Theoretical Inflation During Stay-In-Place Behavior

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Abstract Theoretical inflation diverges from official price statistics when major product categories are unavailable due to stay-in-place behavior. In this paper, the word “theoretical” designates inflation that is consistent with price measurement theory (Diewert and Fox 2020) (Diewert et al. 2019). It does not imply computational mistakes or data problems with official price statistics. This paper uses price measurement theory to develop a simple formula to calculate theoretical inflation. The paper then calibrates that simple formula to pre-pandemic research studying online shopping (Dolfen et al. 2021), tourist behavior, and consumer spending by state. Finally, the paper collects empirical data on actual stay-in-place behavior and calculates theoretical inflation by state and month from March 2020 until June 2021.

The paper finds large and policy-relevant differences between theoretical inflation trends and official inflation trends. The officially reported inflation deceleration of 0.03 percentage point per month in 2020 reverses to a theoretical inflation acceleration of 0.22 percentage point per month and the officially reported inflation acceleration of 0.36 percentage point per month during the first half of 2021 reverses to a theoretical inflation deceleration of 0.33 percentage point per month. The paper also finds that theoretical inflation is higher in states with higher nominal consumption per capita. As a result, the paper calculates that deflating state income by theoretical inflation lowers inequality across states by 7 percent in 2020.

Keywords Inflation, Price Index, Cost of Living Index, Regional Price Parity, Inequality, Coronavirus, Covid-19, Stay in Place, Lockdown, Social Distancing, New Goods

JEL codes E31, I18, K32

Introduction

Measured inflation rose sharply during the first half of 2021 according to statistics published by the Bureau of Economic Analysis (BEA 2021a). Furthermore, 2020 saw a noticeable increase to a measure of inequality across states which the paper calculates from the official state income statistics (BEA 2021b). Both the recent inflation acceleration and the longer-term inequality growth have attracted public attention (Vinopal 2021) (Pew Research Center 2021). In addition, they have also been discussed by policymakers at the Federal Reserve (Powell 2021) and in Congress (Manchin 2021). However, neither measured inflation nor calculated inequality are theoretically consistent when major product categories are unavailable due to stay-in-place behavior.

This paper updates and revises a previous BEA working paper titled "Consumer Prices During a Stay-In-Place Policy: Theoretical Inflation for Unavailable Products" (Soloveichik 2020). This new paper draft has three important changes. First, it revises the theoretical inflation formula to recognize different theoretical inflation rates for nonessential products which are only available remotely and nonessential products which are completely unavailable. Second, it uses pre-pandemic survey data from the 2017 Economic Census, BEA's state consumption statistics, and other sources to calculate state-specific estimates of theoretical inflation. Third, it extends the time series studied until June of 2021.

In this paper, the word "theoretical" designates a cost-of-living index that is consistent with price measurement theory that discusses product unavailability. It does not imply any data problems or computational mistakes with the Consumer Price Index (CPI) published by the Bureau of Labor Statistics (BLS), the personal consumption expenditure (PCE) deflator published by the Bureau of Economic Analysis (BEA), or other official price statistics.

The paper first develops a formula to calculate theoretically consistent prices and then applies that formula to actual stay-in-place behaviors by state and month from March 2020 until June 2021. During 2020, the officially reported inflation deceleration of 0.03 percentage point per month reverses to a theoretical inflation acceleration of 0.22 percentage point per month and the 3 percent increase to inequality across states which is calculated from the official state income statistics reverses to a 4 percent decrease to theoretical inequality across states. During the first half of 2021, the officially reported inflation acceleration of 0.36 percentage point per month reverses to a theoretical inflation deceleration of 0.33 percentage point per month.

This paper is divided into four sections. Section 1 reviews the previous price measurement literature and adapts that literature to develop a simple formula to calculate theoretical prices when broad categories of products are unavailable. Section 2 gives summary statistics on product unavailability and theoretical inflation in each state during a full stay-in-place policy. Section 3 estimates actual stay-in-place behaviors for each state from March 2020 until June 2021. This section then combines those actual stay-in-place behaviors with the theoretical inflations during a full stay-in-place policy estimated in Section 2 to calculate theoretical inflation during actual stay-in-place behavior by state and month. The section then presents summary statistics on aggregate theoretical inflation and calculated inequality across states from March 2020 until June 2021. Appendix A in the paper supplements section 1 with a simple model of tourist behavior that is used to calculate a theoretical price for completely unavailable products.

1. Brief Review of Price Measurement Literature

For simplicity, this paper focuses on calculating a Laspeyres price index for a basket of *n* products. Product prices in the base period (t=0) are designated as (p_{10}, …, p_{n0}), spending weights for products in the base period are designated as (w_{10}, …,w_{n0}), and product prices in the period *t* are designated (p_{1t}, …, p_{nt}). If those vectors are known, then the Laspeyres formula is simple:

(1) $\text{Laspeyres Index}_t = w_{10}(p_{1t}/p_{10}) + w_{20}(p_{2t}/p_{20}) + \ldots + w_{n0}(p_{nt}/p_{n0})$

The Laspeyres formula above cannot be calculated when prices are not observable, but analysts can salvage the situation by imputing the missing prices. This paper studies a scenario in which all products are available at the base period, but only 1 to j are available in time *t*. The paper designates the observable prices for available products as (p_{1t}, …,p_{jt}) and the imputed prices for unavailable products as (ip_{j+1t}, …, ip_{nt}). The Laspeyres formula is now:

(2) $\text{Theoretical Laspeyres Index}_t = w_{10}(p_{1t}/p_{10}) + \ldots + w_{j0}(p_{jt}/p_{j0}) + w_{j+10}(ip_{j+1t}/p_{j+10}) + \ldots + w_{n0}(ip_{nt}/p_{n0})$

BLS assumes that unobservable prices track observable prices for similar products (Gomes 2018) and therefore uses observable prices to impute unobservable prices when calculating its published consumer price indexes. In normal economic times, BLS's assumption appears to be quite accurate, and therefore the published CPI tracks closely with a cost-of-living index that is consistent with price measurement theory (Bradley 2003). However, this paper argues that unobservable prices may not track observable prices during stay-in-place behavior that makes broad categories of goods and services completely unavailable. As a result, price measurement theory is needed to measure inflation rates.

Imputing Prices for Products That are Available Remotely but Not In-Person

This section defines remote products as goods or services that can be produced and purchased while socially distanced. Remote products can be purchased online, over the phone, by mail, or even at a vending machine. The most obvious example of remote products is goods that are purchased from online marketplaces —but many services can be delivered remotely as well. For example, restaurants often provide food via take-out windows or delivery (Fantozzi 2021) and many doctors have started providing medical advice through video or telephone consultations (Patel et al. 2021). This paper uses product line detail from the 2017 Economic Census, academic research, and expert judgment to identify products that are available remotely but not in-person during stay-in-place behavior.

BLS's normal price measurement methodology calculates inflation by comparing prices for a particular product at a particular outlet over time. This methodology cannot calculate inflation when an in-person outlet closes and is replaced by an unaffiliated remote outlet because the closed in-person outlet has no current prices to link with past prices, and the remote outlet has no past prices to link with current prices (BLS 2018). On the other hand, this methodology does produce an inflation estimate when an in-person outlet switches to remote sales only. In that case, current prices at the remote outlet are linked with past prices at the in-person outlet without any adjustment for the changing sales channel.

The **outlet substitution bias literature** has the simplest approach to imputing prices: it assumes that consumers are indifferent to various outlets that sell a particular product (Reinsdorf 1993) (Hausman and Liebtag 2009) (Greenlees and McClelland 2008). In other words, the elasticity of substitution between outlets is assumed to be extremely high. If that same simplifying assumption was applied during stay-in-place behavior, then the theoretical price increase for goods that are unavailable in-person would be the difference in price between online outlets and in-person stores. However, the papers cited earlier focus on standardized products that are bought for off-premises usage. This paper argues that in-person availability is an important product attribute for other types of products. For example, clothing may require physical examination before purchase. Therefore, it is not theoretically consistent to link in-person prices with remote prices without adjustment.

The **variety bias literature** studies the theoretical price impact of introducing new products when the elasticity of substitution between those products is not extremely high. The variety bias literature typically assumes a very specific utility function, and then solves that utility function to calculate variety-adjusted price indexes for the categories studied (Feenstra 1994) (Broda and Weinstein 2010) (Handbury and Weinstein 2014). Pre-pandemic research studying Visa card users (Dolfen et al. 2021) estimated a substitution elasticity of 4.3 between online merchants and offline merchants, means that a forced switch from the desired purchasing method to the undesired purchasing method is theoretically equivalent to a 23 (1/4.3) percent price increase.[1] Section 2 of the paper estimates that 10 percent[2] of aggregate consumer spending is forced to switch from in-person purchase to remote availability only during a full stay-in-place policy. Therefore, the paper calculates that products which are only available remotely contribute 2.3 percent (23 percent * 10 percent) to aggregate theoretical inflation during a full stay-in-place policy.

Imputing Prices for Products That Are Completely Unavailable

There are few pre-pandemic papers studying the problem of imputing prices for suddenly unavailable products. The reason for lack of previous literature is simple: past public health interventions were generally restricted to high-risk groups, like travelers or individuals with known symptoms (Tognotti 2013). Because public health authorities rarely—if ever—tried complete lockdowns of entire regions before the COVID-19 pandemic, there is neither previous epidemiological research estimating its impact on disease transmission (Stone 2020) nor previous economic research estimating its impact on either consumer welfare or cost-of-living indexes. Similarly, it was very rare for popular product categories to be suddenly unavailable for nonhealth reasons.

The **new goods literature** offers some useful insights to the problem of imputing prices for suddenly unavailable goods. That literature studies the theoretical price impact of introducing entirely new product categories to the market basket. The new goods literature typically uses economic theory and empirical data to create sophisticated demand models. The literature then goes on to solve those sophisticated demand models to estimate theoretical prices for products before they are available (Hausman 1999) (Hausman 1997) (Petrin 2002) (Goolsbee and Petrin 2004) (Berndt et al. 1996) (Nordhaus 1996) (Diewert and Feenstra 2019) (Diewert et al. 2019). By construction, the Laspeyres price increase associated with a product disappearance is the exact converse of the Paasche price decrease associated with a product appearance. Hence, the theoretical background developed in these papers may shed light on the general problem of unavailable products. However, the sophisticated

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[1] The paper also calculates a substitution elasticity of 6.1 between offline merchants. Therefore, the theoretical price increase may be slightly lower if the relevant substitution is to an essential store rather than online purchase.

