010, employment in goods-producing industries declined in 49 states as employment in service-providing jobs grew, with only North Dakota gaining slightly in goods-producing jobs. (North Dakota also had the fastest recovery in total private employment in the nation at 22 months.) After 2010, goods-producing jobs in most states continued to decline or did not change. In the District of Columbia, goods-producing jobs declined and then rebounded, so from 2007 to 2016, industry composition had no net change. In the District, goods-producing jobs composed only 3.1 percent of total private employment. From 2007 to 2016, goods-producing jobs declined an average of 14.8 percent as a share of total private employment statewide. Most of this decline, however, was from 2007 to 2010 (−13.5 percent), with a decline of −1.5 percent from 2010 to 2016. In contrast, the number of service-providing jobs in each state increased an average of 3.6
percent over the decade. Again, most of this growth occurred between 2007 and 2010 (±3.3 percent) and was essentially unchanged from 2010 to 2016 (±0.3 percent).

Figure 3 shows the percent change from December 2007 to December 2016 of employment in manufacturing and education and health services. Nationwide, manufacturing employment declined 10 percent over that period, while employment in education and health services increased by 21 percent. Each of the nonrecovered states experienced double-digit percentage declines in manufacturing employment. Employment in education and health services increased in these nonrecovered states over the decade. Healthcare jobs, in particular, fared well—previous research has determined that these types of jobs are “recession proof.”[8]

Looking at the nonrecovered states

As stated earlier, the unrecovered states that had not recovered their prerecession total private employment by December 2016 were Alabama, Connecticut, Mississippi, New Mexico, West Virginia, and Wyoming. These nonrecovered states experienced a greater decrease in the number of goods-producing jobs from 2007 to 2016 than did other states (−18.2 percent versus −14.3 percent), but they also experienced a greater increase in the share of service-providing jobs over the same period (5.5 percent versus +3.4 percent). Employment in goods-producing jobs in the other 44 states and the District declined in the recessionary years and stabilized afterward. However, for the nonrecovered states, employment in goods-producing jobs continued to decline throughout the postrecession years. When industry supersectors of each of the nonrecovered states are indexed as a share of
total private employment to December 2007 (the start of the Great Recession), figures 4 through 9 show the recovery across each of the nonrecovered states by industry.

**Alabama**

As figure 4 shows, Alabama’s employment declined primarily in MLC, manufacturing, and information. Manufacturing slowly increased through the end of 2016 from a trough in January 2011, but employment in December 2016 was a 12.6-percent decrease from January 2007. In contrast, MLC and information continued to decline over the 10-year period. Alabama’s share of this industry was the same as the average of the recovered states, 7.6 percent. Because Alabama’s share of employment in MLC is smaller, roughly half the size of the share of nonrecovered states New Mexico, West Virginia, and Wyoming, the decline in this industry in Alabama appears greater compared with that of the other nonrecovered states. Employment in this industry declined 25.9 percent from December 2007 to December 2016.

**Connecticut**

As shown in figure 5, goods-producing employment declined in Connecticut in both MLC and manufacturing; however, by the end of 2016, decline had slowed. Employment in education and health services showed no decline as a share of total private employment over the decade. Among the nonrecovered states in 2007, Connecticut had a higher share of employment in financial activities than the average share of recovered states (10.0 percent versus 7.0 percent). Connecticut also had a higher share of employment in financial activities in 2016 (9.0 percent versus 6.7 percent). The average share of financial activities as a share of total private employment for all states was largely stable from 2007 to 2016, from 6.9 percent to 6.6 percent.
Connecticut’s share of employment in MLC remained relatively stable over the 10-year period, only declining by 0.7 percentage point. Employment in this industry declined 15.3 percent from December 2007 to December 2016. While the recovered states saw a 14.4-percent decrease in the share of MLC employment as a proportion of total private employment, the nonrecovered states experienced a 21.8-percent decrease, showing that they were affected more than recovered states.

**Mississippi**

In Mississippi, declines in the share of MLC employment were greater than the declines in shares of MLC employment in the other nonrecovered states, a decline of 24.6-percent versus an average decline of 15.6 percent from 2007 to 2016. This difference was driven by declines in both mining and logging starting in January 2015 and construction starting in November 2013. (See figure 6.) Employment in education and health services steadily increased over the 10-year period, declining for only a few months in 2007. Professional and business services employment declined from 2008 to 2011 but, after that period, increased through the end of 2016, for an increase in employment of +12.6 percent from December 2007 to December 2016. Trade, transportation, and utilities and leisure and hospitality had slightly greater employment in December 2016 than in December 2007, +2.0 percent and +5.2 percent, respectively.
New Mexico

In addition to New Mexico experiencing employment declines in MLC and manufacturing, the state experienced employment declines in the information industry throughout the 10-year period. (See figure 7.) Trade, transportation, and utilities; financial activities; and professional and business services declined modestly, between 4.3 and 5.3 percent from 2007 to 2016. New Mexico had a higher share in professional and business services than did the other nonrecovered states in 2007, or an average of 16.2 percent of total private employment. Therefore, the decline in employment in this industry over the 10-year period brought the share of professional and business services down to 15.9 percent. This percentage is still higher than that of the other five states but is similar to the share of Connecticut for this industry in 2016 (15.2 percent). Education and health services increased by 22.7 percent, whereas manufacturing decreased by 21.8 percent.
West Virginia

West Virginia’s MLC employment increased 8.0 percent during the recessionary months, from December 2007 to November 2008. (See figure 8.) From November 2008 to February 2010, employment decreased 17.1 percent; from February 2010 to February 2012, it increased 19.1 percent; and from February 2012 to December 2016, it decreased 29.3 percent. This pattern is noticeably different from the pattern for the other five states, in which employment declined steadily over the 10-year period, with no return to prerecession employment levels. West Virginia’s employment in mining and logging, on the one hand, and construction, on the other, reveals almost identical patterns of growth and decline over the 10-year period. (See figure 9.) Employment saw modest increases in professional and business services, education and health services, and leisure and hospitality from December 2007 to December 2016 (+6.1 percent, +13.2 percent, and +1.2 percent, respectively). In contrast, employment in trade, transportation, and utilities; financial activities; and other services decreased slightly over the same period (–7.7 percent, –8.5 percent, and –2.8 percent, respectively), similar to employment trends in those industries in New Mexico.
Figure 8. Indexes of West Virginia employment by industry, seasonally adjusted, January 2007–December 2016

Figure 9. West Virginia employment in mining, logging, and construction; mining and logging; and construction, seasonally adjusted, in thousands, January 2007–December 2016
Wyoming

Wyoming experienced a large increase in employment, both in education and health services and in other services. (See figure 10.) When indexed to its respective December 2007 level, employment in the other services sector increased more than that in education and health services, +22.3 percent versus +16.5 percent. By March 2016, the employment level of other services increased as high as 25.4 percent above its prerecession level, compared with the +17.3-percent increase in education and health services (the increase occurred in both March and July 2016). Leisure and hospitality was the only other service-providing industry to have employment above its prerecession level by the end of 2016. From December 2007 to the end of 2016, MLC experienced the worst decline—31.2 percent—among industries in Wyoming. As with West Virginia’s employment experience, Wyoming’s employment in mining and logging, on the one hand, and construction, on the other, followed similar patterns of growth and decline over the 10-year period. (See figure 11.)
Conclusion

Before the Great Recession, the nonrecovered states had higher shares of employment overall in MLC, education and health services, leisure and hospitality, and other services industries than did the recovered states. This finding was still true in 2016. MLC had the biggest decline in the share of employment among the nonrecovered states over the decade, with Wyoming showing the greatest decline among the nonrecovered states. Over the decade, nonrecovered states saw gains in education and health services, followed by leisure and hospitality, professional and business services, and other services. In contrast, recovered states declined the most in shares of employment in manufacturing, MLC, and trade, transportation, and utilities. In addition, they experienced gains in the same service industries as the nonrecovered states, but at smaller shares of employment. In most states, not just the nonrecovered states, goods-producing jobs made up a smaller share of total private employment in 2016 than in 2007, with most of this structural shift occurring by the end of 2010.

Employment growth since the Great Recession in 2007–09 has been almost exclusively in service-providing industries at both the national level and the state level. This article has examined how the nonrecovered states with the slowest recovery from the Great Recession differed from all other states. The nonrecovered states started the recession with a larger share of employment in goods-producing industries than did other states and saw slightly larger gains in service-providing industries over the following decade than other states saw. However, for these nonrecovered states, the losses in goods-producing industries were greater than the subsequent gains in service-providing industries.
Meredith Miller, "Examining industry composition effects in state employment," *Monthly Labor Review*, U.S. Bureau of Labor Statistics, July 2020, [https://doi.org/10.21916/mlr.2020.13](https://doi.org/10.21916/mlr.2020.13).

**NOTES**

1. The official length of the Great Recession is defined by the National Bureau of Economic Research.

2. For more information on state and metro area employment, hours, and earnings that the Current Employment Statistics (CES) program produces, see [https://www.bls.gov/sae/](https://www.bls.gov/sae/).

3. The supersectors are mining, logging, and construction; manufacturing; trade, transportation, and utilities; information; financial activities; professional and business services; education and health services; leisure and hospitality; and other services.

4. John P. Mullins and Brittney E. Forbes, “CES employment recovers in 2014,” *Monthly Labor Review*, April 2015, [https://www.bls.gov/opub/mlr/2015/article/ces-employment-recovers-in-2014.htm](https://www.bls.gov/opub/mlr/2015/article/ces-employment-recovers-in-2014.htm).

5. For more information on guaranteed publication levels for the CES State and Area program, see [https://www.bls.gov/sae/additional-resources/guaranteed-publication-levels-and-the-ces-small-domain-model-sdm.htm](https://www.bls.gov/sae/additional-resources/guaranteed-publication-levels-and-the-ces-small-domain-model-sdm.htm).

6. Examples of industries that fall under other services (North American Industry Classification System code 81) include repair and maintenance, personal services, and religious and civic organizations.

7. Erica L. Groshen and Simon Potter, “Has structural change contributed to a jobless recovery?” *Current Issues in Economics and Finance*, vol. 9, no. 8 (New York City, Federal Reserve Bank of New York, August 2003), p. 6, [https://www.newyorkfed.org.medialibrary/media/research/current_issues/ci9-8.pdf](https://www.newyorkfed.org.medialibrary/media/research/current_issues/ci9-8.pdf).

