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Is Inflation Still Low In The Digital Economy?

The weights of digital goods and services in inflation statistics should be updated frequently to reflect the growing importance of the digital economy.

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EXECUTIVE SUMMARY

The inflation rate has grabbed headlines in recent months by reaching heights not seen in the past four decades. The price of a wide variety of products, including food, housing, vehicles, and gasoline, have all risen dramatically, contributing to a higher overall consumer price index.

smartphones, have either fallen or risen much less than prices in the economy overall.

In addition, the rapid development of new goods and services in the digital economy is hard for traditional measures of inflation to keep up with. New product models are not added to price indexes quickly enough to fully account for improvements to quality or reductions in prices. This problem was exacerbated by the COVID-19 pandemic, which forced many people to do their shopping online and to rapidly adopt digital services like Zoom to work, study, and stay connected with friends and family. These errors in measurement of the digital economy tend to overstate the overall inflation numbers.

Correcting this mismeasurement of prices in the digital economy will require more frequent addition of new digital goods and services into price indexes. Also, improvements in how these prices are weighted in overall inflation figures would more accurately capture the digital economy's role in moderating price increases. Faster updating of the weights to keep up with what consumers are buying and what producers are selling, including more rapid incorporation of the latest Economic Census data, would enable the inflation figures to reflect more fully the growing importance of the digital economy.

INTRODUCTION

For three decades, the digital economy — defined as comprising information and communications technology (ICT) goods and services, online platforms, and e-commerce vendors — tended to have flat or declining prices, helping to keep inflation down. Although the behavior of prices in the digital economy has been affected by recent inflation, official and private price indexes for goods and services supplied by the digital economy show that inflation remains significantly lower in the digital economy than in the traditional economy. Thus, the digital economy has continued to play a moderating role in inflation.

Among the lasting deflationary influences on digital economy prices are effects of decreasing technology production costs, improving product quality, innovation to take

lower prices both in the digital economy and beyond.

Research has found that the deflationary influence of the digital economy was even greater than indicated by the official indexes. One reason is that at times of rapid growth of the digital sector, the weights used to calculate inflation may not fully reflect the pace of digitization. For example, the pandemic greatly accelerated adoption of digital innovations such as e-commerce, so it's reasonable to suspect that the price statistics are undercounting the impact of low digital inflation.

Feasible measurement improvements would likely help the main inflation indicators reflect the deflationary influence of digital economy prices more fully. These include increasing the representation of e-commerce prices in consumer price index (CPI) samples and updating the weights of the CPI annually. It is also important to reduce the lag in incorporating the results of the latest Economic Census in calculating the Producer Price Index (PPI), whose weights are still based on the 2012 Economic Census. These objectives may require legislation to facilitate incorporation of e-commerce prices in official indexes and collaboration in processing non-public data among the statistical agencies.

However, it should also be noted that recently global supply chains for semiconductors (and other products) have proven to be vulnerable to shocks from COVID, natural disasters, and rapid shifts in demand. These disruptions have led to problems in the supply of products as diverse as cars and appliances, contributing to the reemergence of high inflation.

IS THE DIGITAL ECONOMY STILL HELPING TO MODERATE INFLATION?

After almost four decades of relative quiet, inflation has soared. The 7.3% increase registered by the CPI-U in 2021 (as measured by comparing an average of the December 2021 and January 2022 indexes to an average of the December 2020 and January 2021) marks an abrupt end to a long era of moderate or low inflation. This period started with a large drop in the trend rate of inflation during the recessions of 1980-1982 and was followed by smaller declines in the recessions of 1990-1991 and 2008-2009 (Figure 1). The producer price index (PPI) for final demand also showed high inflation, with an increase