[2] Products that were sold remotely before the coronavirus pandemic are assumed to be unaffected by stay-in-place policies and are not included in the 10 percent figure above. The paper also assumes that consumers preferred in-person purchasing for all products that were not available remotely before the coronavirus pandemic.

demand models used in those papers are difficult to create or solve when many broad product categories are suddenly unavailable.

This paper develops a novel approach to calculate prices for completely unavailable products: it compares regional cost-of-living indexes to calculate a theoretical price for products available in one region but not another. There is rich economic literature showing that dense urban regions have higher prices than rural regions for seemingly similar housing units (Aten and D'Souza 2008) (Gyourko, Mayer, and Sinai 2013) (Glaeser and Gyourko 2018), physically identical goods (Stroebel and Vavra 2019), and physically identical nonhousing services (Paredes and Loveridge 2014). There is also rich literature showing that dense urban regions offer a wide variety of nonessential products like in-person dining, live entertainment, in-person clothing stores, and other desirable amenities (Glaeser, Kolko, and Saiz 2001) (Florida 2018) (Couture et al. 2020). This paper combines these two bodies of literature to calculate theoretical prices for completely unavailable products.

Appendix A of the paper creates and solves a simple model of tourist behavior when some amenities are unavailable in the rural region. Based on that model, the paper calculates that complete product unavailability is theoretically equivalent to a 59 percent theoretical price increase. Section 2 of the paper estimates that this category accounts for 16 percent of aggregate consumer spending. Therefore, the paper calculates that products which are completely unavailable contribute 9.4 percent (59 percent * 16 percent). This is over and above the 2.3 percent theoretical inflation associated with an undesired switch from in-person spending to remote spending for other products.

Price Measurement Questions Not Studied in This Paper

This paper does not study quality changes. Some economists have suggested viewing product unavailability through the lens of quality change (Cowen 2020), and previous researchers have explored treating temporarily unavailable items in grocery stores as a reduction in retail service quality (Matsa 2011). However, measuring quality changes consistently for all goods and services impacted by the COVID-19 pandemic would be a difficult empirical project. Furthermore, a portion of service model changes may be captured in the quality adjustments that are already part of the published CPI (BLS 2019). This paper will not study quality adjustment further.

This paper also does not study consumer utility. In some models, household inventories of previously purchased goods and home production can partially substitute for products that are currently unavailable in the market sector (Becker 1965). In other models, consumption is determined by network effects so that the cost of a collective switch is lower than the cost of individual product unavailability (Liebowitz and Margolis 1994). Researchers who are focused on the dynamic problem of measuring consumer utility throughout the COVID-19 pandemic may need to model both household inventories, home production, and network effects carefully.

2. Product Availability During a Full Stay-in-Place Policy

The section splits the fifteen consumer spending categories tracked in BEA's state consumption statistics[3] into fifty-two subcategories that correspond better with public health guidance. For example, BEA's consumer spending on clothing category is split between remote clothing purchases and in-person clothing purchases. Across the entire United States, average spending per person in 2019 was $7,763 for essential goods, $1,966 for nonessential goods purchased remotely, $3,983 for nonessential goods purchased in-person, $8,168 for essential housing, $5,354 for essential services, $6,054 for nonessential remote services, and $9,324 for nonessential in-person services. These spending numbers include health spending paid for by insurance, gambling services, and other spending categories that BLS treats as out-of-scope for the consumer market basket (BLS 2018).

Spending on Essential Products by State

The paper assumes that essential products remained available throughout the coronavirus pandemic.[4] It may be true that shortages of important items, like toilet paper, were common early in the COVID-19 pandemic and scattered shortages continued for months (Gasparo and Stamm 2020) (Cavallo and Kryvtsov 2021). However, it is common for individual goods to be out of stock and shoppers can generally compensate for partial product unavailability by selecting a close substitute or visiting another store (Andersen 1996). As a result, a slight decrease in the variety of essential products available for purchase in one particular retailer is likely to cause little welfare loss. Furthermore, calculations based on the papers cited earlier suggest that tracking in-store shortages of essential goods only slightly raises product unavailability in April 2020 and has even less impact afterwards.

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[3] https://apps.bea.gov/itable/iTable.cfm?ReqID=70&step=1

[4] A small percentage of essential goods are sold at outlets, which primarily sell nonessential products and are therefore closed to the public. This unavailability is tracked in section 2 and included in the paper's calculations.

Figure 1. Spending on Essential Products As a Share of Total Consumption

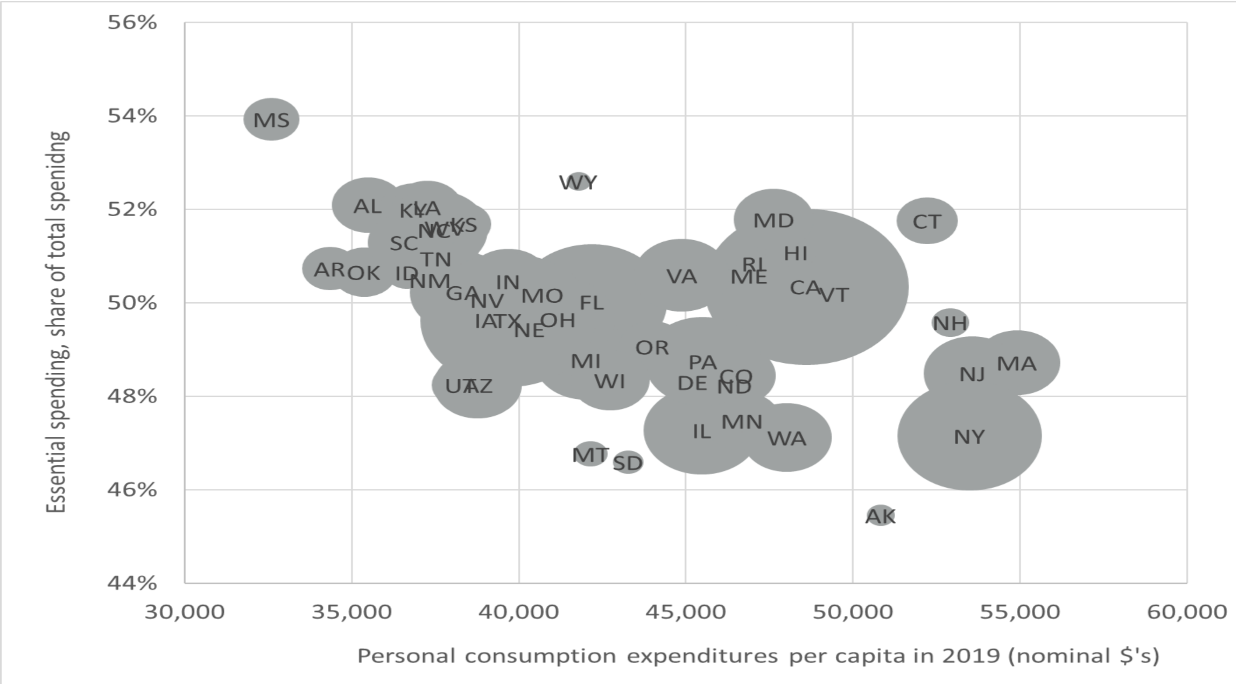


Figure 1 shows that the essential spending share is negatively correlated with income. As discussed earlier, stay-in-place policies are targeted towards nonessential products only. As a result, a seemingly neutral nationwide stay-in-place policy will impact a larger share of spending in states with higher nominal consumption per capita. This difference in spending patterns contributes to the differences in theoretical inflation that will be calculated later.

Remote Spending on Nonessential Products by State

This paper assumes that products that were sold remotely in 2019 remained available during a stay-in-place policy. The only major exception to this rule is cable sports packages, which were not available because the risk of coronavirus transmission among players (Sherman 2020). The data on goods purchases are calculated from credit card transactions collected by Earnest Research. This dataset tracks remote purchases separately from in-person purchases and allocates remote purchases to the buyer's home location rather than the store's location. This paper aggregates the Earnest data to the state-level and then calibrates this aggregated data to a Census survey that estimated national e-commerce in 2019. The data on remote nonhousing service purchases are calculated using product detail from the 2017 Economic Census, academic sources, and expert judgment.

Figure 2. Spending on Remote Nonessential Products in 2019 as a Share of Total Consumption