8. Michael L. Dolfman, Matthew Insco, and Richard J. Holden, “Healthcare jobs and the Great Recession,” *Monthly Labor Review*, June 2018, [https://www.bls.gov/opub/mlr/2018/article/healthcare-jobs-and-the-great-recession.htm](https://www.bls.gov/opub/mlr/2018/article/healthcare-jobs-and-the-great-recession.htm).

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In "Invisible Women: Data Bias in a World Designed for Men," author Caroline Criado Perez uses data to reveal the existence of a gender data gap and to argue that this gap puts women at a disadvantage. The author depicts a world with a “default male” perspective, describing the consequences it has for women. These consequences range from eliminating women from the narrative of history (with female work often being attributed to men) to subjecting them to outdated office temperature settings (a 1960 formula still in use bases these settings on an average 154-pound, 40-year-old man). Using data from various surveys and studies, Perez points to specific situations in which the default male perspective is most likely to occur and to hurt women. The author also relies on research conducted by others to illuminate the need for data that could inform better decisions in establishing a more equal work–life balance, creating accommodating workplaces and equipment designs for women, and achieving better female healthcare outcomes.

One of the main discrepancies in the experiences of women and men is related to unpaid work (cooking, cleaning, and doing laundry for a household). Perez cites a 2010 U.S. study which found that the unpaid work of female scientists adds 10 extra hours per week to their workload, compared with 5 extra hours for male scientists. (These extra hours are on top of a nearly 60-hour workweek.) These data are important because they may have direct health implications. A 2015 Finnish study cited in the book found that unmarried women had higher rates of recovery from heart attacks, and a 2016 Canadian study found that women’s household burdens contributed to their having worse outcomes after heart surgery. Further, according to a University of Michigan study, a marriage penalty exists whereby “husbands create an extra seven
hours of housework a week”—an imbalance that persists irrespective of the employment statuses of household members. Combined, these studies reinforce the view that gender discrepancies in unpaid work can hurt women.

In the workplace, the gender data gap can be observed in contexts as simple as parking-space assignment. We all have noticed handicap parking places, which have been established by federal law. But what about parking places for, say, pregnant women? Perez recounts the case of a pregnant Chief Operating Officer at a Fortune 500 company who, tired of walking across a parking lot every day, brought up the issue with the company's Chief Executive Officer (CEO). The CEO agreed that pregnancy parking places should be created, but before the issue was raised, no thought had been given to it.

How about when it comes to equipment designs? Perez provides many real-world examples of designs initially meant for men and subsequently scaled down for female use. These "smaller" designs were not based on female specifications, and yet they were falsely thought to be the answer. Companies often have warning labels that caution against wearing ill-fitted gear, because such gear can increase the risk of an accident. A 2009 survey conducted by the Women's Engineering Society found that 74 percent of personal protective equipment (PPE) was specifically designed for men. As Perez notes, there seems to be a one-size-fits-men design for most PPE. Unisex designs would seem like a good idea, but they would still not account for actual differences between women and men. The car-crash test dummy introduced in 1950, for instance, was based on the 15th-percentile (5-foot, 9-inch and 167.5-pound) male body. At the time, no equivalent crash-test dummy existed for women (although a call was made to create one in 1980), and when one was introduced in 2011, it lowered vehicle safety ratings because most car manufacturers did not account for female body characteristics when designing automobiles. The author notes that the female crash-test dummy is still not being tested on the driver side, but only on the passenger side. By overlooking how a car driven by a woman performs in a crash, car manufacturers create a gender data gap.

Researchers have found that when women are involved in a car crash, they are 17 percent more likely to die, 47 percent more likely to be seriously injured, and 71 percent more likely to be moderately injured than men.

Turning to healthcare, Perez points to a 2014 Federal Drug Administration study which found that adverse drug reactions are more common among women (2 million recorded cases) than among men (about 1.3 million recorded cases). A possible explanation for this finding could be that many studies do not specify the sex of their participants or do not include women in clinical trials. This practice can have adverse effects because what benefits one sex may be harmful to the opposite sex. For example, in one medical technology study, an analysis of a cardiac resynchronization therapy device found that a 150-millisecond threshold for the time the heart completes a full circuit worked for men but was 20 milliseconds too high for women. Thus, lowering the optimal threshold for women would benefit them by reducing heart failures and deaths.

Overall, Perez’s book shows that addressing the gender data gap would require collecting data disaggregated by sex. In addition, there is a need to collect information in areas in which no data are currently being collected. The many examples in the book illustrate how these approaches can make women visible and immune to potential harm from universal male standards. The book is thoroughly researched, pulling data and insights from various sources to make the case for closing the gender data gap.
You will often hear statistics citing how much more pay on average a person who has a bachelor’s degree earns versus a person who has completed an associate’s degree. However, there is little information between the comparisons of a person who earned a bachelor’s degree and a person with a master’s degree. In “The labor market returns to advanced degrees” (National Bureau of Economic Research, Working Paper 26959, April 2020), authors Joseph G. Altonji and Ling Zhong compare earnings of people across 19 advanced degrees. For those considering advancing their schooling, learning the pay differential can help them make a more informed decision.

In their analysis, the authors only include full-time workers ages 24 to 59 and exclude those workers with a PhD and those who obtained a bachelor’s degree before turning 23. People who obtained a master’s degree after age 49 are also excluded. The authors also exclude another group of individuals from the sampling who went to graduate school right after finishing their bachelor’s degree.

The authors estimate returns for specific degrees, while controlling for each college major, and they examine how bachelor’s degrees could affect the returns of master’s degrees. They also account for the occupation of a person (by looking at work experience) before and after obtaining an advanced degree. For example, a teacher with an education degree who decides to obtain a graduate degree in finance to work as a financial analyst would receive a substantial boost in earnings. In this scenario, the earnings of the person with the advanced degree would be inflated as the person went from one occupation to a different occupation that may pay substantially more. The authors account for this by looking at the bachelor degree held by the individual before graduate school and the work history before and after. In a different scenario, a person with a bachelor’s degree in business who later obtains a master’s degree in finance and continues working in similar occupations before and after acquiring an advanced degree would not experience a substantial increase in income compared with the income increase of the person in the previous example. The authors define this scenario as the personal fixed effects.

The findings reveal that the highest paying fields were medicine ($164,302) and law ($127,540), whereas the lowest paying fields were psychology and social work ($64,554), and humanities ($61,474). These figures are in 2013 dollars. Looking at closely related fields and occupations shows that the mean earnings of people with a preadvanced degree are $69,459 (standard deviation $26,578) and with a postadvanced degree $94,047 (standard deviation $30,626). The authors also calculate the internal rate of return between the 19 advanced degree fields and counterfactual net present value earnings to discover that only 3 returned negative rates (master’s in other science- and engineering-related fields, master’s in arts, and master’s in the humanity fields).

The authors caution that their findings are a starting point for learning more about graduate school returns and about estimates that can vary across colleges (ivy league versus nonivy league, for example). A takeaway is that an advanced degree will increase earnings.
Making volunteer work visible: supplementary measures of work in labor force statistics

Under the current definitions of labor force status, one person can be working in a job (in retail sales, for example) and be counted as employed because he or she is being paid, while another person can be working in a nearly identical job (such as in retail sales for a charity organization’s consignment shop) and be counted as not in the labor force because he or she is not receiving pay. Retirees doing substantial amounts of volunteer work are classified as not in the labor force, even when their work is done in a traditional workplace. We do not suggest changes in the official statistical concepts of the U.S. Bureau of Labor Statistics; however, we discuss issues relating to an expanded measure of work to supplement the current definition to include volunteers, and we construct measures consistent with that definition from currently available surveys. These measures could be particularly useful for understanding the labor force activity of older people, especially those who are retired from regular employment and are volunteering. Further, in 2020, the COVID-19 pandemic has highlighted the importance of volunteering—both the kinds of volunteer work that are currently measured and those that are not. This article calls attention to this measurement issue and other matters relating to the understanding, collection, and presentation of data on volunteers.

The Current Population Survey (CPS) is one of the oldest, largest, and most well-recognized surveys in the United States. It is immensely important, providing information on many of the things that define us as individuals and as a society—our work, our earnings, our education.[1]—U.S. Census Bureau and U.S. Bureau of Labor Statistics
To understand how the economy is functioning and changing over time requires measuring and valuing all productive unpriced labor time. —Henry M. Peskin and Burton A. Weisbrod

Including volunteering as a subset of work means that the tangible and invaluable contributions volunteering makes to individuals and society are being recognized as a force that should be tracked and measured so that it can be better supported and fostered. —The Johns Hopkins Volunteer Measurement Project

As the economy changes over time, it is useful to reconsider fundamental labor force measurement issues. In 2020, the coronavirus disease 2019 (COVID-19) pandemic has raised many such issues; for instance, it has highlighted the impact of volunteering, including forms of volunteering that are not currently included in the available statistics on volunteers. In this article, we examine an issue of language and measurement. The definition of work has important implications at both the micro- and macrolevels. At the microlevel, the definition of work affects our understanding of how people spend their time. As the opening quotation about the Current Population Survey (CPS) suggests, how work is defined also affects how people define themselves. At the macrolevel, it affects our understanding of the aggregate amount of productive activity people are undertaking in the labor force. In this article, we discuss the definition of work in labor force statistics and analyze issues relating to a supplementary measure that includes volunteering as a subset of work.

Under the current definitions of labor force status, one person can be working in a job (in retail sales, for example) and be counted as employed because he or she is being paid, while another person can be working in a nearly identical job (such as in retail sales for a consignment shop of a charitable organization) and be counted as not in the labor force because he or she is not receiving pay.

The COVID-19 pandemic has highlighted the importance of volunteering, especially activities done individually rather than through organizations. Examples include grocery shopping for older neighbors or friends and making face masks to give to people who could not obtain them. The people doing this type of volunteering—termed “direct volunteers”—are not counted as employed or as volunteers in U.S. statistics because they are not doing this work through an organization. They are counted as not in the labor force. The 2020 Presidential Proclamation announcing National Volunteer Week specifically mentions some of the types of volunteering that are “invisible” in current statistics. Although this article focuses on the labor force status of measured volunteers, it also calls attention to matters involving the understanding, collection, and presentation of data on volunteers.

Currently, the U.S. Bureau of Labor Statistics (BLS) has six measures of labor underutilization (U-1 to U-6), one of which (U-3) is the official unemployment rate. This framework of measures recognizes that one definition alone does not suit all data users. We consider issues relating to whether there should be additional measures of labor utilization. In particular, we consider the case of whether there should be an expanded definition of employment that is based on the nature of the activity people are doing and not solely on monetary compensation. Under the current definition, people are considered employed only if they worked for pay or profit.