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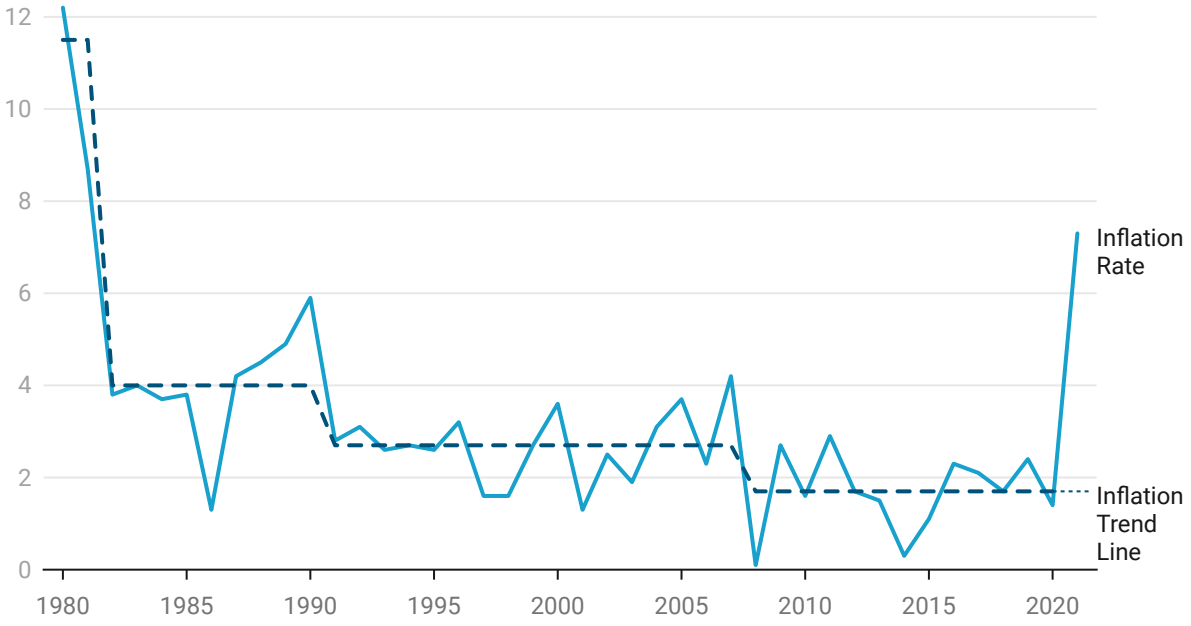
Figure 1: Growth Rate of the CPI-U, 1980-2021



Note: Growth between year endpoints measured by as an average of adjacent December and January indexes

Source: U.S. Bureau of Labor Statistics, All-items CPI-U • Get the data • Created with Datawrapper

The recent resurgence in inflation has not affected all products equally. Unsurprisingly, attention has centered on the largest price increases, including those for energy (28% in 2021), used vehicles, (39%) and new vehicles (12%). More than half the 2021 acceleration in inflation can be attributed to energy and vehicles; if their prices had increased by 2% (the average growth rate of the CPI-U in 2016-2020), the rise in CPI in 2021 would have been 4.3% rather than 7.3%. Yet, in addition to asking where inflation was highest, it is also worth considering the segments of the economy that are continued to exert a moderating influence on inflation.