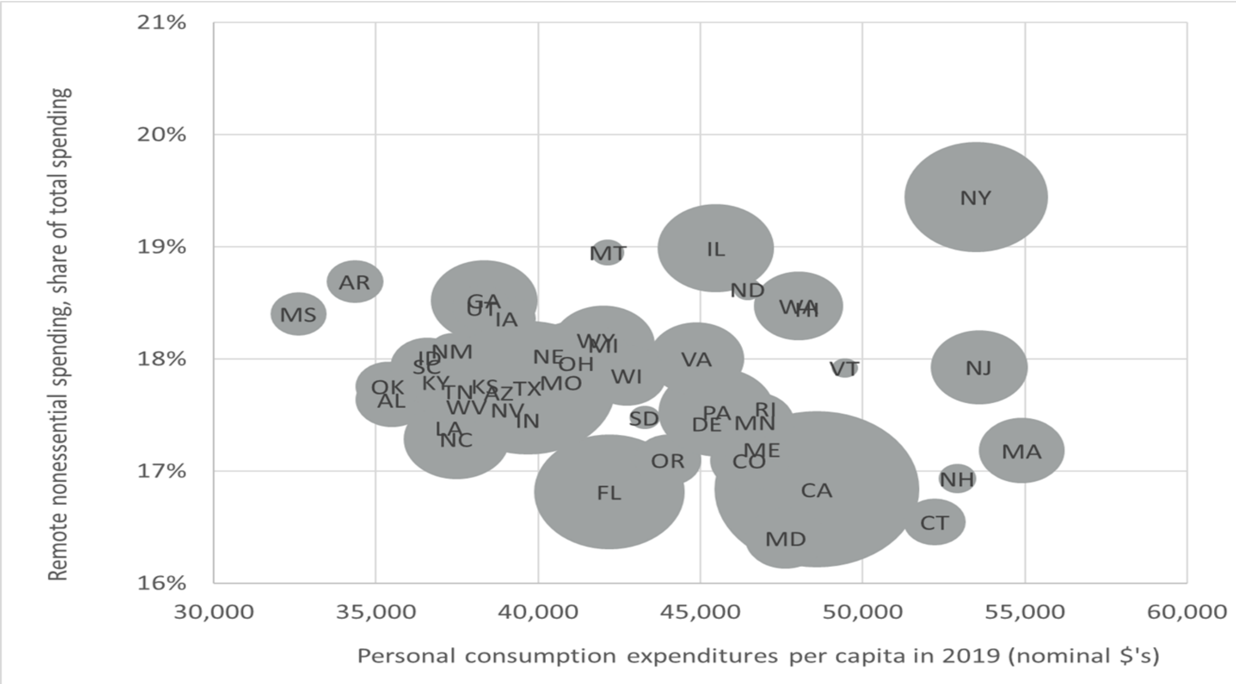
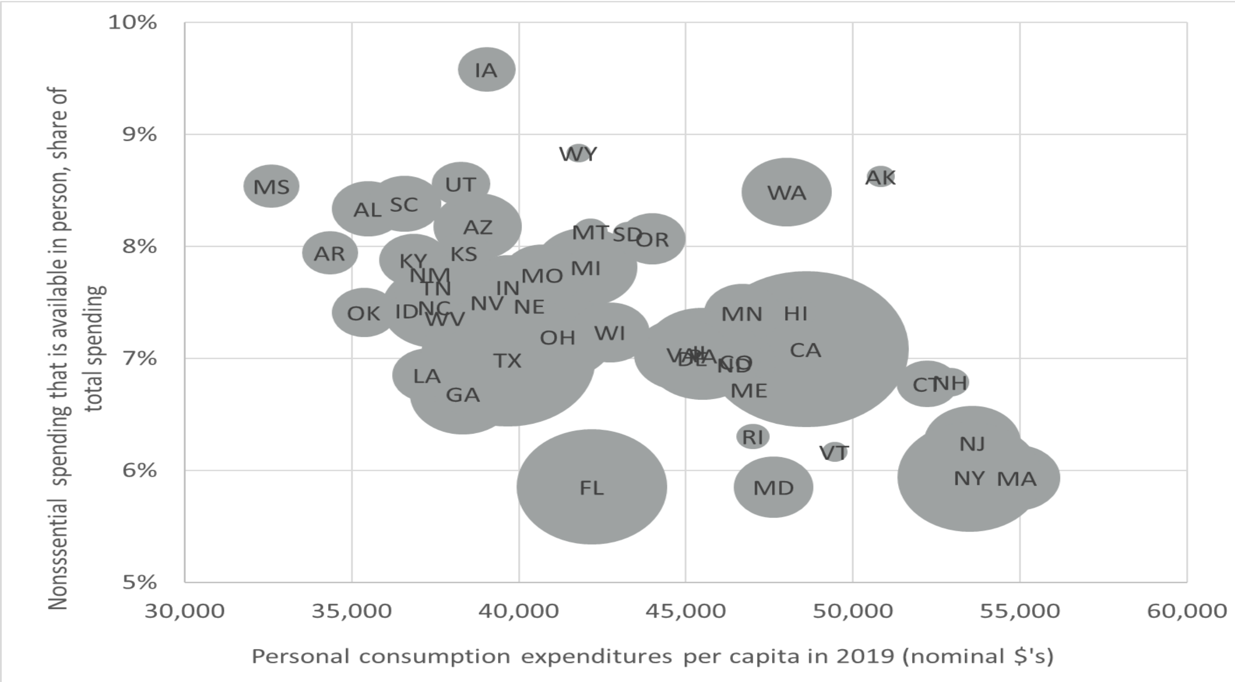


Figure 2 shows that remote spending is negatively correlated with state income. Most of this negative relationship is driven by financial services and other remote products, which have a similar absolute spending level in states with high nominal consumption per capita and states with low nominal consumption per capita. However, the correlation between remote spending and state income shown in figure 2 is weaker than the correlation between essential spending and state income shown in figure 1. Interested readers may use the state labels in figure 2 and their own expert judgment to determine other factors which are correlated with residual variation in remote spending.

Spending on Nonessential Products That Are Normally Purchased In-Person by State

Stay-in-place policies are typically imposed at the store level and therefore allowed essential businesses to sell nonessential products. For example, general merchandise stores that sell food are also allowed to sell clothing. The 2017 Economic Census tracks product detail by kind of business and state, so it is possible to calculate availability for nonessential products based on both the retailer mix in each state and the mix of products sold at each retailer type.

Figure 3. Nonessential Products That Are Available In-Person, as a Share of Total Spending



Figures 3 shows a strong negative correlation between in-person availability and state income. This difference is due to the composition of retailers. States with high nominal consumption per capita typically have many specialized retailers. During a stay-in-place policy, retailers specializing in nonessential goods are closed, and consumers must buy their nonessential goods remotely. In contrast, states with lower nominal consumption per capita typically have a few general merchandise stores which sell both essential products and nonessential products during a stay-in-place policy. In other words, states with more retailer variety have less in-person product availability during a stay-in-place policy. The paper assumes that all goods are available remotely during a stay-in-place policy. Therefore, the budget share for nonessential goods that are not available in-person is basically the converse of Figure 3. To save space, the paper will not show that graph.

Figure 4. Nonessential Services That Are Completely Unavailable, as a Share of Total Spending

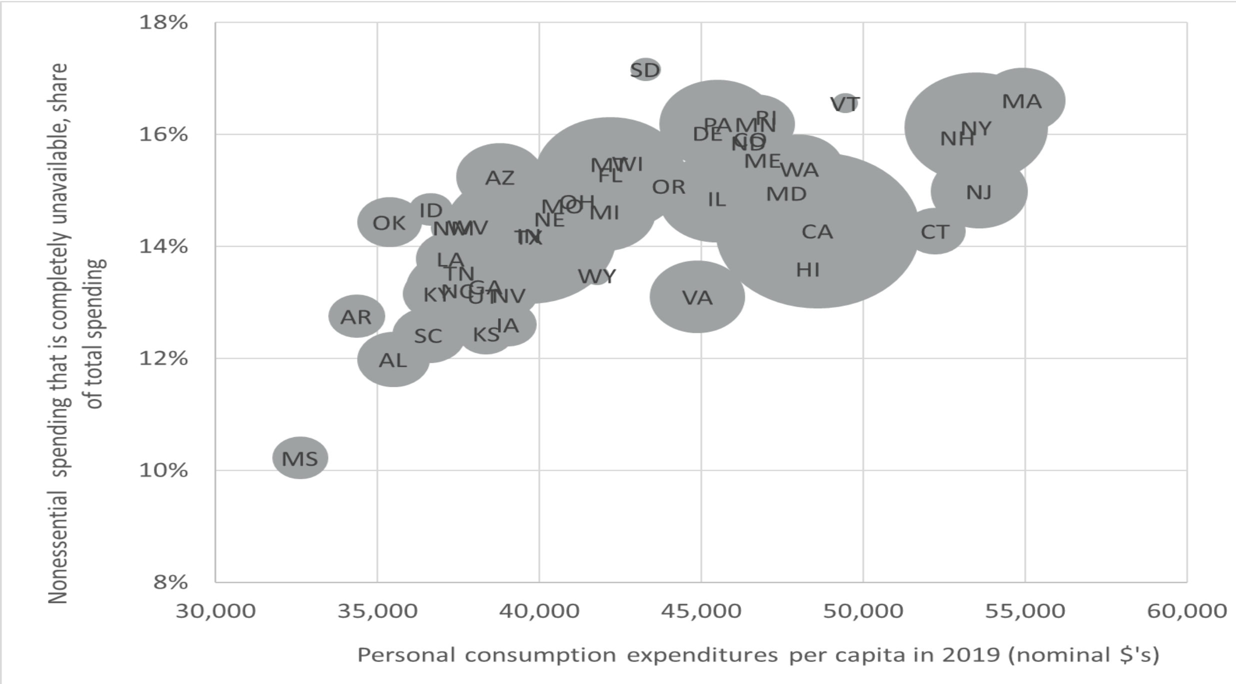


Figure 4 shows that complete product unavailability is highly correlated with state income. This high correlation is driven by the negative correlation between wealth and the budget share for essential products shown in figure 1, the negative correlation between wealth and the budget share for remote nonessential products shown in figure 2, and the negative correlation between wealth and the budget share for in-person, nonessential products shown in figure 3.

Theoretical Inflation During a Full Stay-in-Place Policy

Theoretical inflation is then calculated using the formula developed in section 1, the availability estimates shown in figures 1 to 4, and other data on product availability. BEA's personal consumption expenditure deflator uses consumer price data from BLS and accordingly implicitly incorporates BLS's assumption. As mentioned earlier, this paper calculates additional theoretical inflation parameters of 23 percent for products that are forced to switch from in-person purchase to remote purchase and 59 percent for products that are completely unavailable. The theoretical inflation rates calculated in this paper are somewhat sensitive to the weights assigned to each product. For simplicity, this paper uses the 2019 spending shares reported in BEA's state consumption statistics to weight products. Hence, theoretical inflation in each state is simply BEA's official inflation statistics plus 23 percent times the

2019 budget share for products that are only available remotely plus 59 percent times the 2019 budget share for products which are completely unavailable.