An expanded definition could supplement the current definition and provide an additional measure of work that could be useful in enhancing our understanding of the transition from work to retirement and the productive contributions of older people. Such a definition would recognize that many people, particularly retirees with
pension benefits, do not require or need monetary compensation but will engage in volunteer work because of its nonmonetary benefits, including psychological and health benefits.

According to BLS statistics, in 2015, among the U.S. civilian population ages 16 and over, 63 million people, or 25 percent, volunteered. Among people ages 65 and over, 11 million volunteered, or about 24 percent of the population in that age group. [6] Although its volunteer rate was about the same as that of the total population, the older population accounted for median annual hours of volunteering that were close to double the median for the total population ages 16 and over. Overall, most volunteers combined paid work with volunteer work; however, for the older population, three-quarters of the volunteers were not in the paid labor force.

The concept of work that we analyze in this article would not replace existing concepts or measures of labor force activity but would supplement them, providing a different and possibly fuller picture of work in the labor force. Our focus is on volunteers as defined by BLS, particularly those volunteers who are ages 65 and over, in order to capture volunteer work done by retirees who are mostly out of the officially defined labor force. We recognize, but do not attempt to measure, a wider concept of volunteer work (informal volunteer work carried out on one’s own directly for individuals and not for an organization), as well as other forms of unpaid work.

The official BLS definition of the labor force includes some unpaid workers—unpaid family workers who work at least 15 hours per week in a family farm or business. The number of such workers has dwindled from more than 1 million in 1970 to fewer than 100,000 in December 2019, trending downward with the decline in traditional family farms. [7] Such family workers are counted as employed, in recognition of their economic contribution, while millions of people who make similar contributions by performing unpaid volunteer work are not counted as employed.

Research conducted by Yvon H. Pho for the U.S. Bureau of Economic Analysis has parallels with the concept we consider here. [8] Just as Pho gives a national accounting perspective on volunteers and estimates the value of their work, our article offers a labor force activity perspective on volunteers. Pho estimates the value of volunteer work at around 1 percent of gross domestic product; we show how an alternative labor force participation rate increases—and quite substantially for the older population—when volunteers who are currently classified as not in the labor force are counted as part of the labor force. Much like Pho, we are looking outside the scope of the official definitions in order to acknowledge volunteers’ contributions as workers.

The article begins with a discussion of a theory of economic measurement, illustrating why the current definition of work may bear reexamination in a changing economy. Next, we discuss the concept and definition of work. We then consider an expanded concept based on the nature of the activity rather than on the nature of the compensation. This concept for a definition of work could supplement the existing definition and is in close accord with recommendations made by the International Labour Organization. [9] We then briefly introduce some of the research on the nonmonetary aspects of compensation. We proceed to the definition of volunteer work and some of the BLS data on volunteering. Using two BLS sources, we then estimate the magnitude of the effect of including volunteers in an expanded concept of labor force participation. These estimates have advantages and disadvantages that we describe. We provide several suggestions for improving the presentation and measurement of the data on volunteers, and we follow with a few concluding comments.

A theory of economic measurement
A 2002 article cowritten by staff from BLS and the U.S. Census Bureau includes the following statement: “The labor force concepts and definitions used in the CPS have undergone only slight modification since the survey’s inception in 1940.”[10] Although this kind of historical continuity is desirable in many ways, statistical measures need to be revised from time to time, as demographics and the economy change, economic theory progresses, and new concepts are developed. In the current era, changes in the economy include the aging of the population, increased life expectancy, better health at older ages, and a much larger number of people who are able to perform work without compensation because of Social Security and pension benefits. Economic theory is progressing as it increasingly incorporates concepts from psychology and behavioral economics, with growing recognition that work often provides psychological benefits as a form of compensation.[11]

In addition, different statistics may be needed for different age groups. For example, Leslie A. Muller and John A. Turner argue that measures of poverty for older age groups should differ from those for younger age groups because of the selectivity bias at older ages that results from the positive relationship between income and life expectancy.[12] In this article, we consider whether a different measure of work may be needed for older people because, given that they are receiving Social Security and pension benefits, they are able to work for nonmonetary compensation.

The definition of work

In this section, we discuss the definitions of work used by various statistical agencies.

U.S. statistical agency definitions

The Current Population Survey (CPS), which is cosponsored by BLS and the Census Bureau, is the nation’s primary source of labor force statistics for the working-age population.[13] According to explanatory information about the CPS on the BLS website, “The basic concepts involved in identifying the employed and unemployed are simple: People with jobs are employed.”[14] Other CPS documentation states the following: “People are considered employed if they did any work at all for pay or profit during the survey reference week. This includes all part-time and temporary work, as well as regular full-time, year-round employment.” It also notes that unpaid family workers are included among the employed if they worked in a family business or farm for at least 15 hours per week. The CPS definition of employment specifically excludes people “whose only activity consisted of work around their own house (painting, repairing, cleaning, or other home-related housework)” and those performing “volunteer work for religious, charitable, or other organizations.” Although the documentation does not mention them, family caregivers are also excluded.[15]

International definitions

The International Labour Organization (ILO) is a United Nations agency whose primary mandate is to set international labor standards in order to promote economic and social justice. The ILO conducts its activities through a permanent secretariat known as the International Labour Office.[16] One function of the ILO is to recommend standards for defining and measuring “work statistics,” which it defines as “productive activities of people.” Among these activities, “employment” is defined by the ILO as work done for compensation or for profit and “volunteer work” as noncompulsory work done for others without compensation.[17] In addition, in 2011 the ILO published a manual on measuring volunteering that further defines volunteer work as “time individuals give without pay to activities performed either through an organization or directly for others outside their own
household,” including “activities that produce goods and/or services which contribute something of potential value to its recipients.”[18] The ILO definition of work is independent of the form of compensation (i.e., monetary or nonmonetary), independent of the nature of the employer (for profit or nonprofit), and independent of whether it is done voluntarily or under compulsion, although the ILO has refined the recommended definition of volunteers to exclude compulsory volunteering.

Furthermore, at the October 2013 International Conference of Labour Statisticians, the ILO adopted a resolution that introduced a new statistical framework for a broad range of human productive activities. The resolution significantly expanded the conceptualization of work, and it separately identified five mutually exclusive forms of work. This was the first time that a comprehensive set of operational concepts, definitions, and guidelines had been agreed upon internationally that attempted to cover all forms of work, whether paid or unpaid.[19] This new framework on different forms of work—with volunteer work identified as one form—has increased countries’ interest in measuring volunteer work, as evidenced by many new data sources on volunteering that are being introduced worldwide.[20] The new framework supplements current measures of employment, rather than replacing them.

A framework for measuring work

In this section, we explain an aspect of the concept of work that we are proposing. This concept of work can be divided into two broad categories: work in the labor force and unpaid work in the person’s own home. Work in the labor force can be divided into work for pay or profit (employed and self-employed) and unpaid work. We are focusing on unpaid work. Unpaid work can be divided into noncompulsory volunteer work for nonmonetary benefits, compulsory “volunteer” work (such as high school graduation requirements), and unpaid work with the expectation of future pay based on the work experience, such as an unpaid internship. We are focusing on volunteer work, including compulsory “volunteer” work, which is within the scope of the BLS definition of volunteers.[21] Thus, we are focusing on volunteer work done for an organization and not considering volunteer work done directly for another person.

We consider the option that, for the purpose of calculating an expanded measure of labor force participation, people who are currently classified as not in the labor force but are doing volunteer work of at least 1 hour per week be placed in a separate category. Thus, the basic framework we consider would divide people into the following four categories with respect to labor force participation: working for pay or profit, working not for pay or profit (i.e., volunteering), unemployed, and not in the labor force. The current framework includes three categories: working for pay or profit, unemployed, and not in the labor force. People working without pay or profit can be in any of the other three categories. They can be employed and also volunteering, they can be unemployed and also volunteering, and they can be not in the labor force and also volunteering. In order to avoid double counting, we focus on those who are currently classified as not in the labor force. Under current BLS definitions, the labor force consists of people who are employed and those who are unemployed, the latter defined as people who are actively seeking employment but are unable to find it. According to BLS classification rules, if people are in more than one of the official categories at the same time—such as a person who currently has a job while also seeking another one—employment always takes precedence over unemployment so that double counting is avoided.
As the CPS documentation states, “The CPS focuses on the labor force status (employed, unemployed, not in labor force) of the working-age population and the demographic characteristics of workers and nonworkers.”[22] Under the current definitions, people who are actively working in a volunteer capacity—but not in family businesses and not for pay—are classified as being not in the labor force. For example, a person can work for more than 1,000 hours a year as a volunteer without pay and still be classified as someone who is not in the labor force.

Our concept of work would include some “unpaid work”—that is, work not done for pay or profit. For example, under this approach, if a person worked in retail sales for a nonprofit thrift store as a volunteer, that person would be considered as working (or employed) under the expanded definition, just as if he or she were working in retail sales at a store for pay. Thus, the expanded definition of work that we propose is based on the nature of the activity, rather than on the nature of the compensation. Our definition would include the current group of employed workers plus some workers who are currently classified as not in the labor force—namely, those who are working as volunteers. (Volunteers who are currently employed or actively seeking employment are already classified as being in the labor force.) This expanded definition would provide a more complete picture of the productive activity that people perform.

**Nonmonetary aspects of compensation**

A similarity between paid work and unpaid work is that generally both provide nonmonetary forms of compensation. The current exclusion of unpaid work seems to be based on the concept that work is something that people would only be willing to do for pay because of the marginal disutility of the activity. Although that concept applies to many work-for-pay situations, it does not apply to all work situations. A Gallup survey conducted in 2015 and 2016 found that 33 percent of workers are actively engaged in their work, while 51 percent are disengaged and 16 percent have negative feelings toward their work.[23] One possible reason volunteer work is less likely to have disutility at the margin is that the hours are generally flexible, and people can adjust their hours so that they do not reach the point at which the last hour results in disutility.