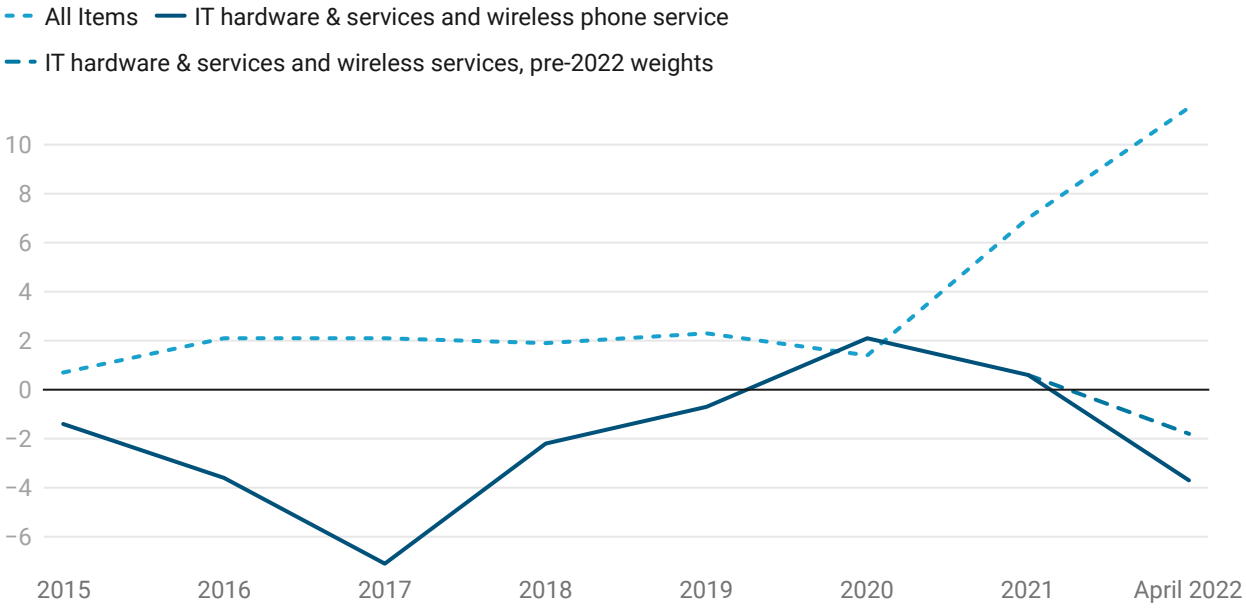
BLS PRICE INDEXES FOR DIGITAL PRODUCTS AND INDUSTRIES

Price declines were long common in the digital economy.[1] The recent re-emergence of inflation has changed price behavior throughout the economy, and the price indexes for digital products and industries included in the CPI, PPI or import price index (MPI) from the Bureau of Labor Statistics (BLS) have begun to show increases. Nevertheless, the

The digital CPI can be defined as including information technology hardware and services and wireless phone service, with each item weighted in proportion to its weight (or "relative importance") in the CPI. The moderating influence on inflation of these products is evident, as the digital CPI rose just 0.6% in 2021 and fell in the first four months of 2022 (Figure 2). Falling prices of digital products also helped to keep inflation low in the pre-pandemic years. In the first year of the pandemic, however, the digital CPI increased 2.1% while overall inflation fell to 1.4%.

The data used to calculate the digital CPI can also be used to illustrate the potential for weights to have a significant impact. BLS introduces updated CPI weights in January of even-numbered years. The annualized rate of decline of the digital CPI in the four months beginning with January 2022 would have been 1.8% if the old weights had continued to be used, compared with 3.6% implied by the updated weights. Furthermore, the growth rate of the all-items CPI would have been 11.6% rather than 11.5%.

The CPI for information and information processing published by BLS differs from the digital CPI by including landline telephone service prices. It exhibits slightly more inflation, but its growth rate in 2021 is still low, at around 1% (Table 1). Furthermore, the products included in the digital CPI have low or moderate inflation rates in 2021. Prices declined in 2021 for telephone hardware and other information items, wireless telephone service, and software and computer accessories. Providers of internet and electronic information services had a moderate price increase of 2.6%. However, the CPI for computers and peripherals had a significant rise of 3.2% in 2021 driven by strong demand and a semiconductor shortage. This followed a 1.2% rise in 2020.



Source: Author's calculations using price and relative importance data from BLS • Get the data • Created with Datawrapper

Producer prices also showed almost no inflation in 2021 for major digital services, but digital equipment and components prices had significant increases at the producer level (Table 2). The PPI for computers and peripheral equipment rose slightly more that the CPI for computers. This increase was, however, preceded by a 1.8% decline in 2020, so the two-year average annual rate of change of this PPI was just 1.1% per year. The broader PPI for computer and electronic product manufacturing, was up 3.6% in 2021, while the detailed PPI for semiconductor and other electronic component manufacturers was up 3.3% in 2021, with a two-year average rate of change of 0.3% per year. Inflation in producers' communications equipment prices was slightly lower; they were up 2.7% after a history of being flat. The PPI uses hedonic techniques to quality-adjust prices of semiconductors and computers but not prices of telecommunications equipment.