Figure 5. Theoretical Inflation During a Full Stay-in-Place Policy

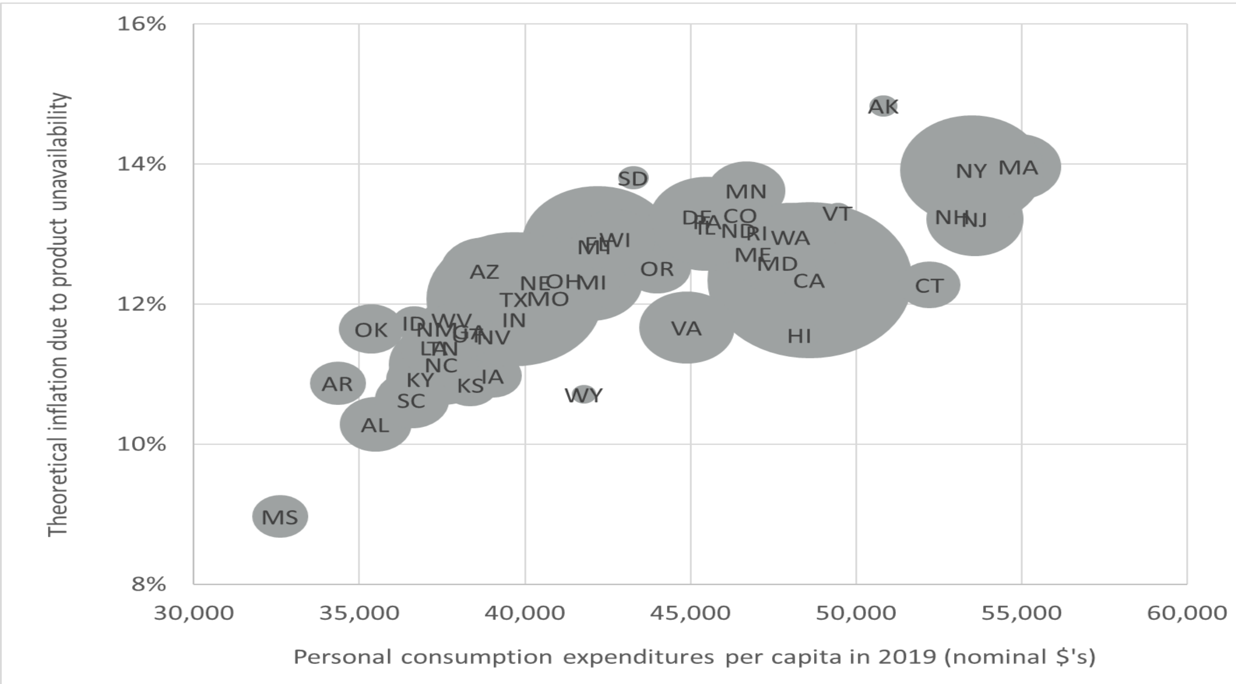


Figure 5 shows that the differences in product availability shown in figure 4 are economically significant. Even during a seemingly neutral nationwide stay-in-place policy, states with lower nominal consumption per capita have a very different experience than states with higher nominal consumption per capita. Mississippi (the state with the least per capita spending) suffers from only half the theoretical inflation of Massachusetts (the state with the most per capita spending). The precise theoretical inflation rates shown in figure 5 are somewhat sensitive to changing the assumptions used to estimate spending and availability by product subcategory, but the qualitative results across states are robust.

The theoretical inflation shown in figure 5 only measures consumer prices. In addition to the unavailable consumer products studied earlier, the paper calculates that approximately one-sixth of government spending[5] and one-sixth of nonmarket activities[6] are unavailable during a full stay-in-place

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[5] Based on expert judgment classifying the government functions tracked in BEA table 3.16. https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=2&isuri=1&1921=survey

[6] This estimated is based on the American Time Use Survey (ATUS). Nonmarket time is assumed to be impacted by stay-in-place behavior if respondents report a nonhousehold member is present during that activity. The ATUS

policy, which is roughly similar to the 17 percent of consumer spending that is unavailable in-person. BEA's previous research suggests that including government output and household production totals approximately half of consumer spending (Kanal and Kornegay 2019). Figure 5 shows that the average welfare loss from product unavailability in the consumer sector is 12 percent. If product unavailability in the government and household production sectors creates the same relative welfare loss, then the average welfare loss associated with those three sectors may sum to 18 percent of consumer spending.

A welfare loss of 18 percent of personal consumption expenditures might seem high, but it is consistent with early surveys from Sweden. To remind readers, Sweden was the only major country where the government did not implement an official stay-in-place policy early in the pandemic – so it was possible to ask respondents about hypothetical restrictions on their movement only. One survey found that the average Swedish household required monetary compensation equal to 20 percent of personal consumption expenditures in order to accept hypothetical restrictions similar to early stay-in-place policies in the United States (Andersson et al. 2020).[7] Hence, the welfare loss of 18 percent calculated in the paragraph above seems plausible.

3. Actual Stay-in-Place Behavior and Theoretical Inflation

This section estimates theoretical inflation based on actual stay-in-place behavior. To be clear, a large portion of the stay-in-place behavior is due to explicit stay-in-place policies issued by city or state governments (Dave et al. 2020; Allcott et al. 2020). However, many businesses closed voluntarily, and many consumers avoided open businesses voluntarily (Takashi 2020) (Molla 2020). Conversely, some businesses started reopening before government stay-in-place orders were lifted (Lee 2020). This paper does not attempt separately estimate the contribution of government policies, business decisions, and consumer decisions; rather, it studies how all three factors combine to create theoretical inflation.

The paper estimates theoretical inflation indirectly with the help of several strong assumptions. First, and most important, adjusted time spent at retail and recreational locations is assumed to proxy for the

does not ask about companions during sleep or personal care time, so those activities are excluded. The paper defines nonmarket time as time that is not devoted to market work, purchasing goods, or consuming services.

[7]This paper converts the GDP share in that paper to a fraction of consumer spending.

availability of both products sold at those locations[8] and availability of products sold at other nonessential locations. Second, the paper assumes that the sample of cell-phone users tracked by Google is representative of the overall consumer spending basket tracked in section 2. Finally, the paper assumes that theoretical inflation varies linearly with time spent at 'retail and recreational locations'. For example, a month where time spent dropped by 10 percent is assumed to have half of the theoretical inflation as a month where time spent dropped 20 percent. The precise level of theoretical inflation is very sensitive to changing these three assumptions, but the qualitative results over time or across states are more robust.

Expected Impact of Stay-in-Place Behaviors on Retail and Recreation Time

Figure 6. Potential Reduction in Retail and Recreational Time During a Full Stay-in-Place Policy

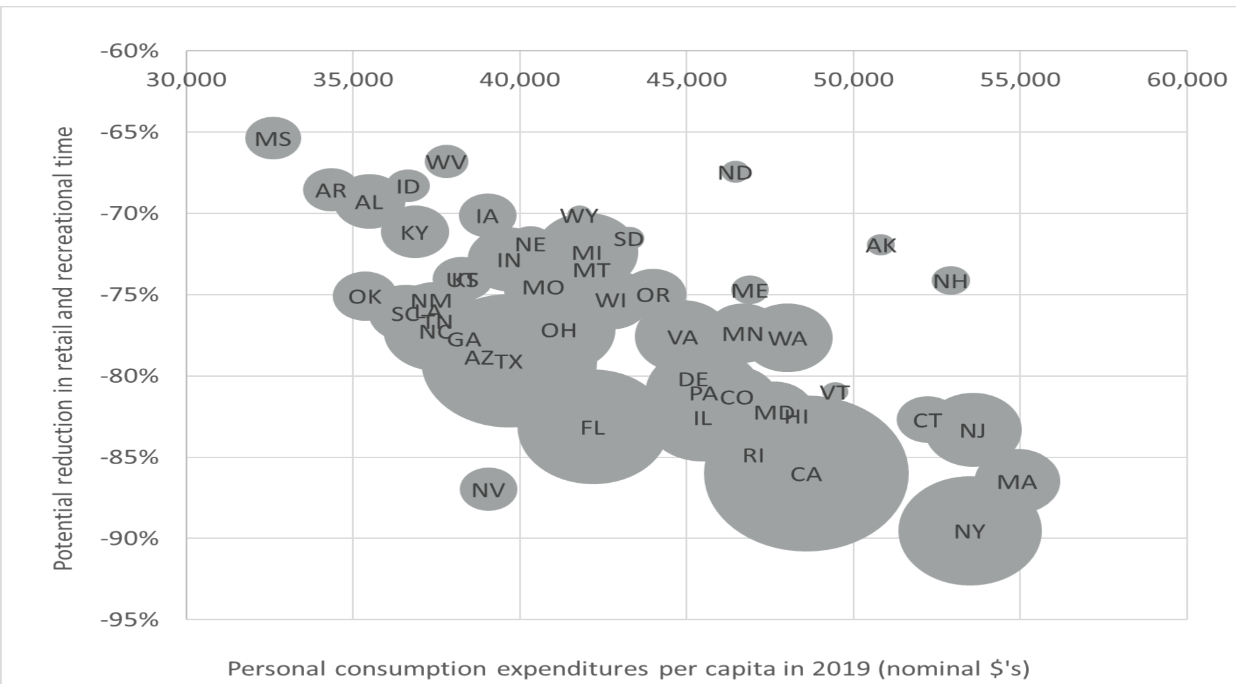

Figure 6 shows a strong negative correlation between state income and the predicted change in retail and recreational time. One might think that time spent at retail and recreational locations would be zero if actual behavior complied with the full stay-in-place policy studied in section 2. In fact, the Google

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[8] From Google's published COVID-19 Community Mobility Reports https://www.google.com/covid19/mobility/ Google's "retail and recreation" category includes libraries, museums, and other government locations. The empirical analysis in this paper adjusts for those locations, but results are substantially similar without adjustment.

category “retail and recreation” includes essential businesses like auto part stores and general merchandise stores. This paper first uses data from the 2017 Economic Census and the American Time Use Survey (ATUS) to predict the reduction in retail and recreational time that would occur during a full stay-in-place policy. Just like figure 4, the negative correlation seen in figure 6 is explained by the different industry mix across states. Within Google’s “retail and recreational location” category, states with lower nominal consumption per capita tend to have more essential businesses and fewer restaurants, recreational locations, or other nonessential businesses. The negative correlation in figure 6 approximately cancels out the positive correlation shown in figure 5, so that the ratio of theoretical inflation to the potential reduction in retail and recreational time is not correlated with state income.