Historically, economists have tended to focus on the monetary compensation associated with work, but more recently, with the incorporation of concepts from psychology into economics, economists have increasingly come to recognize the nonmonetary compensation associated with work. For example, in a 2018 study, Isabel V. Sawhill and Christopher Pulliam write, “lack of work likely leads to social isolation, diminished self-worth, and too much unstructured time. In short, work provides more than income. It provides self-respect, a sense of contributing, an identity, and connection to others.” The authors report that the General Social Survey, a nationally representative survey conducted by the National Opinion Research Center at the University of Chicago, asks respondents the following question: “If you were to get enough money to live as comfortably as you would like for the rest of your life, would you continue to work or would you stop working?” Seventy percent of Americans reported that they would continue to work. Thus, this survey provides evidence against the definition of work as an activity that a person would only do for pay because of its disutility. It supports the concept that nonmonetary compensation can also be an important reason to work.[24] Supporting evidence is provided by the RAND 2015 American Working Conditions Survey, which shows that 56 percent of workers report that they have very good friends at work.[25]
Defining volunteer work

This section looks more closely at definitions of volunteer work. BLS defines volunteers as follows: “Volunteers are defined as persons who did unpaid work (except for expenses) through or for an organization.”[26] Thus, BLS recognizes volunteering as a type of work, but it does not include volunteers as part of the labor force. The BLS definition also does not include volunteering that is done directly, such as helping an older neighbor or one with a disability, as opposed to volunteering through an organization. Volunteers do a wide range of work activities that contribute to society, including serving food, mentoring and tutoring students, and coaching youth sports teams. In addition, many people engage in more than one kind of volunteer activity. Figure 1 shows CPS data collected in September 2017, covering the previous 12 months, according to types of volunteer activity by people ages 16 and over.

![Figure 1. Volunteer activity as a percentage of all volunteer activities reported, 2017](chart)

The ILO Manual on the Measurement of Volunteer Work, published in 2011, states the following: “The objective [of collecting and publishing data on volunteers] is to make available comparative cross-national data on a significant form of work which is growing in importance but is often ignored or rarely captured in traditional economic statistics.” The manual defines volunteer work as follows: “Unpaid non-compulsory work; that is, time individuals give without pay to activities performed either through an organization or directly for others outside their own household.”[27] Subsequently, this definition was modified so that it would exclude persons volunteering to help
family members living in other households.[28] The wording was amended again at the 2013 ILO International Conference of Labour Statisticians to that shown in exhibit 1. This exhibit includes key features of the ILO-recommended definition and its measurement. This is a broader definition of volunteers than the one BLS uses in its surveys on volunteering because it includes volunteer work performed directly for others, rather than only that done through an organization. At the same time, however, it is also a narrower definition in that the ILO excludes all forms of “compulsory” volunteering, whereas BLS includes people who volunteer under court order as well as students who engage in volunteer activities as a requirement for high school graduation.[29]
Exhibit 1. ILO recommendations for defining and measuring volunteer work

Definition of volunteers: All those of working age who, during a short reference period, performed any unpaid, noncompulsory activity to produce goods or provide services for others.

Key features:

• The work should contribute to production of goods and services that fall within the general production boundary of the economy as defined in the System of National Accounts.
• It is unpaid, although reimbursement for out-of-pocket expenses is allowed.
• It is noncompulsory, involving the element of choice. Court-mandated unpaid work, student volunteer work required for graduation, and unpaid training programs are excluded.
• It should consist of at least 1 hour of work during a specified recent period.
• It does not include unpaid work for a member of the household or a family member in another household.
• The definition embraces “direct volunteers” as well as those who volunteer through an organization.

Key elements of measurement:

• Labor force surveys offer the best platform for measuring the nature and extent of volunteer work, for many reasons. A major reason is that labor force surveys make it possible to observe volunteer work in the same classification framework as paid work, resulting in a complete picture of the labor market.
• Prompts should be used to make the definition of volunteering clear in the respondent’s mind.
• A 4-week reference period should be used, instead of the 1-year period frequently used in volunteer surveys. The shorter reference period is consistent with optimal recall by respondents.

Sources: International Labour Office, Manual on the Measurement of Volunteer Work (Geneva, Switzerland: International Labour Organization, March 2011), pp. 11–20, https://www.ilo.org/wcmsp5/groups/public/---dgreports/---stat/documents/publication/wcms_162119.pdf; and “Report of the Conference,” Report III, 19th International Conference of Labour Statisticians, Geneva, October 2–11, 2013 (Geneva, Switzerland: International Labour Organization, October 2013), pp. 54–55, https://www.ilo.org/wcmsp5/groups/public/---dgreports/---stat/documents/publication/wcms_234124.pdf. The latter source provided some amendments to the definition cited in the Manual.

The ILO has established a partnership with the United Nations Volunteers (UNV) program to advance survey methods for producing statistics on volunteer work. Between 2018 and 2021, The ILO and UNV are partnering with interested national statistical offices to test a module on volunteer work suitable for attachment to national labor force surveys in order to provide practical guidance and to help countries implement the module in their national labor force surveys.[30] The ILO reports that as of 2019, nearly 60 countries had measured volunteer work via modules attached to their national surveys. National data collected on volunteers are available from the ILO.
Department of Statistics website. However, the ILO warns that because countries use different approaches and tools for collecting these data, they do not recommend direct cross-country comparisons.[31]

Data on volunteering

Data on volunteers in the United States come primarily from two sources: (1) a September supplement to the CPS and (2) the American Time Use Survey (ATUS), which uses a sample derived from the CPS. Both surveys use the same definition of volunteering, but they collect the data over different timeframes; the September CPS supplement collects data for a “reference year,” whereas the ATUS collects data for a single day, based on the entries to a diary kept by the respondent. The September supplement has undergone some recent changes that we describe below. We then highlight some of the results from the 2015 September supplement to the CPS.

The September CPS supplements

Beginning in 2002, BLS published data annually on volunteering through a special September supplement to the CPS.[32] After the 2015 survey, however, BLS stopped publishing data on volunteers. Instead, beginning in 2017, the sponsor of the September supplement, the Corporation for National and Community Service (CNCS), an independent federal agency that supports national volunteering efforts, took responsibility for publishing these data. After 2017, the September supplement to the CPS became biennial.[33] New questions were added that combine data collection for volunteers with data collection on civic engagement. Along with volunteering, civic engagement includes such activities as talking to and spending time with friends, family, and neighbors; posting views about political, social, or local issues on the internet or on social media; voting in local elections; attending public meetings; and belonging to civic organizations and clubs. The questions on the other types of civic engagement come before the questions on volunteering. This change, along with others discussed later in the article, has affected the historical continuity of the series. The changes in the survey were the result of recommendations made by the National Academies of Sciences, Engineering, and Medicine Committee on National Statistics, which was commissioned by the CNCS in 2010 to improve understanding of civic engagement, including measures of volunteers. The committee issued their report and recommendations in 2014.[34] The Census Bureau continues to collect data from the September supplement on volunteering, but the data are published by the CNCS on its website. The CNCS publishes these data for all 50 states and the District of Columbia.[35]

The technical note to the 2016 BLS news release on volunteering includes the following language from the survey referencing September 2015:

Following this introduction, respondents were asked the first supplement question: “Since September 1st of last year, have you done any volunteer activities through or for an organization?” If respondents did not answer “yes” to the first question, they were asked the following question: “Sometimes people don’t think of activities they do infrequently or activities they do for children’s schools or youth organizations as volunteer activities. Since September 1st of last year, have you done any of these types of volunteer activities?”[36]

In 2017, the survey began asking a more probing second question that includes a long list of volunteer organizations that are read to the respondent, as follows: civic, political, professional or international; educational or youth service; environmental or animal care; hospital or other health; public safety; religious; social or community service; sport, hobby, cultural or arts; other.[37] This question, along with other changes in the
questionnaire, seem to have created a discontinuity in the data, probably explaining an increase in the volunteer rate from 24.9 percent in 2015 to 30.3 percent in 2017, as well as an increase in the number of volunteers over that period, from 63 million to 77 million.[38] Over the period from 2011 to 2015, the survey showed a stable volunteering rate of about 24 or 25 percent.

According to the September 2015 volunteer supplement, about 62.6 million people volunteered through or for an organization at least once between September 2014 and September 2015. Overall, the volunteer rate for the population ages 16 and over was 24.9 percent in 2015, and the rate for those ages 65 and over was not much different, at 23.5 percent. However, these figures obscure a much higher intensity of volunteer work among older workers. Median annual hours spent on volunteer activities ranged from a high of 94 hours for those ages 65 and over to a low of 36 hours for those under the age of 35.

A relatively early study found that older people accounted for 19 percent of total volunteer hours in 1989.[39] That percentage is higher now with the retirement of the baby-boom generation: the 2015 volunteers supplement indicates that people ages 65 and over accounted for 25 percent of total volunteer hours. The total number of hours volunteered by the population ages 16 and over in 2015 was 8.9 billion, with workers ages 65 and over contributing 2.2 billion of those hours. In fact, a 2015 study finds that volunteering by people ages 65 and over accounts for 45 percent of volunteer hours among adults ages 25 and over.[40]

Although additional age cohorts for the older population are not published for the latest surveys, these cohorts are available in a 2003 Monthly Labor Review article based on the 2002 survey.[41] Among people ages 65 and over, the volunteer rate declined with age. For example, 26.3 percent of people ages 65 to 69 volunteered, compared with 25.0 percent of people ages 70 to 74, 22.9 percent of people ages 75 to 79, and 16.1 percent of people ages 80 and over.

Among people who volunteered in 2015, 6.8 percent of those ages 55 to 64 volunteered for 500 or more hours per year, and 9.4 percent of those ages 65 and over volunteered for 500 or more hours per year. People ages 65 and over had the highest percentage for any age group, and we suspect the percentage would be even higher for people ages 65 to 74.

Thus, these data on volunteer rates and labor force participation rates suggest that an expanded definition of work to include unpaid work would have its largest effect on the statistics for people ages 65 and over, a rapidly growing segment of the population because of the aging of the baby-boom generation. Data from the ATUS discussed in the next section show similar results for volunteering among the population ages 65 and over.

**The American Time Use Survey**

Since 2003, the ATUS has provided national estimates of how Americans ages 15 and over spend their time, covering the full range of market and nonmarket activities, including volunteering.[42] The ATUS is a continuous survey conducted for BLS by the Census Bureau. The sample is drawn from participants in the CPS, with respondents assigned a day about which they report their activities over the entire 24 hours. Thus, ATUS involves less recall bias than the CPS September supplements, which ask respondents to remember their volunteer activity over the course of an entire year.
The ATUS reports data in terms of average hours per day per activity. Figure 2 shows averages for the period from 2011 to 2015 on the percent of the population ages 15 and over who volunteered on an average day. The highest rates of volunteer activity are found among those ages 65 and over. About 9 percent of the population in this age group volunteered on an average day, compared with 6 percent of the entire population ages 15 and over.[43]

The effect of adding volunteers to labor statistics

What if the productive activity of volunteers were recognized by including volunteers in a supplemental measure of the labor force? In the following exercise, we investigate the impact of including volunteers in labor force participation rates and employment–population ratios in 2015. The purpose is to show whether including volunteers as workers would change our perception of the economic contribution of the population generally or of older people. We make estimates for the total working-age population (ages 16 and over) and for the older population (ages 65 and over).