The major digital services industries with nearly flat PPIs in 2021 were wireless telecommunications carriers, software publishers, and data processing, hosting, and related services. Furthermore, the PPI for internet access services fell 0.5% and the dollar margins received by electronic shopping industries fell by 1.3% in 2021 after rising by 7.9% in 2020. Even the broader PPI covering wired and wireless telecommunications showed well-subdued inflation, with prices up just 1.6% (Retail dollar margins tend to increase with the price of goods sold, but with more volatility. With a constant cost of

However, two digital services had significant price increases. Video programming distribution via wired connections rose 3.6%, while the price of advertising on digital platforms rose 7.2%. As of the writing of this paper, the price of video programming distribution via wired connections shows a 2.3% increase in April 2022 compared to April 2021, while the price of advertising on digital platforms shows only a 1.4% increase in April 2022 compared to April 2021. But the latter index, in particular, seems to be subject to large month-over-month revisions, so it takes time to establish clear trends.

Import prices are also important to consider because they influence domestic inflation. Changes in import prices are at least partially passed through to the prices consumers pay. In the case of investment goods directly by a business, the import price is the price paid by the final user. The import price indexes (MPIs) are also of interest because they reflect developments in global supply chains, parts of which are under the control of multinational enterprises headquartered in the U.S. The import prices for computers and telecommunications equipment show little sign of inflation, as their MPIs rose less than 2% (Table 3). Nevertheless, the MPI for computer accessories, peripherals, and parts (which include semiconductors) rose by almost 6%, and the more detailed import index for semiconductors rose by 4.8%. The increases in prices of imported computer accessories and parts, which are in sharp contrast to their previous behavior, appear to reflect supply chain disruptions.

ONLINE SHOPPING

Advantages of convenience, selection, and lower prices have given e-commerce a steadily rising share of retail spending over the past 20 years.[2] The pandemic accelerated this trend, with e-commerce rising from 5% of non-gasoline retail spending in 2010 to 12% in 2019, and then jumping to almost 15% in 2020-2021 according to Census Bureau data. Adobe's online marketing and web analytics unit found an even bigger jump in online spending of 42% in 2020.[3] The rapid growth of e-commerce is likely to cause under representation of e-commerce outlets in CPI outlet samples for products frequently bought online.

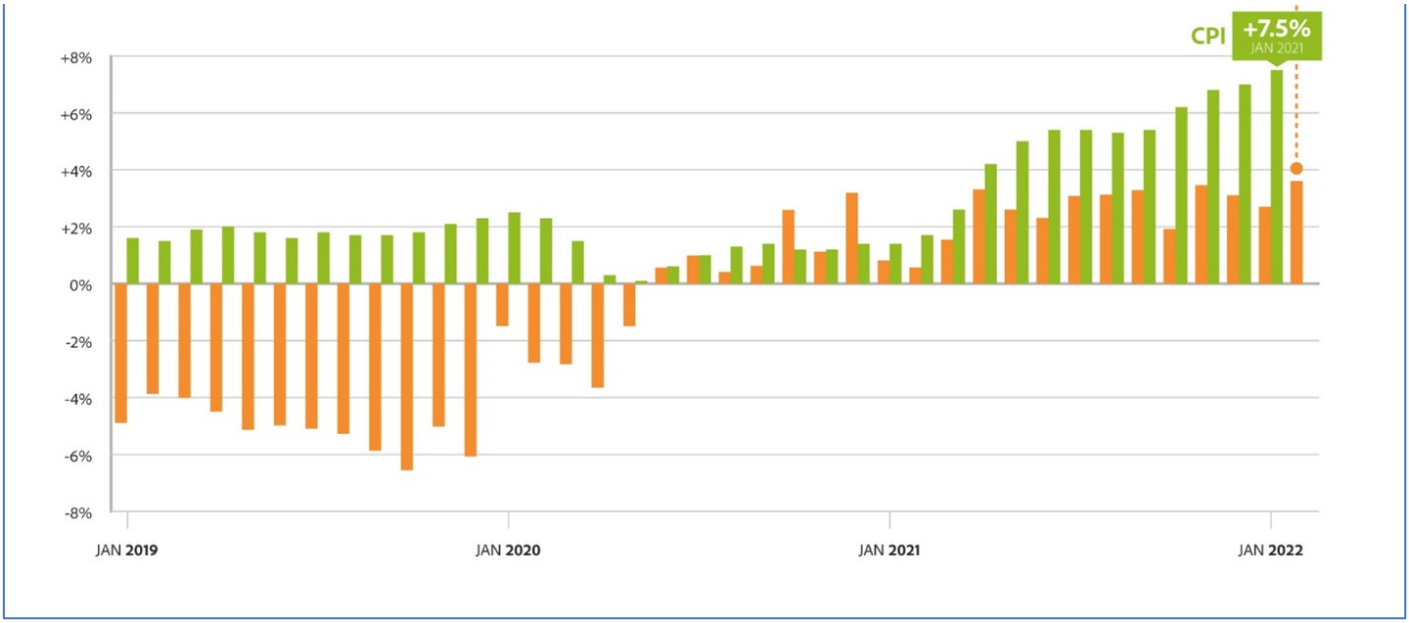
BLS does not publish CPIs for e-commerce prices, but information on e-commerce prices is available from the Adobe Digital Price Index (DPI). This index incorporates data on online transactions at 80 of the top 100 retailers.[4]