Figure 7. Ratio of Theoretical Inflation to the Potential Reduction in Retail and Recreational Time

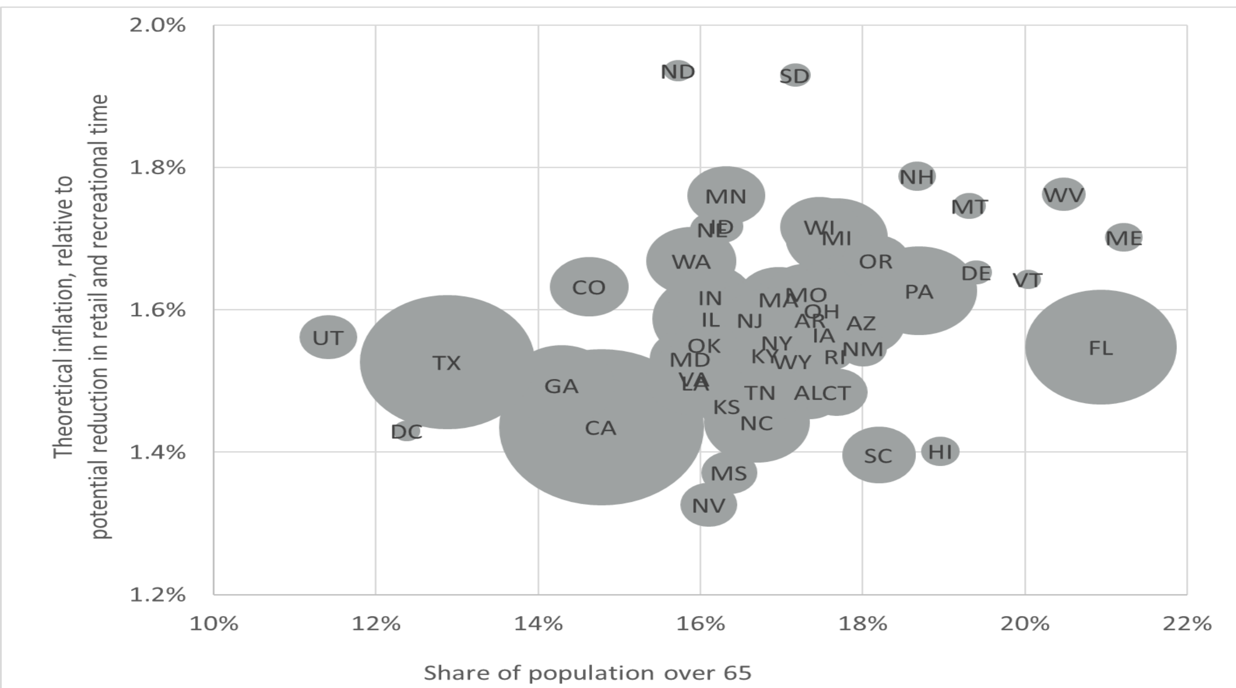

Figure 7 shows that older states generally experience more theoretical inflation from a fixed 10 percent drop in potential retail and recreational. This larger expected inflation may be driven by the fact that older states spend a higher percentage of their nonessential budget on medical care and other services that are not counted in Google’s “retail and recreational location” category. In other words, seemingly uniform stay-in-place behavior might involve a young person staying home from parties while an older person stays home from nonemergency doctor visits. As a result, researchers who focus on Google’s published mobility numbers might underestimate the cost of stay-in-place behavior to older individuals.

Retail and Recreational Time by State and Month

Figure 8. Google's Published Mobility Numbers for Selected States by Month

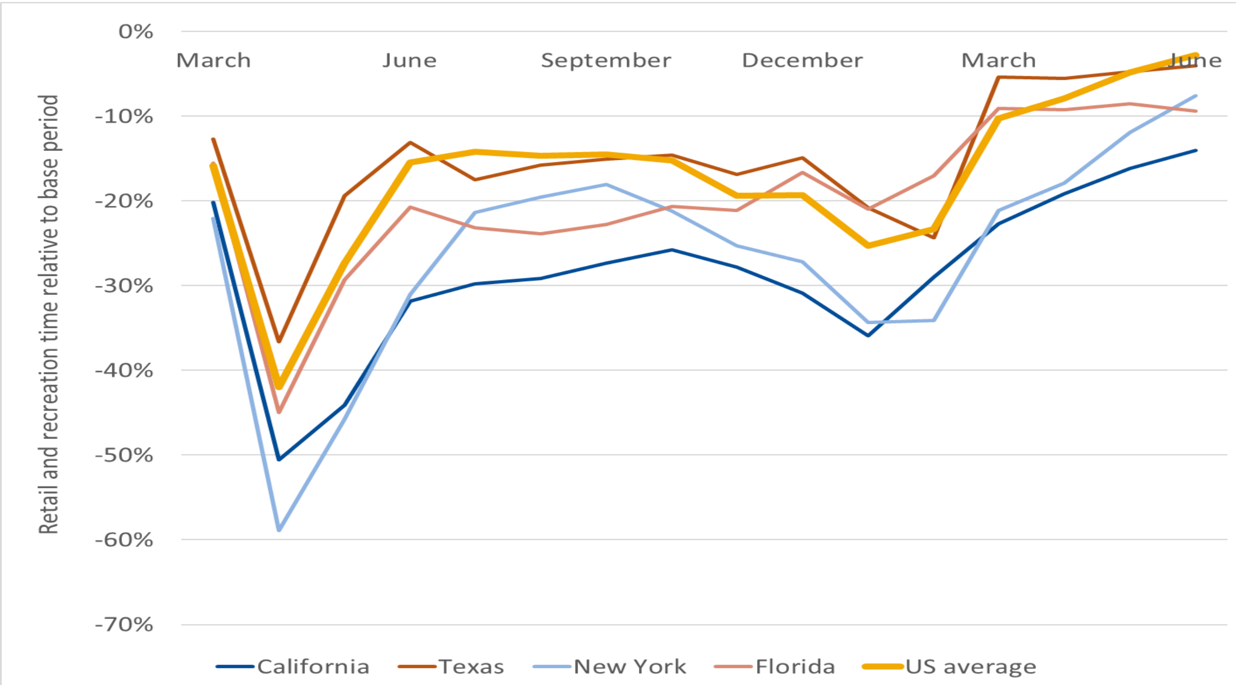

Figure 8 shows a clear pattern to the coronavirus pandemic. Mobility fell quickly early on and then partially recovered to hover around a 20 percent reduction for the next three quarters. Mobility then started to recover quickly in the second quarter of 2021. The changes in mobility shown in figure 8 are much larger than any previous variation reported in the ATUS across regions or over time. Furthermore, many states still had not returned to normal when the paper's study period concluded in June 2021. Clearly, the coronavirus pandemic caused a large and persistent change in time usage.

Over time, consistency requires adjustments to the changes in retail and recreational time reported in Google's published mobility statistics. First, and most important, previous research has shown that retail and recreation time is higher during pleasant weather (Soloveichik 2020) and higher when sunset is later (Farrell et al. 2016). This paper purchased daily temperature data by county from Degreedays.net[9] and calculated daily sunset time by county. The paper then estimated the impact of

[9] The paper's regression summarizes weather into three statistics: weighted time below 70º F, weighted time above 70º F, and daily temperature variation. The paper interacts all three weather statistics with sunset time.

temperature and sunset time and adjusted for that impact. The paper also estimated the normal impact of holidays using historical data from ATUS. The net impact of weather and holidays provides an estimate of seasonally adjusted seasonally adjusted mobility for each county/day observation. Second, the paper adjusts Google's mobility statistics for apparent changes in the number of cellphones tracked in that county/day observation.[10] Third, the paper weights Google's **relative** mobility numbers by normal retail and recreational time in each county to get aggregate retail and recreational time.[11]

Figure 9. Smoothed Retail and Recreational Time from February 15th, 2020 until June 30th, 2021

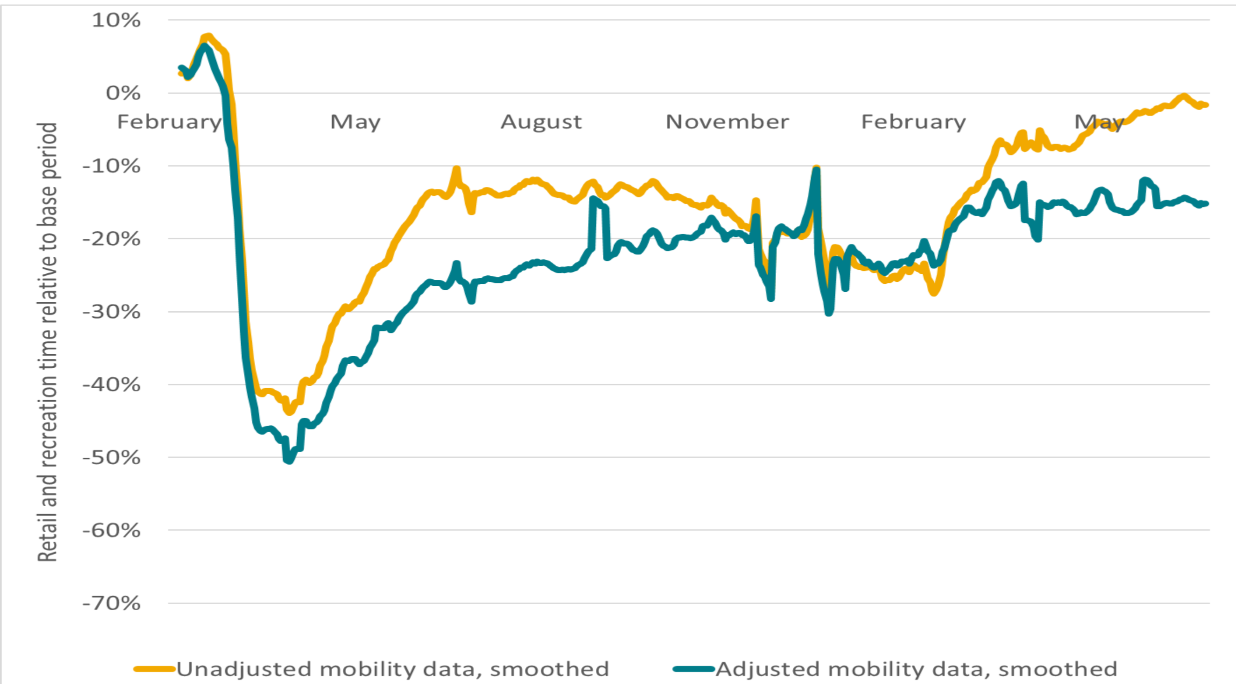

Figure 9 shows that seasonal adjustments have an important impact on average stay-in-place behavior. Most important, Google's unadjusted mobility shows a noticeable rise during the pre-pandemic period of February 15, 2020 to March 7, 2020. The difference in difference regression described earlier attributes a portion of this pre-pandemic increase to normal seasonal variation associated with the end of winter. Consistent with that attribution, the same period in 2021 also shows a sharp increase in mobility. In other words, the raw Google mobility underestimate actual stay-in-place behavior because it compares retail and recreational time to a winter base period rather than the seasonal normal.