We tried two different approaches. Our first approach was an attempt to replicate the CPS definition and reference period by using other data sources. However, we were unable to arrive at supportable estimates compatible with the monthly CPS because such calculations would have involved mixing surveys with different reference periods,
requiring numerous and often questionable assumptions. Instead, we used an approach that combines the results of two CPS supplements, which allows us to make reasonable calculations without additional data collection.

The method adopted used a “work experience” approach. That is, we calculated yearlong participation rates and employment–population ratios. The data sources are two CPS supplements: (1) the “work experience” portion of the Annual Social and Economic Supplement (ASEC) to the CPS and (2) the CPS September supplement on volunteers. An explanation of the methodology follows. Table 1 shows the calculations and sources.

**Table 1. Adjusting data on work experience of the population to include volunteers as employed, 2015 (levels in thousands)**

| Characteristics                                           | Ages 16 and over | Ages 65 and over |
|-----------------------------------------------------------|------------------|-----------------|
| Work experience data                                      |                  |                 |
| Civilian noninstitutional population                      | 252,766          | 47,547          |
| Total who worked or looked for work                       | 165,495          | 11,157          |
| Percent of population                                     | 65.5             | 23.5            |
| Total who worked during the year                         | 162,329          | 10,953          |
| Percent of population                                     | 64.2             | 23.0            |
| Not in the labor force during the year                   | 87,271           | 36,390          |
| Data on all volunteers                                    |                  |                 |
| Total who volunteered during the year                    | 62,623           | 11,024          |
| Percent of population                                     | 24.9             | 23.5            |
| Employment status of volunteers                           |                  |                 |
| Civilian labor force                                      | 42,563           | 2,682           |
| Employed                                                  | 40,701           | 2,528           |
| Unemployed                                                | 1,861            | 154             |
| Not in the labor force                                    | 20,060           | 8,341           |
| Adjusted after adding volunteers who were not in the labor force | 185,555          | 19,498          |
| Percent of population                                     | 73.4             | 41.0            |
| Employed                                                  | 182,389          | 19,294          |
| Percent of population                                     | 72.2             | 40.6            |

Note: The work experience data are collected in the Annual Social and Economic Supplement to the Current Population Survey (CPS) and refer to work activity performed during the entire 2015 calendar year. The data on volunteers are collected in a September supplement to the CPS and cover the period from September 1, 2014, through the survey period in September 2015. The population figures for the two measures differ accordingly. The adjusted levels are calculated by adding volunteers who were counted as not in the labor force to the work experience totals for the labor force (worked or looked for work) and the employed.

Source: U.S. Bureau of Labor Statistics, Current Population Survey.

We start with data reported in the work experience survey conducted from February to April 2016 for the 2015 calendar year. This survey collects information on employment and unemployment experienced during the previous calendar year. Overall, 65.5 percent of the population ages 16 and over worked or looked for work (i.e., were in the labor force at some time in 2015), while 64.2 percent worked at some time during the year (i.e., were employed). For the population ages 65 and over, the rates based on the work experience data are much lower, at 23.5 percent and 23.0 percent, respectively. These published work experience data are shown at the beginning of table 1.
Data from the CPS volunteers supplement were collected in September 2015; respondents were asked to recall their volunteer activities over the period from September 2015 back to September 1, 2014. Thus, both the work experience and volunteer surveys use reasonably comparable timeframes. Statistics from the supplement are also shown in table 1, indicating volunteer rates of 24.9 percent for the population ages 16 and over and 23.5 percent for those ages 65 and over.

To obtain a yearlong participation rate that includes volunteers, as well as to avoid double counting, we must exclude the volunteers who are already counted as in the labor force. The volunteers supplement reports data on the employment status of volunteers by age groups. The number of volunteers who are not in the labor force is the volunteers total to be added to the reported labor force and employment data from the work experience survey to arrive at work-experience-based, year-long participation rates and employment–population ratios. These estimates are not to be confused with the official CPS figures for these two measures, which are based on data collected according to labor force activity in reference weeks.

The calculations show a relatively moderate increase in the yearlong labor force participation rate for people ages 16 and over—from the reported figure of 65.5 percent to the adjusted figure of 73.4 percent. For those ages 65 and over, as expected, the increase resulting from adding volunteers to the labor force is much larger, from 23.5 percent to 41.0 percent. This sizeable increase for older people occurs because three-quarters of them are classified as not in the labor force, whereas most of the population ages 16 to 64 were working or actively seeking work and therefore were already included in the labor force. The results for employment–population ratios are similar. (See table 1.)

As mentioned previously, these calculations bring together data from two different CPS supplements that are collected for different purposes—one to enumerate volunteers and the other to present data on work experience. These surveys also have slightly different timeframes. Thus, the estimates provided here cannot be considered exact values, but rather as values that provide a rough order of magnitude. The advantage of these estimates is that they are based on data collected from the same CPS population and survey methodology; they are transparent calculations that can be verified with relative ease; and the timeframes are reasonably comparable. Another important advantage of these estimates is that they do not require additional data collections, but instead use existing and ongoing data sources based on the CPS. They do not affect data comparability over time because they do not affect existing labor force measures; rather, they provide a supplement to those measures.

**Making volunteers visible**

Linking volunteers into a supplementary labor force statistics framework, as shown in the previous section, could change the perception of the economic contributions made by different groups of people, especially the older population. The exercise on estimating work-experience-based participation rates and employment–population ratios including volunteers shows that the impact is sizable for older workers. This calculation clearly makes volunteer work more visible.

Some other issues could be considered relating to the understanding, collection, and presentation of data on volunteers: recall bias, more detailed age breakdowns of economic statistics, and data that cover all volunteers, not only those who volunteer through organizations. These issues are considered in the next three subsections.
Recall bias

The September volunteer supplements use a reference year rather than a reference week (as in the monthly CPS). Because volunteer work is often sporadic and does not always adhere to a regular work schedule, the survey responses for the longer reference period in the volunteer survey are subject to a higher level of recall bias. Although all surveys that rely on a respondent’s memory are subject to recall bias, this may be more prevalent for sporadic activity among people of older ages. The longer the reference period, the more difficult it is to recall the requested information accurately, and thus the surveys need to provide additional prompts to try to help respondents remember. A strong additional prompt question has indeed been asked of respondents since 2017. Nevertheless, respondents may forget activities performed near the beginning of the reference year. A high level of recall bias may distort the results.

The ILO Manual recommends a 4-week recall period to take care of most of the issues of recall, noting that testing of the ILO survey module “suggests that the four-week reference period should be long enough to capture irregular activity but not so long as to make recall unduly difficult.” Even a quarterly survey that requires the recall of volunteer activities over the previous 3 months would involve fewer recall problems than an annual recall period. More frequent enumeration of volunteers over the course of a year would likely lead to a higher count of volunteers, making them more visible in economic statistics.

The Alzheimer Society of Canada makes the following point about age-related memory decline, which is relevant for recall bias at older ages: “Almost 40 per cent of people over the age of 65 experience some form of memory loss. When there is no underlying medical condition causing this memory loss, it is known as ‘age-associated memory impairment,’ which is considered a part of the normal aging process.” Age differences in recall have long been discussed in the scientific literature, with, for example, a laboratory investigation documenting them in 1987. Thus, recall bias, taking the form of not remembering volunteer activities over a recall period of 1 year, presumably is a more serious problem for older people than for younger ones. For this reason, the survey responses for older people may understate (or even overstate) the actual amount of volunteer work being performed. However, we believe that people are more likely to make an error of not remembering something that did happen than to make an error of imagining something that did not happen.

Age breakdowns

Changes in the age structure of the U.S. population may necessitate changes in the age groups for which data are routinely published. The percentage of the population ages 65 to 74 increased from 3.8 percent in 1930 to 7.0 in 2010 and is projected to increase to 10.8 percent by 2030. With the growth of this age group, standard age groups, which often have the 65-and-over group as the oldest one, could be further divided to include people ages 65 to 74 and those ages 75 and over. It would be particularly useful to have statistics for those ages 65 to 74 because people in that age group are often transitioning from full-time work to retirement by volunteering. As stated previously, data on volunteering for these age groups were published in 2003, but they have not been published since then. Publishing data for the older age groups would also help make older volunteers more visible. Since 2017, the CNCS has published data online by generational categories—Generation Y, millennials, Generation X, baby boomers, the Silent Generation—rather than by specific age groups.

Covering all volunteers
In this section, we consider the option of collecting data for all volunteers, as opposed to collecting data only for people who volunteer for or through an organization. As mentioned previously, the COVID-19 pandemic has highlighted the contributions made by “direct volunteers”—those who see a need and respond to it directly, without working through an organization. They represent a mostly unmeasured component of volunteers in the United States.[48] A study for the National Academy of Sciences states the following:

Time spent helping others informally is arguably as or more important than formal volunteering. As the population ages, we might expect an increase in the reliance on friends, family, and neighbors to help out with grocery shopping, yard work, and other activities of daily life. Some of these activities fall conceptually between household production and volunteer work. The practical problems of measuring and valuing volunteer labor activity not connected with a formal organization may be severe; still, we want to highlight its omission from traditional economic accounts and because such activity clearly contributes to real output, encourage attention to it.[49]

The Alzheimer’s Association notes that 18.4 billion hours of care annually, valued at $232 billion, are provided by family and other unpaid caregivers.[50] In addition, the American Time Use Survey shows that each year 41.3 million people provide unpaid care to people ages 65 and over.[51] According to an estimate prepared for the 2018 State of the World’s Volunteerism Report by the United Nations, 70 percent of global volunteer activity occurs through direct person-to-person engagement, while 30 percent takes place formally through organizations.[52]

The ILO concluded its 2020 announcement of the celebration of International Volunteer Day with the following statement: “A key contribution of statisticians is to make the invisible visible through more and better data. This clearly applies to the important work done by volunteers throughout the world.”[53]

**Conclusions**

Expanding the basic framework for measuring work would have advantages and disadvantages. The advantages include creating a broader view of the labor force that incorporates volunteer workers within a familiar framework that enables better understanding of the labor force activity of older people. A potential disadvantage is that changing the definition of work would create a break in the historical data series—data from the period after the definition change would not be comparable to data from the period before the change. This disadvantage is somewhat mitigated, however, because the definitions would not be changed in the historical data. The expanded definition would create a new data series that would begin when the change was made. In addition, most of the changes could be made within the existing framework of the current CPS, although collecting data on all volunteers, including those who volunteer directly and not through organizations, would require adding new questions to the questionnaire.