however, the 12-month growth of the DPI turned positive in June and exceeded that of the CPI[5] in October and December (Figure 3). In 2021, the 12-month growth of the DPI accelerated to around 3% (and it went on to reach 3.6% in February 2022).

Nevertheless, an online inflation rate of around 3% in 2021 remains significantly lower than overall inflation as measured by the all-items CPI. Furthermore, the top category for online spending, electronics, still had a falling DPI in 2021, and just four of eighteen product categories had significant higher inflation online than in the corresponding CPI (Table 4). The unweighted average of the price changes for the product categories with detailed DPIs is 2.7%, compared with 4.3% for the corresponding CPIs.

Most of the rise in the overall DPI in 2021 can be attributed to the 16.2% increase in online apparel prices, which have a relatively large weight in the DPI. Supply chain disruptions (including shipping bottlenecks and cost spikes) and a recovery of demand for apparel as pandemic restrictions eased contributed to the increase in online apparel prices. Also, part of the apparel price increase in 2021 was a retracing of an earlier price decline when demand for apparel was depressed by the pandemic: the two-year average growth rate of the DPI for apparel is just 6.2%. Finally, Goolsbee and Klenow (2018a) found a chain drift of 2.4% per year in earlier years in the DPI for apparel, suggesting that this source of index number distortion may have exaggerated the increase in the apparel DPI in 2021.[6]

Figure 3: Adobe DPI compared with the All-Items CPI



Source: Adobe Analytics

DISINFLATIONARY INFLUENCE OF THE DIGITAL ECONOMY PRICES IN EARLIER YEARS

Data on digital economy prices before the pandemic show the durability of the forces that have given the digital economy's prices their current moderating role in inflation. Price indexes for computers and peripherals declined by double digits for many years starting in the early 1990s, and other ICT prices were also flat or declining after 1995. Around 2010, the rate of decline of prices of computers and peripherals and computer components slowed to the low single digits, perhaps reflecting a winding down of Moore's Law (Flamm, 2021).[7] Inflation was still below zero in 2015-19 for most of the digital products in the CPI, PPI, and MPI.

The DPI, which begins in 2014, shows that e-commerce prices also declined in the years preceding the pandemic. Moreover, the detailed DPIs show lower inflation at e-commerce retailers than for the similar products at the outlets in the CPI. Goolsbee and Klenow (2018b) used DPI data to construct indexes of online prices for 65 "entry level items" of the CPI. The weighted average growth rate of the CPIs for those entry level items is -0.3% per year in 2014-2017, while the average growth rate of the corresponding DPIs is -1.6%. Methodological differences (the DPIs include new varieties as soon as they start

In the case of apparel, information on Amazon's prices is also available. An analysis by researchers from Amazon and academia suggests that the inflation rate for apparel from Amazon was well below the rate of change for the CPI for apparel from 2014 to 2017. To summarize, Amazon's chief economist Patrick Bajari and academic co-authors (2021) constructed hedonic indexes of Amazon's apparel prices where prices of items with non-matching characteristics are adjusted for quality differences so that they can be compared. The authors used artificial intelligence techniques to adjust for quality differences and tested two methods for calculating long run indexes. One method calculates month-to-month indexes and chains them together to calculate annual indexes and other longer run indexes. The other method constructs direct annual indexes that compare a month to the same month of previous year. Monthly chaining of the hedonic apparel indexes implied an average inflation rate of -5.3% per year from 2014 to 2017, while annual chaining implied an inflation rate of -0.77% per year. The annually chained index is unlikely to overstate deflation, yet its rate of change is three-quarters of a percentage point below the rate of change of the CPI for apparel, which is near zero. The Adobe DPI (which is matched models index with monthly chaining) is more consistent with the Amazon indexes, as its average rate of change in 2014-2017 is -1.3% per year.