[10] The papers sums four broad Google time usage categories ('retail and recreational locations', 'grocery and pharmacy locations', 'workplaces', and 'residential locations') to get total time. Changes in the total time relative to the winter base period are assumed to be due to changes in population or cellphone usage per person.

[11] County population is the main factor determining a county's daily weight. But the paper also adjusts for differences in retail and recreational time per person across metropolitan statistical areas and days of the week.

Across states, consistency requires adjustments to the average retail and recreational time reported in Google's published mobility statistics. First, the paper uses the temperature and day length parameters estimated earlier to adjust mobility in each county's base period. Second, the paper divides the reduction in retail and recreational time reported by Google with the potential reduction in retail and recreational time shown in figure 6. This adjustment allows states with a different business mix to be compared on a consistent basis. Third, the paper weights the adjusted county/day observations and aggregates to get total retail and recreational time per capita by state and month.

Figure 10. Adjusted Minus Unadjusted Mobility by State, Average 3/20-6/21

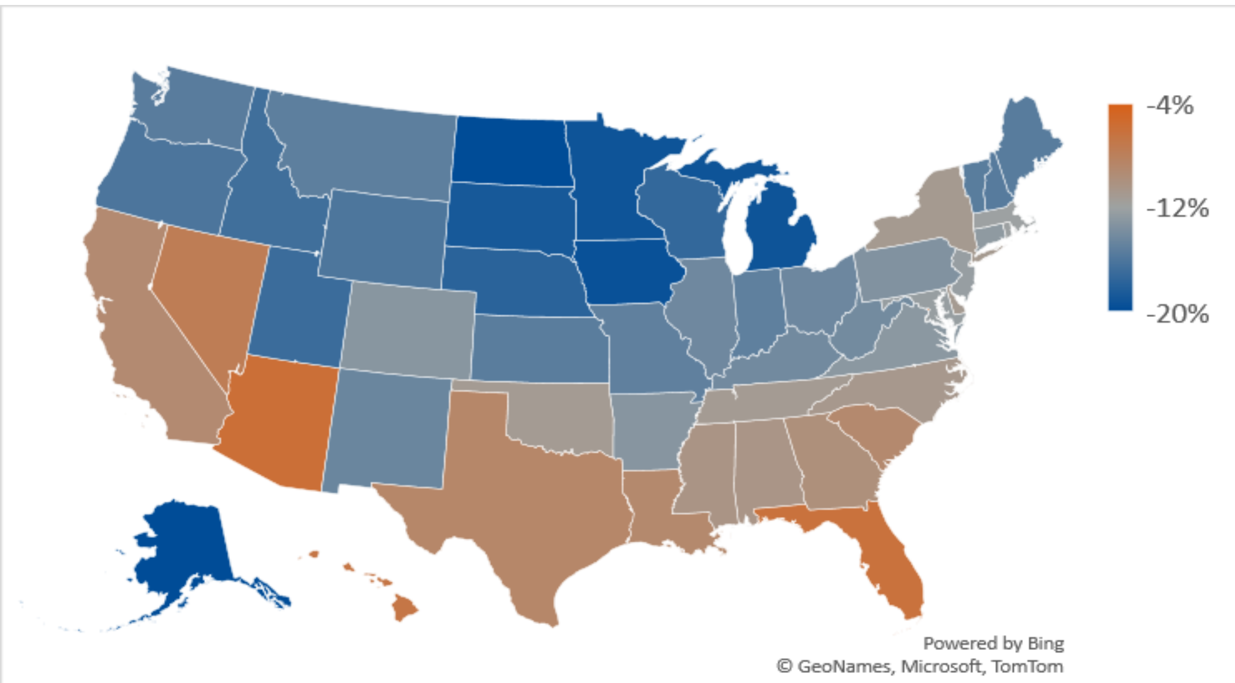

Figure 10 shows that seasonal adjustments vary widely by state. To remind readers, Google's published mobility numbers are all reported relative to a base period of January 3rd to February 6th of 2020. Northern states typically have unpleasantly cold weather during the winter and pleasant weather during the rest of the year. Furthermore, northern states have very early sunset during the winter and late sunset in the rest of the year. In contrast, southern states have more moderate weather during the winter and less variation in sunset time. As a result, the mean seasonal adjustment is closer to zero in southern states. Focusing on individual states, the paper finds that adjusting for seasonal factors allows a better picture of how income and demographics influence stay-in-place behavior.

Figure 11. Average Adjusted Stay-in-Place Behavior by State from March 2020 to June 2021

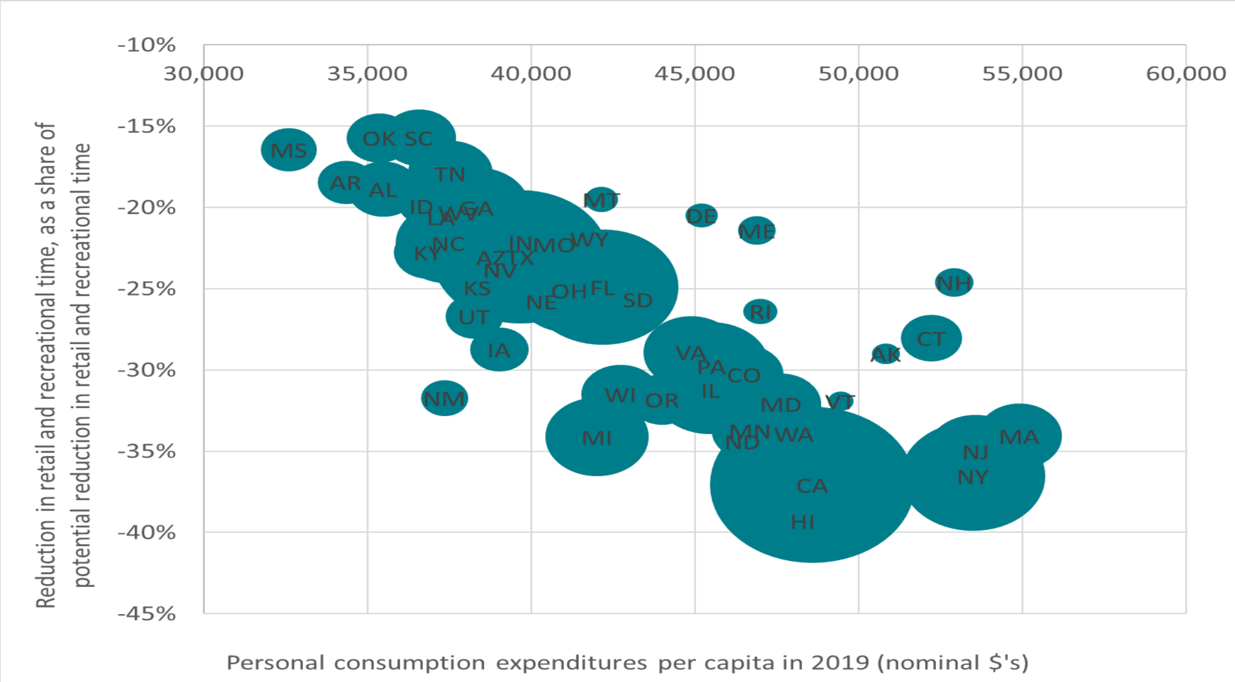

Figure 12. Average Theoretical Inflation Across States

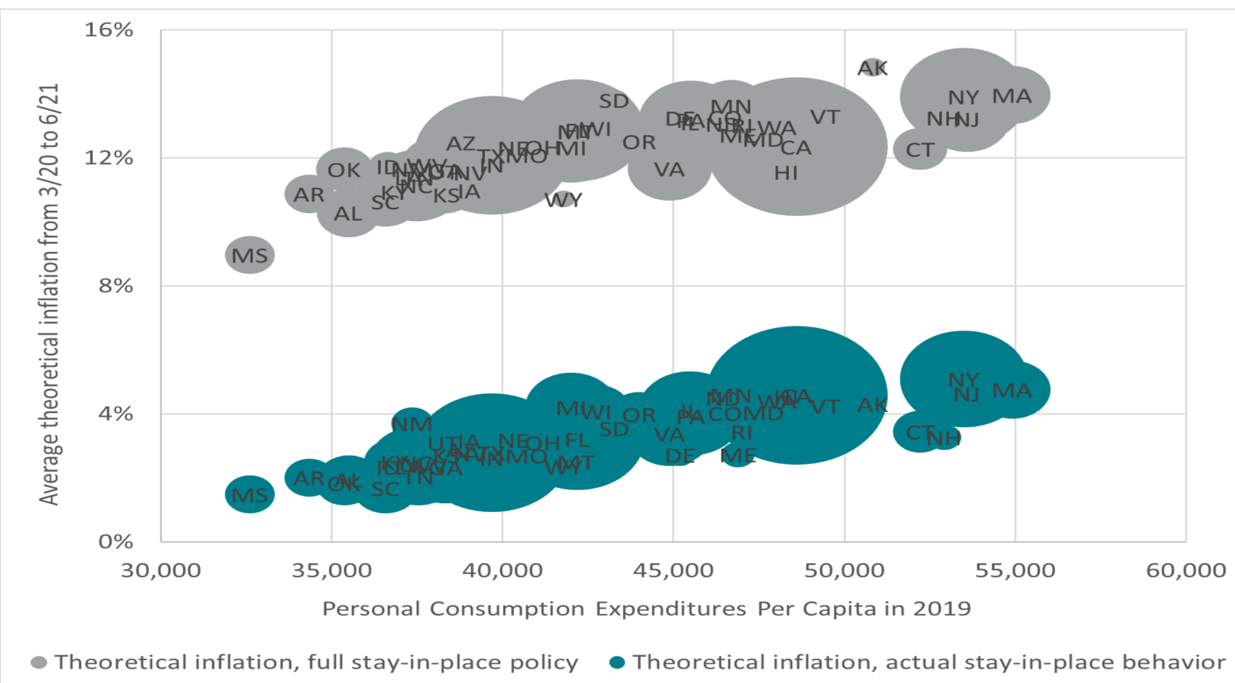

Figure 11 shows a strong positive correlation between state income and the average mobility reduction during the coronavirus pandemic. This positive correlation emerged very early in the pandemic, and therefore should not be attributed to recent disagreements. Instead, it seems plausible that adherence to public health advice is a normal good and states with higher nominal consumption per capita can afford more adherence than other states. This paper is focused on measuring consumer prices and will not examine any health consequences associated with different levels of adherence.