In 2020, the COVID-19 pandemic has highlighted the importance of volunteering, not only activities done through organizations, but also those done by “direct volunteers”—such as grocery shopping for their older neighbors and friends or sewing face masks to give to people who otherwise might not be able to obtain them, including healthcare workers. This kind of volunteering is currently not counted in U.S. statistics on volunteers, leaving a wide gap in the data on this subject.
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NOTES

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The consistency of economic recoveries over the 1949–2019 period

Jonathan Yoe

In their paper, "Why has the U.S. economy recovered so consistently from every recession in the past 70 years?" (National Bureau of Economic Research, Working Paper 27234, May 2020), Robert E. Hall and Marianna Kudlyak use Current Population Survey data to study the recovery path of the unemployment rate after each negative economic shock that has occurred over the past 70 years (1949–2019). Normally, an economic recession results in a spike in unemployment. Hall and Kudlyak discover that the unemployment rate has declined in a predictable way, at an average of 0.55 percentage point annually after every recession since 1949. This decline has occurred notwithstanding the causes of the recession or the monetary and fiscal policy tools implemented to combat the recession.

The causes of recessions are many and heterogeneous. However, the authors of this study find that the recovery of the unemployment rate is actually homogenous—it declines by about 0.55 percentage point each year until reaching between 3 and 5 percent. The authors discuss the “widespread” belief that the recovery from the financial crisis of 2008 took longer than other recoveries, such as the 2001 recession or the recessions of the early 1980s. In fact, the growth rate of gross domestic product was slower to recover following the 2007–09 recession, but the unemployment rate recovered in a way similar to that of the other recessions during the 70-year period. When the unemployment rate is 10 percent, though, the recovery takes longer. Hall and Kudlyak try to explain why the decline in the unemployment rate was both slow and linear after each recession during the 1949–2019 period.

The authors use Job Openings and Labor Turnover Survey data and other sources to study different types of job loss: layoffs, job destruction, worker displacement, and unemployment insurance claims. All of these measures of job loss tend to spike after a negative shock to the economy; however, they all recover rather quickly, while the aggregate unemployment rate takes much longer. In addition, the authors argue that individual jobseekers seem to find employment faster than the overall unemployment rate declines. Although these findings suggest that individual people find jobs more quickly than the unemployment rate indicates, this can be explained by the fact that people often fluctuate from being employed to unemployed until they find the right job, which adds to the persistence of a higher unemployment rate.

The aggregate unemployment rate also takes time to recover because there are “frictions in rebuilding unemployment” that cause the rate to decline slowly. For example, many people seeking employment creates an adverse selection problem for firms that want to hire new employees, because they have to vet all of the job applicants. This raises the costs of the hiring process, which results in fewer jobs being offered. The credit market provides another example. During a recession, banks are more reluctant to lend money, which raises the cost of capital, making it more difficult for firms to expand and hire.
Although Hall and Kudlyak use various models to try to explain the linearity of the unemployment rate’s recovery, none could explain it fully. The models instead predicted a convex recovery path, meaning that the unemployment rate would recover in larger increments at the beginning and smaller increments as the unemployment rate approached the range of 3 to 5 percent.

This paper is timely, as the COVID-19 pandemic has pushed the United States into a recession—the Business Cycle Dating Committee of the National Bureau of Economic Research determined that the U.S. economy reached a peak in February 2020, marking the beginning of an economic downturn. The unemployment rate rose from a 2019 annual average of 3.7 percent to 14.7 percent in April 2020 (the rate was 11.1 percent in June 2020). Although this recession is highly unusual because of the pandemic, studying past recessions and recoveries can nevertheless help us understand the present one.
Measuring the substitution effect in Producer Price Index goods data: 2002–16

This article examines the substitution effect in Producer Price Index (PPI) data for final- and intermediate-demand goods. The analysis demonstrates that PPIs calculated with Fisher and Tornqvist formulas, which allow for substitution, are generally lower than PPIs calculated with a Laspeyres formula. This result implies that the effect of substitution toward relatively less expensive goods dominates the effect of substitution toward relatively more expensive goods.

The Producer Price Index (PPI) measures 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 article, are the Final Demand–Intermediate Demand (FD–ID) price indexes. Final-demand PPIs measure price change for outputs sold for 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.\(^1\)

PPIs are calculated with a modified Laspeyres formula. To accurately reflect the relative importance of items included in an overall index category, the PPI program calculates its price indexes by using weights. In the modified Laspeyres formula, these weights are fixed quantities (over a 5-year period), but the formula allows prices to vary monthly. Having fixed quantities as weights restricts product substitution in response to relative price change, causing PPI data not to reflect the substitution effect, which is the effect on price measurement of shifts in production and purchase patterns in response to relative price changes.

Using fixed-base Laspeyres, Paasche, Fisher, and Tornqvist formulas, this article examines the substitution effect in PPI data by reestimating, on an annual basis, selected FD–ID PPIs from 2002 through 2016. To measure the substitution effect, the analysis compares the indexes calculated with Fisher and Tornqvist formulas (both of which allow for substitution) with corresponding indexes calculated with a Laspeyres formula. Importantly, there are no clear expectations about the direction of the substitution effect. In theory, purchasers tend to shift toward relatively less expensive products in an effort to reduce costs or increase utility, whereas producers tend to shift toward
relatively higher priced products in order to maximize profits. The substitutions observed in the market are the net result of producer and purchaser responses that potentially work in the opposite directions.

Several studies have analyzed the substitution effect by using consumer price data. These studies typically find that the dominant substitution effect is one of consumers shifting toward relatively cheaper products. For example, Steven D. Braithwait measures the substitution effect by comparing a Laspeyres index with a cost-of-living index from 1958 through 1973. Using annual price and quantity data, the author finds that, compared with the cost-of-living index, the Laspeyres index overstated inflation by approximately 1.5 percentage points (about 0.1 percentage points per year) over the entire 15-year period. By examining detailed product categories within personal consumption, Braithwait also finds that the substitution effect varied by class of product. For example, from 1958 through 1973, the substitution effect for household durables was approximately 3.9 percentage points, whereas that for housing and utilities was only 0.1 percentage points. Using personal consumption data for 101 commodities from 1959 through 1985, Marilyn E. Manser and Richard J. McDonald examine the substitution effect by comparing fixed-base Laspeyres and Paasche indexes with Tornqvist and Fisher indexes. The authors find that, compared with the Tornqvist index, the Laspeyres index overstated inflation by approximately 0.19 percentage points per year over the entire period. Using weights based on annual consumer expenditure data for 207 product categories, Ana M. Aizcorbe and Patrick C. Jackman measure the substitution effect in the Consumer Price Index (CPI) by calculating fixed-base and chained Laspeyres indexes from 1982 through 1991 and comparing them with fixed-base and chained Tornqvist and Fisher indexes. The authors estimate that the Laspeyres index exceeded the Tornqvist index by 2.6 index points over the period, which is approximately 0.2 percentage points per year. Finally, a 1996 report by the U.S. Advisory Commission to Study the Consumer Price Index (commonly known as the Boskin Commission report) found that the CPI overstated inflation by 0.15 percentage points per year because of upper level (cross-commodity) substitution and by 0.25 percentage points per year because of lower level (within-commodity) substitution.

While commonly examined with consumer price data, the substitution effect is rarely studied with producer price data. In a 1998 working paper cited by Keith Waehrer, Jack Galvin and Kenneth Stewart use both Laspeyres and Paasche formulas to calculate high-level PPI commodity indexes from 1987 to 1992. The authors find that, for 13 of the 15 commodity groups they examined, the Laspeyres index increased more than the Paasche index, indicating substitution into relatively cheaper products. Like Galvin and Stewart’s paper, the present article examines the substitution effect by using producer price data. This examination is important because, unlike studies using consumer price data, it can reveal substitution patterns at an earlier point in the supply chain. The article demonstrates that the experimental FD–ID indexes calculated with formulas allowing for substitution are generally lower than the indexes calculated with a Laspeyres formula. This result implies that the effect of substitution toward relatively less expensive products dominates the effect of substitution toward relatively more expensive products.

Methodology

As noted earlier, the PPI program’s FD–ID indexes are high-level indexes that measure price change for outputs sold for personal consumption, as capital investment, to government, and as exports (final demand) and outputs sold to businesses as inputs to production (intermediate demand). These 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 (e.g., beef and veal, processed poultry,
unleaded regular gasoline, hardwood lumber, or automobiles). At their lowest level, commodity indexes are calculated directly from detailed price data with the use of a modified Laspeyres formula, in which weights are derived from data collected from survey respondents. To construct the FD–ID indexes, PPI aggregates commodity indexes into higher level price indexes by using a modified Laspeyres formula. The calculation uses aggregation weights based on value-of-shipments data from the quinquennial Economic Census and use-of-commodities-by-industry data from the U.S. Bureau of Economic Analysis. Every 5 years, PPI updates the weights used to calculate the FD–ID indexes.

In analyzing the substitution effect in PPI data, this article uses fixed-base Laspeyres, Paasche, Fisher, and Tornqvist formulas to estimate, on an annual basis, experimental FD–ID goods indexes for 2002–16. The article focuses on goods because an annual weight source is more readily available for detailed goods products included in the PPI than for services and construction products. (A description of how weights were constructed is provided toward the end of this section.) The experimental FD–ID indexes are estimated from the annual average values of 662 component PPI commodity indexes. The component commodity indexes are those calculated by the PPI program with the use of its standard modified Laspeyres formula. The FD–ID index calculation formulas can be written as follows:

\[
\begin{align*}
I_L^t & = \sum_{i=1}^{n} RI_i^0 \left( \frac{P_i^t}{P_i^0} \right) \\
I_P^t & = 1 / \sum_{i=1}^{n} RI_i^t \left( \frac{P_i^0}{P_i^t} \right) \\
I_F^t & = (I_L^t + I_P^t)^{1/2} \\
I_T^t & = \prod_{i} \left( \frac{P_i^t}{P_i^0} \right)^{w_i t}
\end{align*}
\]

In these formulas, the subscript \(i\) denotes each of the component commodities included in the index calculation, \(I_L^t\) is the Laspeyres 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 \(t\), \(P_i^0\) is the component index value in the base period, and \(P_i^t\) is the component index value in period \(t\). The relative importance for component \(i\) in period \(t\) is calculated as

\[
RI_i^t = \frac{VOS_i^t}{\sum_{i=1}^{n} VOS_i^t}
\]

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

Statistical agencies, including the U.S. Bureau of Labor Statistics, often use Laspeyres indexes to measure price change because doing so requires only base-period value-of-shipments data for weighting. Current-period value-of-shipments data are typically not available in a timely manner. As noted earlier, however, using base-period weight data restricts substitution in response to relative price change. In contrast, Fisher and Tornqvist indexes use a combination of current-period and base-period value-of-shipments data for weighting, relaxing the substitution
restriction imposed by Laspeyres indexes. The Fisher and Tornqvist indexes are superlative indexes generally considered better approximations of the theoretical indexes on which PPIs are based. Assuming that a superlative index (such as a Fisher or a Tornqvist index) is a better measure of producer price change than a nonsuperlative index, one can measure the substitution effect by comparing the superlative index with the nonsuperlative Laspeyres index.