THE UNMEASURED DEFLATIONARY INFLUENCE OF THE DIGITAL ECONOMY

Even though price indexes for digital products often fall, or at least fail to rise, the deflationary influence of the digital economy has not been fully captured in official measures of inflation. The first and perhaps biggest issue is that the weights and varieties used by the Bureau of Labor Statistics to calculate the consumer price index and the producer price index may significantly lag behind the rapid pandemic-driven digitization of the economy. Frequent introductions of new models and new products and rapid growth of e-commerce make inflation in the digital economy challenging to measure. BLS has procedures to adjust key ICT products for quality change, but for all the needed quality adjustments to take place, new models and varieties must be brought into the elementary index promptly after they appear. That applies to new services as well as goods. Consider, for example, the dramatic surge in home and education usage of video

Importantly, e-commerce outlets could be significantly underrepresented in current CPI pricing samples. The BLS reports that it rotates the CPI outlet samples at 4-year intervals (BLS, 2018), which is unlikely to keep up with the rapid growth of online shopping during the pandemic. For consumer goods frequently purchased online today, that could mean that the measured inflation rate is overestimated.

More generally, outdated weights tend to dilute the influence on inflation estimates of fast-growing segments of the economy such as the digital sector. The CPI updates its higher-level weights at two-year intervals with a one-year lag from the end of the expenditure measurement period, so the average age of the weights over the cycle is three years. Under ordinary circumstances, that's not much of a problem. But given the rapid pace of digitization during the pandemic, it could have a measurable impact. The effect of the weight update of January 2022 on the digital CPI above is an example.

The Producer Price Index poses a different issue. The scary headline numbers are generated by weighting individual industry and commodity inflation rates using data collected in the Economic Census every five years. The latest Economic Census was done in 2017, which already reflects a much different economy from today. However, the BEA has not yet published the detailed benchmark input-output tables for 2017.

The weights of the final demand PPI are currently based on the Economic Census of 2012 and input-output accounts developed from the 2012 Economic Census.[8] These PPI weights do not account for the growth in importance of the digital economy since 2012 or for the tendency of the falling relative prices of digital products to generate increased demand. As a result, the indicators used to adjust for changes in the economy since the benchmark year may underestimate the growth of fast-growing digital activities with many new entrants. The last time the benchmark year of the national accounts was updated, the annual growth rate of the digital economy over the preceding ten years was revised up from 5.6% to 7.8% per year (Jolliff and Nicholson, 2019).

In addition to underweighting of digital products in higher level aggregates and under-representation of e-commerce outlets in the CPI, researchers have identified other issues that could dilute influence of digital economy prices on key inflation indicators. These include: (1) under adjustment for quality improvements enabled by better technology, (2)

These measurement problems are not new. To put them into perspective, Moulton (2018) updated the estimates in Lebow and Rudd (2003) and found that for all types of products and outlets in the CPI, the inflation rate mismeasurement due to under adjustment for quality change could amount to +0.37 percentage points, and inflation mismeasurement due to outlet substitution bias could amount to +0.08 percentage points. An analysis of the differences between personal consumption expenditure (PCE) weights and CPI weights also suggested that the inflation mismeasurement due to weighting problems in the CPI could amount to +0.1 percentage points.

However, the changes in outlet and product spending patterns in the period leading up to and including the pandemic may have been unusually rapid. In addition, BLS has continued to improve its quality adjustment techniques. It is therefore useful to consider these measurement issues separately.