Figure 12 shows states with higher nominal consumption per capita have both higher theoretical inflation in a full stay-in-place policy, and also higher theoretical inflation in actual stay-in-place behavior. Interestingly, all states exempted the same absolute spending share and therefore the two lines shown above have the same slope. The reason for this surprising result deserves more study.

Aggregate Economic Statistics Over Time

Figure 13. Comparing Theoretical Inflation with Official Inflation by Month

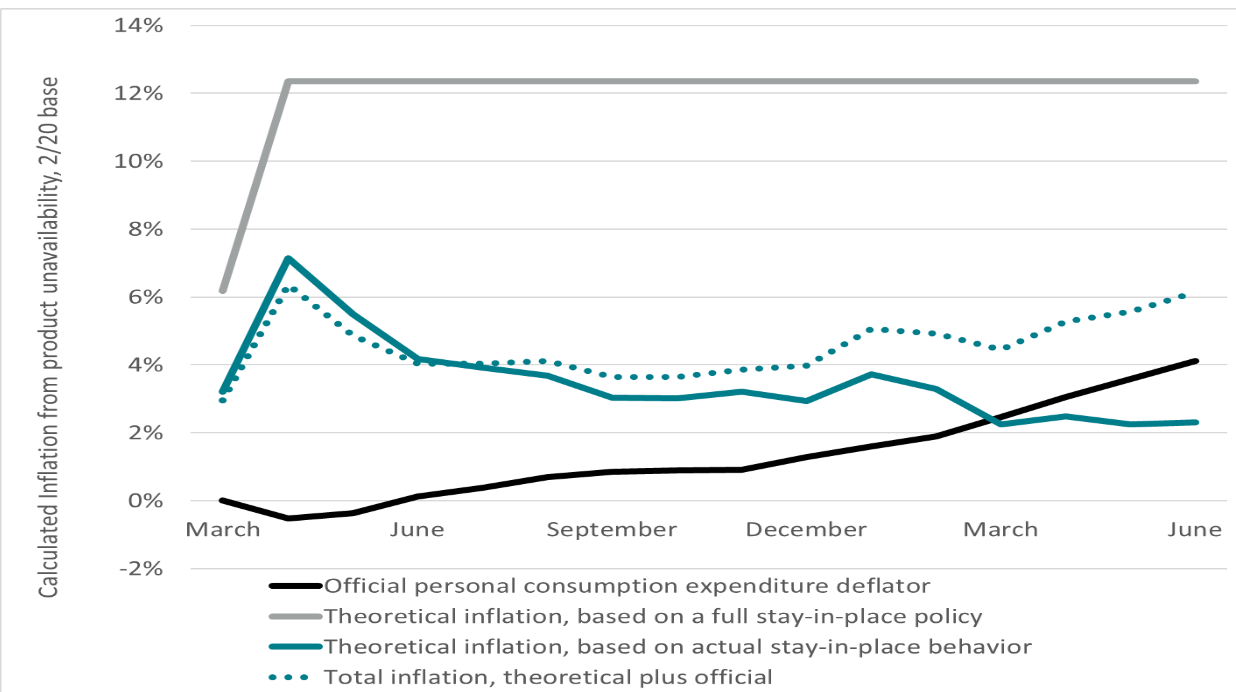

Figure 13 shows that theoretical inflation is large during the coronavirus pandemic. It may be true that the theoretical inflation associated with actual stay-in-place behavior is never as large as the theoretical inflation associated with a full stay-in-place policy. Nevertheless, a sudden jump in the theoretical cost-of-living indexes by 6 percent is large enough to have noticeable welfare implications.. Furthermore, theoretical inflation is larger than official inflation throughout the first year of the coronavirus pandemic. In the past few months, many journalists and policy-makers have extensively discussed the welfare costs associated with the official inflation shown in the black line (Adamczyk 2021) (Walsh 2021) (Powell 2021) (Manchin 2021). This paper argues that the welfare costs associated with theoretical inflation may also be important.

Figure 14. Calculated Inequality Across States Over Time

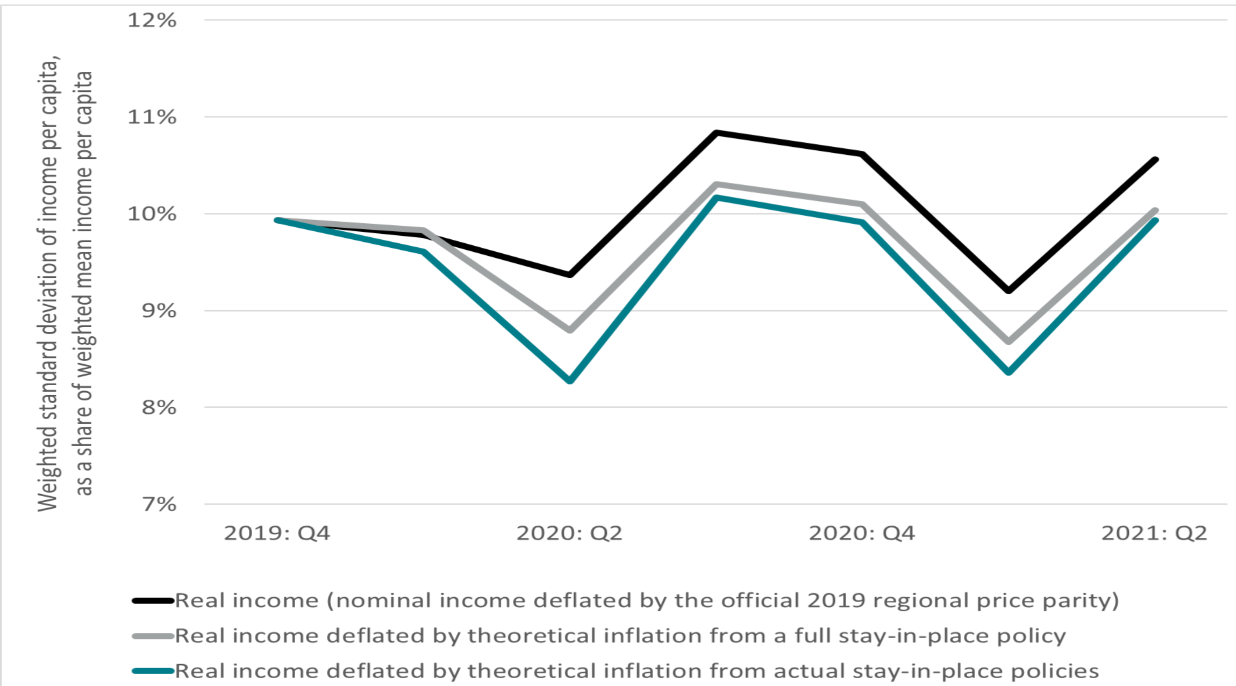

Figure 14 shows that real income across states is noticeably more equal when it is deflated with the theoretical inflation for each state. To be clear, the reduction in inequality across states associated with stay-in-place policies and behavior is small relative to the reduction in inequality across states from deflating nominal income with BEA's preexisting regional price parities. Nevertheless, it is enough to change the currently calculated increase in real inequality to a slight decrease in real inequality. Real inequality across regions may decrease even more if theoretical inflation could be calculated at the level of a county or metropolitan statistical area.

Conclusion

This paper uses price measurement theory and pre-pandemic data to construct a theoretical cost-of-living index when major product categories are unavailable. The paper found large and policy-relevant differences between theoretical inflation trends and official inflation trends. The officially reported inflation deceleration of 0.03 percentage point per month in 2020 reverses to a theoretical inflation acceleration of 0.22 percentage point per month and the officially reported inflation acceleration of 0.36 percentage point per month during the first half of 2021 reverses to a theoretical inflation deceleration of 0.33 percentage point per month. The paper also finds that theoretical inflation is higher in states with higher nominal consumption per capita, and therefore the 3 percent growth in 2020 of inequality across states which is calculated from the official state income statistics (BEA 2021b) reverses to a theoretical decrease of 4 percent to inequality across states.

Bibliography

Adamczyk, A. 2021. "For Everyday Americans, Inflation is a Double Blow to Bank Accounts," *CNBC*, August 20, 2021. Accessed September 30, 2021.

Allcott, H., L. Boxell, J. Conway, M. Getzkow, M. Thaler and D. Yang. 2020. "Polarization and Public Health: Partisan Differences in Social Distancing During the Coronavirus Pandemic," National Bureau of Economic Research (NBER) Working Paper 26946. (August).

Andersen Consulting. 1996. "Where to Look for Incremental Sales Gains: The Retail Problem of Out-of-Stock Merchandise," Study Conducted for the Coca-Cola Retailing Research Council.