Calculating the indexes in equations (1) through (4) first requires constructing annual weights for the component indexes. Value-of-shipments data from the U.S. Census Bureau Annual Survey of Manufactures are used to construct weights for the manufacturing sector commodities. Weights for agricultural products are constructed with data from the annual Census of Agriculture of the U.S. Department of Agriculture, and finfish and shellfish weights are constructed with data from the annual Fisheries of the United States report of the National Oceanic and Atmospheric Administration. An annual data source for mining and utilities weights is not available. To overcome this problem, the analysis uses U.S. Census Bureau data when available (every 5 years), and for missing years, it uses estimates obtained by multiplying these data by the appropriate annual changes in the Federal Reserve’s indexes for industrial production (to account for commodity quantity changes) and then by the annual change in PPIs (to account for commodity price changes). The census, industrial production, and PPI data are all available in a form based on the North American Industry Classification System (NAICS). Missing census values are therefore estimated by using the closest matching NAICS-based indexes for industrial production and producer prices. After constructing the weights, the analysis estimates the FD–ID indexes by using formulas (1) through (4). In cases in which a component index value is missing, the missing value is estimated by using information for the closest available substitute index.

The design of this study only allows estimation of the substitution effect based on substitution across PPI commodity categories and not within commodity categories. In the calculation of 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 with a Laspeyres formula, which restricts substitution in response to relative price change. Therefore, this study examines only the substitution effect arising from responses to relative price change across commodities.

**Results**

To examine the substitution effect, the analysis looks at both long- and short-term index movements.

**Long-term analysis**

Figure 1 presents the PPI for final-demand goods from 2002 through 2016. The index is calculated with the use of Laspeyres, Paasche, Fisher, and Tornqvist formulas. As seen in the figure, the Laspeyres index is higher than the Paasche index over the entire 14-year period, and the Fisher and Tornqvist indexes 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 period, but it narrows between 2009 and 2011. Over the entire period, the Laspeyres and Paasche indexes rise by 37.1 percent and 31.7 percent, respectively. Both the Fisher and Tornqvist indexes rise by about 34 percent. The substitution effect, calculated by subtracting the Tornqvist index from the Laspeyres index, is positive and approximately 3.4 percentage points per year. These findings for final-demand goods
are very similar to those reported in Manser and McDonald’s and Aizcorbe and Jackman’s studies, which, using consumer data, estimate the annual substitution effect to be 0.19 and 0.2 percentage points, respectively.  

Although the PPI for final demand measures price change based on prices received by producers, it reflects price change for commodities sold to specific types of buyers (consumers, government, capital investors, and foreign purchasers of U.S. 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 dominate producer substitutions into relatively more expensive products. A possible cause of this pattern could be that, during the sample period, supply shifts are occurring more frequently than demand shifts.

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 goods sold to end users). The index for processed goods for intermediate demand measures price change for goods that have undergone some level of fabrication, whereas the index for unprocessed goods for intermediate demand measures price change for business purchases of unfabricated goods. Figures 2 and 3 present the intermediate-demand indexes, calculated with Laspeyres, Paasche, Fisher, and Tornqvist formulas, for the 2002–16 period.
Figure 2. Producer Price Index for processed goods for intermediate demand, 2002–16

Index level (2002 = 100)

- Laspeyres
- Paasche
- Fisher
- Tornqvist

Click legend items to change data display. Hover over chart to view data.

Source: Author’s calculations based on Producer Price Index data from the U.S. Bureau of Labor Statistics.
For processed goods for intermediate demand, the Laspeyres index is higher than the Paasche index in all years except 2008 and 2009. Likewise, for unprocessed goods for intermediate demand, the Laspeyres index is higher than the Paasche index in all years except 2009, 2010, 2013, and 2014. Over the entire 14-year period, the Laspeyres and Tornqvist indexes for processed goods for intermediate demand rise by 143.1 percent and 141.8 percent, respectively. Therefore, compared with the Tornqvist index, the Laspeyres index overstates inflation by an average rate of 0.07 percentage points per year. For unprocessed goods for intermediate demand, the Laspeyres and Tornqvist indexes rise by 154.5 percent and 150.8 percent, respectively, over the period. Thus, compared with the Tornqvist index, the Laspeyres index overstates inflation by 3.7 percentage points, or 0.18 percentage points per year.

As evidenced by both the index for final demand and the indexes for intermediate demand, the substitution effect during the Great Recession and the subsequent recovery years differs from the substitution effect during the rest of the sample period. (The Great Recession began in December 2007 and ended in June 2009, but the economy continued to slowly return to a more normal state for several years after the recession, with the unemployment rate not falling below 5 percent until late 2015.) For final demand, the Tornqvist index is always lower than the Laspeyres index, but the two indexes are closer to each other during the Great Recession. The Tornqvist index for processed goods for intermediate demand actually exceeds the Laspeyres index from 2007 through 2014. In all years prior to the Great Recession, and after 2014, the Laspeyres index for processed goods for intermediate demand exceeds the Tornqvist index. A similar pattern is found for the index for unprocessed goods for intermediate demand. Owen J. Shoemaker also notes this pattern in comparing the chained CPI for All Urban Consumers (CPI-U) (calculated with a Tornqvist formula above the elementary level) with the regular CPI-U (calculated with a modified Laspeyres formula above the elementary level). He observes that, during 2008, the
annual rate of change in the chained CPI-U was higher than the rate in the regular CPI-U. A potential area of future research would be to examine how the substitution effect changes during recessions.

For both final and intermediate demand, a long-term analysis of the substitution effect shows evidence of substitution toward relatively less expensive products. In general, the substitution effect seems stronger for final demand than for 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.

Short-term analysis

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

$$PCI_p^{t,t+k} = \frac{1}{\sum_{i=1}^{n} R_{i}^{t}} \left( \frac{P_{i}^{t}}{P_{i}^{t+k}} \right).$$

Table 1 presents annual percent changes in FD–ID goods indexes obtained from Laspeyres, Paasche, and Tornqvist formulas. For the Laspeyres indexes, the table includes percent changes calculated with the use of both the ratio and true methods. The true percent change is calculated with the Laspeyres formula (whereby the earlier comparison period is the base period), and the ratio percent change is calculated by forming ratios of the index in the two periods of interest. Table 2 presents estimates of the substitution effect, which is calculated by subtracting the annual percent change in the Tornqvist index from the annual percent change in the Laspeyres index. The substitution effect is calculated for both the true and ratio versions of the indexes. (For the full set of index changes measured by formulas, see appendix tables A-1, A-2, and A-3.)

Table 1. Producer Price Index annual percent changes, 2003–16

| Year | Goods for final demand | Processed goods for intermediate demand | Unprocessed goods for intermediate demand |
|------|------------------------|----------------------------------------|------------------------------------------|
|      | Laspeyres   | Tornqvist | Paasche | Laspeyres   | Tornqvist | Paasche | Laspeyres   | Tornqvist | Paasche |
|      | True | Ratio |        | 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 |

See footnotes at end of table.
The short-term analysis provides additional evidence that, in both final- and intermediate-demand PPI data, the Laspeyres index has an upward bias relative to the Tornqvist index. In the vast majority of cases, the annual rate of change in the Laspeyres indexes for final-demand goods, processed goods for intermediate demand, and unprocessed goods for intermediate demand is higher than the annual rate of change in the Tornqvist index. This is especially evident in comparing the values for the true Laspeyres indexes with those for the Tornqvist indexes. In no case is the annual percent change in the final- or intermediate-demand true Laspeyres indexes lower than the change in the Tornqvist indexes. In some cases, the percent changes are equal, but again, this primarily occurs during the Great Recession or the first few years of the recovery. On average, the annual percent changes in the true Laspeyres indexes for final-demand goods, processed goods for intermediate demand, and unprocessed
goods for intermediate demand are 0.16, 0.12, and 0.46 percentage points higher than the corresponding changes in the Tornqvist indexes. Likewise, the annual percent changes in the ratio Laspeyres indexes for final-demand goods, processed goods for intermediate demand, and unprocessed goods for intermediate demand are 0.27, 0.18, and 0.44 percentage points higher than the corresponding changes in the Tornqvist indexes.

The short-term analysis of the substitution effect provides relatively clear evidence of substitution toward cheaper goods for both final and intermediate demand. Like the long-term analysis, the short-term analysis also finds that the substitution effect during the Great Recession is different from the substitution effect in normal economic times.

**Conclusion**

Using fixed-base Laspeyres, Paasche, Fisher, and Tornqvist formulas and annual weights derived from several sources, this article examined the substitution effect in PPI data for final- and intermediate-demand goods by calculating, on an annual basis, selected FD–ID indexes for 2002–16. To estimate the substitution effect, the analysis compared experimental superlative indexes with fixed-base Laspeyres indexes. The substitution effect was examined by looking at both long- and short-term index movements.

In the long-term analysis, the substitution effect for 2002–16 (calculated by subtracting the Tornqvist index from the Laspeyres index) was found to average 0.18 percentage points per year for final-demand goods, 0.07 percentage points per year for processed goods for intermediate demand, and 0.18 percentage points per year for unprocessed goods for intermediate demand. The short-term analysis also found that the substitution effect for purchases of final-demand goods is toward relatively cheaper products. In an annual comparison of true Laspeyres indexes with 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 was found to be upwardly biased by, respectively, 0.16, 0.12, and 0.46 percentage points per year, on average.