UNDER ADJUSTMENT FOR QUALITY CHANGES IN ICT PRODUCTS

Advances in computing technology frequently enable quality improvements in ICT products. To account for these quality improvements, the sample of models and varieties used to calculate the price index must be regularly refreshed to include the new models and varieties as they appear and their prices must be adjusted for quality change.

Both steps are challenging. Official price indexes have therefore tended to under adjust for quality improvements in ICT products. For example, a quality-adjusted deflator for computers and peripherals estimated in a research setting falls 12% per year faster in 2004-14 than the official deflator, and a quality-adjusted deflator for communication equipment falls 7.6 percentage points faster than the official deflator (Byrne, Fernald and Reinsdorf, 2016). Furthermore, a quality-adjusted deflator for smartphones calculated for research purposes falls fast enough to reduce the growth rate of the personal consumption expenditure deflator by 0.05 percentage points in 2010-2017 (Aizcorbe, Byrne, and Sichel, 2019).

The speed with which new models and varieties enter CPI and PPI samples, and gaps in application of quality adjustment techniques may keep quality improvements in digital products from being fully captured. Nevertheless, the historical effect of overlooked quality improvements in digital products on the CPI growth rate appears to be modest, as

the quality changes in smartphone models. The CPI and PPI also adjust for quality change in computers, peripherals, and internet access service; the CPI also quality adjusts other digital products. Furthermore, the weight of the digital products in the CPI is only around 6%.

OUTLET SUBSTITUTION BIAS

E-commerce has fostered increased competition by giving consumers access to merchants outside their local area. Peer-to-peer platforms have also given consumers access to new kinds of service suppliers. The CPI does not track changes in the average price paid caused by changes in the outlets that consumers are buying from. The entry of lower-priced outlets can therefore lead to an overstatement of the change in cost of living, a problem known as outlet substitution bias. Online prices tend to be slightly lower than offline prices (Cavallo, 2017, reports that prices are 5% lower on Amazon than offline), so consumers have been able to pay lower prices by shopping online. Estimating the impact on the cost of living of consumers' savings from paying lower prices online would require correctly measuring the shift to e-commerce and the effect of this shift on prices that consumers are paying.

Peer-to-peer platforms for services such as ridesharing and short-term rentals have also enabled consumers to pay lower prices. Research on substitution to ridesharing has found a substantial decrease in the average cost of trips between fixed pairs of locations. Comparing a pooled index for taxis and ridesharing with an index for taxis alone showed that a decline in the average price paid caused by substitution of ridesharing for taxis subtracted 0.6 percentage points from the growth rate of the pooled index in New York City from Q3 of 2015 to Q4 of 2017 (Aizcorbe and Chen, 2022). Ridesharing's lower inflation rate subtracted an additional 0.4 percentage points from the pooled index's growth rate. A downward correction of 1 percentage point to the growth rate of the CPIs for both intra-city transportation and lodging away from home would reduce the growth rate of the all-items CPI by a small amount.

OTHER IMPACTS ON CONSUMER WELFARE

Broader aspects of consumer welfare could be included in a cost-of-living index and are relevant for understanding the economic effects of the growth of the digital economy.

devoted to non-gasoline non-grocery shopping fell by 27% between 2007 and 2018. This decline reduced unpaid shopping time by 10.5 billion hours in 2018.

Once the pandemic started, this trend accelerated. Time spent shopping for all consumer goods dropped by roughly 25% in 2020 compared to 2019 (for both years, May to December). That includes time spent online, according to the latest release of the BLS American Time Use Survey. When the 2021 ATUS data is released, it will be interesting to see the long-term changes in consumer behavior.

As the shopping example shows, estimates of welfare gains from changes in consumer behavior can be sizeable. One strand of the research on the growth of consumer welfare from the rise of the digital economy finds that including the consumer surplus from free digital platforms such as Facebook significantly raises the growth rate of an extended version of GDP known as GDP-B (Brynjolfsson et al., 2019). Another study finds adjustments for the value to consumers of the expanded selection and convenience offered by e-commerce would significantly reduce the growth rate of an extended version of the PCE deflator (Dolfen et al., 2019). Finally, the measures of output growth and inflation in national accounts do not reflect the rapid growth in consumers' utilization of digital communication and entertainment services (internet access, mobile telephony, cable, and streaming of videos and music). Adjusting the prices paid by consumers for their utilization of these services as measured by data usage and talk time reduces the rate of change of the PCE deflator after 2008 by almost a half percentage point (Byrne and Corrado, 2020).[9]

THE SEMICONDUCTOR SHORTAGE

Prices of digital goods and services are the main way the digital economy influences inflation. However, a non-price effect has also recently become important: the shortage of semiconductors. Over the past 20 years, new applications of digital technology based on semiconductors have enabled quality improvements in a wide range of products, putting downward pressure on prices. Most semiconductors are, however, produced in fragmented global supply chains that are vulnerable to shocks and that may lack flexibility to respond to sudden changes in demand. Disruptions to supply chains have

Semiconductors are not included in the widely used gauges of inflation, and they account for only a small part of the production cost of most products that contain them. Nevertheless, the unavailability of an intermediate input for which there is no substitute can have a disproportionate effect on final demand prices. The effect of rationing on a buyer's price index can be modeled using the hypothetical price that would cause the quantity demanded to equal the rationed quantity. In the case of an irreplaceable input to production, this virtual price would be quite high.

The most important effect of the semiconductor shortage on the CPI has come from the impact on markets for new and used vehicles when the shortage forced auto makers to curtail production. The price increases for new and used vehicles contributed about 1.5 percentage points to the change in the all-items CPI in 2021. Part of this contribution is attributable to the semiconductor shortage (though factors such as fluctuating demand for rental cars also contributed).

POLICY IMPLICATIONS

The flat or falling prices of the digital economy long exerted a deflationary influence on the US economy. These prices continue to play a moderating role in inflation after the recent reemergence of inflation.

Given the value of technology in moderating inflation, policymakers should seek opportunities to promote uses of digital technology to enhance growth and promote price stability. At the same time, the contribution of the semiconductor shortage to inflation shows the need for supply chain improvements both to reduce current inflationary pressures and to reduce risks of future shocks. During the era of globalization, growth of international supply chains that located each step of production where costs were lowest had deflationary effects, but also increased vulnerability to inflation-generating supply disruptions. These risks have recently been exacerbated by COVID and other changes in the international environment.

The focus on inflation in the current economic debate also highlights the importance of accurate measurement of price change. Wider application of timely sample refreshment procedures currently used for smartphone models in the CPI could help to capture

2022). The e-commerce transactions data would also help to improve the representation of e-commerce prices in the CPI. The practical obstacles posed by the size and confidentiality concerns of the e-commerce transactions-level data sets must first be overcome, however. Having the e-commerce merchant calculate indexes or index components with procedures specified by BLS would solve both problems. However, doing these calculations involves more effort than responding to a standard statistical agency survey, so legislation may be required to delegate this responsibility to merchants.

Another measurement challenge where progress should be possible is correctly weighting digital products in top-level indexes of consumer, producer, and national accounts prices. Annual weight updates assisted by information on personal consumption expenditures from the national accounts would improve the timeliness of the CPI weights.

Shortening the six-year lag in benchmarking the national accounts to the new Economic Census would improve the PPI's measurement of current inflation and the national accounts' measurement of the digital economy. The lag could be shortened if the work on the national accounts benchmark estimates could proceed in parallel with the processing of the responses to the Economic Census. However, this would require either unifying the organization of U.S. statistical system or enhancing the ability of the statistical agencies to share non-public data with each other.

CONCLUSION

The promise of the digital economy is a constantly advancing suite of goods and services provided by information and communication technologies. Adjusting inflation figures for the quality of smartphones, computers, streaming media, and e-commerce is vitally important to measuring their contribution to the economy overall. Collection of price data about new goods and services must keep pace with their introduction. This is especially important when a pandemic accelerates the growth of the digital economy. Having up to date prices for information and communications technology will give a more detailed picture of overall inflation.

substantial amounts of time and money. Given these continuous improvements, recent inflation figures may be overstated. More accurate price reporting would help economic policymakers and consumers take action to counteract inflation's effects on government and household budgets.

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APPENDIX

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Based in Washington, DC and part of the Progressive Policy Institute, the Innovation Frontier Project explores the role of public policy in science, technology, and innovation.