Both the long- and short-term analyses indicate that the substitution effect during the Great Recession and immediate postrecessionary years differed from the substitution effect observed at other times in the sample period. Again, a possible area of future research would be to analyze how the substitution effect differs across recessionary periods, periods of high economic growth, and normal economic times. A second possible area of further research would be to extend the present analysis by including data for the services and construction sectors of the economy. As noted earlier, this article focused on goods indexes primarily because annual weight data for detailed PPI products are readily available.

**Appendix**

Table A-1. Changes in the Producer Price Index for final demand, as measured by Laspeyres, Paasche, Fisher, and Tornqvist formulas, 2012–16

Table A-2. Changes in the Producer Price Index for processed goods for intermediate demand, as measured by Laspeyres, Paasche, Fisher, and Tornqvist formulas, 2002–16

Table A-3. Changes in the Producer Price Index for unprocessed goods for intermediate demand, as measured by Laspeyres, Paasche, Fisher, and Tornqvist formulas, 2002–16
Table A-1. Changes in the Producer Price Index for final demand, as measured by Laspeyres, Paasche, Fisher, and Tornqvist formulas, 2012–16

| Index  | Price change from: | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|--------|---------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Laspeyres |                     | 100.00 | 104.07 | 108.07 | 113.48 | 118.26 | 121.92 | 124.81 | 130.35 | 139.48 | 141.73 | 143.06 | 145.04 | 138.99 | 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 | 110.56 | 105.26 | 103.90 |
| 2011   | — — —               | —      | —     | —     | 100.00 | 101.53 | 102.34 | 103.68 | 98.74 | 90.72 | 95.76 |
| 2012   | — — —               | —      | —     | —     | 100.00 | 100.73 | 101.97 | 102.16 | 97.22 | 95.72 |
| 2013   | — — —               | —      | —     | —     | 100.00 | 101.17 | 96.20 | 94.66 |
| 2014   | — — —               | —      | —     | —     | 100.00 | 95.37 | 93.66 |
| 2015   | — — —               | —      | —     | —     | 100.00 | 98.54 |
| 2016   | — — —               | —      | —     | —     | —     | 100.00 |
| Paasche |                     | 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 | 102.15 | 103.38 | 98.31 | 96.14 |
| 2012   | — —                 | 100.00 | 101.53 | 103.38 | 98.31 | 96.14 |
| 2013   | — —                 | 100.00 | 102.15 | 103.38 | 98.31 | 96.14 |
| 2014   | — —                 | 100.00 | 102.15 | 103.38 | 98.31 | 96.14 |
| 2015   | — —                 | 100.00 | 102.15 | 103.38 | 98.31 | 96.14 |
| 2016   | — —                 | 100.00 | 102.15 | 103.38 | 98.31 | 96.14 |
| Fisher |                     | 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 |
### Table A-1. Changes in the Producer Price Index for final demand, as measured by Laspeyres, Paasche, Fisher, and Tornqvist formulas, 2012–16

| Index | Price change from: | Price change to: |
|-------|-------------------|------------------|
|       | 2002   | 2003   | 2004   | 2005   | 2006   | 2007   | 2008   | 2009   | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   |
| 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 | 126.09 | 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 | 107.82 | 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 | 132.85 | 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 | 107.88 | 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 | 110.52 | 103.39 | —      | —      |
| 2011  | —      | —      | —      | —      | —      | —      | —      | 100.00 | 101.53 | 102.25 | 103.53 | 98.39  | 96.46  | —      | —      |
| 2012  | —      | —      | —      | —      | —      | —      | —      | —      | 100.00 | 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 | —      | —      |

Source: Author’s calculations based on Producer Price Index data from the U.S. Bureau of Labor Statistics.
| Index       | Price change from:         |          | Price change to:          |          |
|-------------|---------------------------|----------|---------------------------|----------|
|             | 2002  | 2003     | 2004     | 2005     | 2006     | 2007     | 2008     | 2009     | 2010     | 2011     | 2012     | 2013     | 2014     | 2015     | 2016     |
| Laspeyres   |       | 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   |
|             |       | 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   |
|             |       | 100.00   | 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   |
|             |       | 100.00   | 100.00   | 107.69   | 110.67   | 121.78   | 111.92   | 119.32   | 130.03   | 130.44   | 130.46   | 131.37   | 122.42   | 118.43   |
|             |       | 100.00   | 107.94   | 113.33   | 104.18   | 111.08   | 121.04   | 121.48   | 121.56   | 122.47   | 114.19   | 110.54   |
|             |       | 100.00   | 110.10   | 101.10   | 107.81   | 117.62   | 118.01   | 118.07   | 118.85   | 110.50   | 106.93   |
|             |       | 91.61    | 97.59    | 106.55   | 106.98   | 107.01   | 107.72   | 99.97    | 96.76    |
|             |       | 100.00   | 106.84   | 116.99   | 117.42   | 117.51   | 118.34   | 109.07   | 105.22   |
|             |       | 100.00   | 109.21   | 109.62   | 109.70   | 110.47   | 101.94   | 98.47    |
|             |       | 100.00   | 100.35   | 100.41   | 101.11   | 93.37    | 90.24    |
|             |       | 100.00   | 100.53   | 92.79    | 89.69    |
|             |       | 100.00   | 100.50   | 92.66    | 89.55    |
|             |       | 100.00   | 92.41    | 89.42    |
|             |       | 100.00   | 90.00    |
|             |       | 100.00   | 90.00    |
|             |       | 100.00   | 90.00    |
|             |       | 100.00   | 90.00    |
|             |       | 100.00   | 90.00    |
|             |       | 100.00   | 90.00    |
| Paasche     |       | 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   |
|             |       | 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   |
|             |       | 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   |
|             |       | 100.00   | 107.22   | 110.20   | 121.54   | 110.81   | 117.96   | 128.23   | 129.85   | 129.49   | 130.02   | 120.00   | 115.85   |
|             |       | 100.00   | 102.66   | 113.05   | 103.20   | 109.55   | 118.98   | 120.82   | 120.30   | 121.06   | 111.78   | 107.90   |
|             |       | 100.00   | 110.10   | 100.16   | 106.48   | 115.80   | 117.30   | 116.85   | 117.52   | 108.48   | 104.68   |
|             |       | 90.56    | 96.53    | 105.14   | 106.16   | 105.85   | 106.47   | 98.41    | 94.83    |
|             |       | 100.00   | 106.44   | 115.85   | 116.92   | 116.80   | 117.21   | 108.23   | 104.59   |
|             |       | 100.00   | 108.98   | 109.77   | 109.67   | 110.18   | 101.77   | 98.14    |
|             |       | 100.00   | 100.42   | 100.33   | 100.89   | 93.21    | 89.73    |
|             |       | 100.00   | 99.96    | 100.52   | 92.82    | 89.36    |
|             |       | 100.00   | 100.52   | 92.76    | 89.30    |
|             |       | 100.00   | 100.00   | 96.55    |
|             |       | 100.00   |
|             |       | 100.00   |
|             |       | 100.00   |
| Fisher      |       | 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   |

See footnotes at end of table.
### Table A-2. Changes in the Producer Price Index for processed goods for intermediate demand, as measured by Laspeyres, Paasche, Fisher, and Tornqvist formulas, 2002–16

| Index | Price change from: | Price change to: |
|-------|-------------------|------------------|
|       | 2002   | 2003   | 2004   | 2005   | 2006   | 2007   | 2008   | 2009   | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   |
|       | 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 |
|       | 2011   | —      | —      | —      | —      | —      | —      | —      | —      | —      | 100.00 | 103.38 | 100.37 | 101.00 | 93.29  |
|       | 2012   | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | 100.00 | 101.51 | 92.71  | 89.42  |
|       | 2013   | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | 100.00 | 100.05 | 92.80  |
|       | 2014   | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | 100.00 | 91.35  |
|       | 2015   | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | 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 |
|         | 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 |
|         | 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 |
|         | 2005  | —      | —      | —      | 100.00 | 107.44 | 110.44 | 121.68 | 111.38 | 118.50 | 128.98 | 129.96 | 128.86 | 130.49 | 120.98 |
|         | 2006  | —      | —      | —      | —      | 100.00 | 102.81 | 113.24 | 103.73 | 110.24 | 119.95 | 121.04 | 120.91 | 121.63 | 112.62 |
|         | 2007  | —      | —      | —      | —      | —      | 100.00 | 110.11 | 100.65 | 107.04 | 116.54 | 117.47 | 117.34 | 118.03 | 109.37 |
|         | 2008  | —      | —      | —      | —      | —      | —      | 100.00 | 91.09  | 97.03  | 105.77 | 106.48 | 106.39 | 107.06 | 99.12  |
|         | 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 | —      |

Source: Author’s calculations based on Producer Price Index data from the U.S. Bureau of Labor Statistics.
Table A-3. Changes in the Producer Price Index for unprocessed goods for intermediate demand, as measured by Laspeyres, Paasche, Fisher, and Tornqvist formulas, 2002–16

| 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 | 91.00 |
|         | 2016 | — | — | — | — | — | — | — | — | — | — | — | — | — | 100.00 | 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 |

See footnotes at end of table.
### Table A-3. Changes in the Producer Price Index for unprocessed goods for intermediate demand, as measured by Laspeyres, Paasche, Fisher, and Tornqvist formulas, 2002–16

| Index | Price change from: | Price change to: |
|-------|-------------------|------------------|
|       | 2002   | 2003   | 2004   | 2005   | 2006   | 2007   | 2008   | 2009   | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   |
| 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  | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      |        |
| 2009  | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      |        |
| 2010  | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      |        |
| 2011  | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      |        |
| 2012  | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      |        |
| 2013  | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      |        |
| 2014  | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      |        |
| 2015  | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      |        |
| 2016  | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      | —      |        |

**Tornqvist**

|       | 2002   | 2003   | 2004   | 2005   | 2006   | 2007   | 2008   | 2009   | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   |
|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 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 | 107.88 | 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  | 60.07  |        |
| 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 |        |        |

Source: Author’s calculations based on Producer Price Index data from the U.S. Bureau of Labor Statistics.
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NOTES

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8 The U.S. Bureau of Economic Analysis personal consumption expenditures price index and the chained CPI, both of which use superlative formulas that rely on current-value weights, are subject to revision because final current-period weight information is not available at the time of their initial publication.

9 The International Monetary Fund Producer Price Index manual shows that, under certain conditions, Fisher and Tornqvist indexes can approximate theoretical producer output price indexes. See *Producer Price Index manual: theory and practice* (International Monetary Fund, 2004), pp. 442–444.

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