Andersson, O., P. Campos-Mercade, F. Carlsson, F. Schneider, and E. Wengstrom. 2020. "The Individual Welfare Costs of Stay-At-Home Policies," LUND University Working Paper 9. (Lund, Sweden: May).

Aten, B. and R. D'Souza, R. 2008. "Regional Price Parities, Comparing Price Level Differences Across Geographic Areas," *Survey of Current Business* 88 (November 2008).

Becker, G. 1965. "A Theory of the Allocation of Time," *Economic Journal* 75, no. 299 (September): 493-517.

Berndt, E., L. Bui, D. Lucking-Reiley, and G. Urban. 1996. "The Roles of Marketing, Product Quality, and Price Competition in the Growth and Composition of the U.S. Antiulcer Drug Industry." In *The Economics of New Goods*. Chicago: University of Chicago Press.

Bradley, R. 2003. "Price Index Estimation Using Price Imputations for Unsold Items." In *Scanner Data and Price Indexes*. Chicago: University of Chicago Press.

Broda, C. and D. Weinstein. 2010. "Product Creation and Destruction: Evidence and Price Implications," *American Economic Review* 100, no. 3 (June): 691-723.

Bureau of Economic Analysis. 2021a. "Personal Income and Outlays, July 2021," posted August 27th and accessed September 30th. https://www.bea.gov/news/2021/personal-income-and-outlays-july-2021

Bureau of Economic Analysis. 2021b. "Personal Income by State, 2nd Quarter 2021," posted September 23rd and accessed September 30th. https://www.bea.gov/news/2021/personal-income-state-2nd-quarter-2021

Bureau of Labor Statistics. 2018. "BLS Handbook of Methods, Chapter 17. The Consumer Price Index," Accessed March 30, 2020. https://www.bls.gov/opub/hom/pdf/cpihom.pdf.

Bureau of Labor Statistics. 2019. "Quality Adjustment in the CPI," January 15, 2019. Accessed March 30, 2020. https://www.bls.gov/cpi/quality-adjustment/.

Carlino, G. and A. Saiz. 2019. "Beautiful City: Leisure Amenities and Urban Growth," Philadelphia Federal Reserve Working Paper 19-16. (March).

Cavallo, A. and Kryvtsov. 2021. "What Can Stockouts Tell Us About Inflation? Evidence from Online Micro Data," *NBER Working Paper* 29209.

Charters, H. 2019. "Tourism Spending in Louisiana Parishes 2018," *Report by the University of New Orleans Hospitality Research Center*, posted May 2019. Accessed August 18, 2020. https://www.crt.state.la.us/Assets/Tourism/research/documents/2018-2019/Louisiana%20Parishes%20Spending%20Report%202018%20Rev.pdf.

Cowen, T. 2020. "Pandemics Upend Classic Measures of Inflation," Bloomberg Businessweek, last updated August 26, 2020. Accessed August 27, 2020. https://www.bloomberg.com/opinion/articles/2020-08-26/inflation-in-the-covid-19-pandemic-is-measured-by-more-than-food-prices.

Couture, V., C. Gaubert, J. Handbury, and E. Hurst. 2020. "Income Growth and the Distributional Effects of Urban Spatial Sorting," manuscript available at https://faculty.chicagobooth.edu/erik.hurst/research/!welfare-implications-urban-current.pdf

Dave, D., A. Friedson, K. Matsuzawa, and J. Sabia. 2020. "When Do Shelter-in-Place Orders Fight COVID-19 Best? Policy Heterogeneity Across States and Adoption Time," NBER Working Paper 27091. (June).

Diewert, W.E., and K. Fox. 2020. "Measuring Real Consumption and CPI Bias Under Lockdown Conditions," NBER Working Paper 27144. (May).

Diewert, W. E. and R. Feenstra. 2019. "Estimating the Benefits of New Products," NBER Working Paper 25991. (June).

Diewert, W. E., K. Fox, and P. Schreyer. 2019. "Experimental Economics and the New Commodities Problem," Vancouver School of Economics Discussion Paper 2019-4. (March).

Dolfen, P., Einav, L., Klenow, P., Klopack, B., Levin, J., Levin, L., and Best, W. 2021. "Assessing the Gains from E-Commerce," working paper posted at http://klenow.com/assessing-gains-ecommerce.pdf.

Fantozzi, J. 2021. "Will Delivery Still Be King in a Post-COVID World?," *Restaurant Hospitality*, February 10, 2021. Accessed September 30, 2021. https://www.restaurant-hospitality.com/limited-service/will-delivery-still-be-king-post-covid-world

Farrell, D., Narasiman, V., and Ward, M. 2016. "Shedding Light on Daylight Savings Time." Accessed September 30, 2021. https://www.jpmorganchase.com/content/dam/jpmc/jpmorgan-chase-and-co/institute/pdf/jpmc-institute-daylight-savings-report.pdf

Feenstra, R. 1994. "New Product Varieties and the Measurement of International Prices," *American Economic Review* 84, no. 1. (March): 157-177.

Figueroa, E. and B. Aten. 2019. "Estimating Price Levels for Housing Rents in the Regional Price Parities," *Survey of Current Business* 99 (June).

Florida, R. 2018. "How Urban Core Amenities Drive Gentrification and Increase Inequality," *Citylab*, December 12, 2018. Accessed April 23, 2020. https://www.bloomberg.com/news/articles/2018-12-13/urban-amenities-lure-the-rich-income-inequality.

Franks, C. and S. Osborne. 2019. "U.S. Travel and Tourism Satellite Account for 1998–2018," *Survey of Current Business* 99 (November 2019).

Gasparo, A. and S. Stamm (2020) "Why Are Some Groceries Still So Hard to Find During Covid?" *Wall Street Journal*, last updated August 10, 2020. Accessed August 28, 2020. https://www.wsj.com/articles/why-are-some-groceries-still-so-hard-to-find-during-covid-11597069761

Glaeser, E., J. Kolko, and A. Saiz. 2001. "Consumer City," *Journal of Economic Geography* 1, no. 1 (January): 27-50.

Glaeser, E. and J. Gyourko. 2018. "The Economic Implications of Housing Supply," *Journal of Economic Perspectives* 32, no.1. (Winter): 3-30.

Gomes, H. 2018. "Evaluation of Patterns of Missing Prices in CPI Data," *JSM 2018–Survey Research Methods Section*, Accessed August 30, 2020. https://www.bls.gov/osmr/research-papers/2018/pdf/st180110.pdf.

Goolsbee, A. and A. Petrin. 2004. "The Consumer Gains from Direct Broadcast Satellites and The Competition with Cable TV," *Econometrica* 72, no. 2. (January): 351-381.

Greenlees, J. and R. McClelland. 2008. "New Evidence on Outlet Substitution Effects in Consumer Price Index Data," BLS Working Papers 421. (November).

Gyourko, J., C. Mayer, and T. Sinai. 2013. "Superstar Cities," *American Economic Journal: Economic Policy* 5, no. 4. (November): 167-199

Handbury, J. and D. Weinstein. 2015. "Goods Prices and Availability in Cities," *Review of Economic Studies* 82, no. 1. (January): 258-296.

Hausman, J. 1997. "Valuation of New Goods Under Perfect and Imperfect Competition." In *The Economics of New Goods*, Chicago: University of Chicago Press.

Hausman, J. 1999. "Cellular Telephone, New Products, and the CPI," *Journal of Business & Economic Statistics*, American Statistical Association 17, no. 2. (April): 188-194.

Hausman, J. and E. Liebtag. 2009. "CPI Bias from Supercenters: Does the BLS Know that Wal-Mart Exists?" In *Price Index Concepts and Measurement*, Chicago: University of Chicago Press.

Kanal, D. and Kornegay, J. 2019. "Accounting for Household Production in the National Accounts," *Survey of Current Business* 99(6).

Lee, R. 2020. "Some Small Businesses are Reopening Illegally in NYC," *Spectrum News*, posted May 25, 2020 and accessed August 18, 2020. https://www.ny1.com/nyc/all-boroughs/coronavirus/2020/05/25/some-small-businesses-are-reopening-illegally-in-nyc.

Liebowitz, S. and Margolis, S. 1994. "Network Externality: An Uncommon Tragedy," *Journal of Economic Perspectives* 8(2), ages 133-150.

Manchin, J. 2021. "Why I Won't Support Spending Another $3.5 Trillion," *Wall Street Journal*, posted September 2, 2021. Accessed September 30, 2021. https://www.wsj.com/articles/manchin-pelosi-biden-3-5-trillion-reconciliation-government-spending-debt-deficit-inflation-11630605657

Matsa, D. 2011. "Competition and Product Quality in the Supermarket Industry," *The Quarterly Journal of Economics* 126, no. 3. (August): 153-1591.

Molla, R. 2020. "Chart: How Coronavirus is Devasting the Restaurant Industry, Mandatory Closures Will Only Make It Worse," *Vox*, March 16, 2020. Accessed April 23, 2020. https://www.vox.com/recode/2020/3/16/21181556/coronavirus-chart-restaurant-business-local.

Nordhaus, W. 1996. "Do Real-Output and Real-Wage Measures Capture Reality? The History of Lighting Suggests Not," In *The Economics of New Goods*, Chicago: University of Chicago Press .

Paredes, D. and S. Loveridge. 2014. "How Large is the Rural Cost Advantage? A Big Mac Index for the United States," *National Agricultural & Rural Development Policy Brief* 36. December.

Patel, S., Mehrotra, A., Huskamp, H., Uscher-Pines, L., Ganguli, I., and Barnett, M. 2021. "Variations in Telemedicine Use and Outpatient Care During the COVID-19 Pandemic in the United States," *Health Affairs* 40(2).

Petrin, A. 2002. "Quantifying the Benefits of New Products: The Case of the Minivan," *Journal of Political Economy* 110, no. 4 (August): 705-729.

Pew Research Center. 2021. "Biden Nears 100-Day Mark with Strong Approval, Positive Rating for Vaccine Rollout," April 15, 2021. Accessed September 30, 2021.

https://www.pewresearch.org/politics/2021/04/15/biden-nears-100-day-mark-with-strong-approval-positive-rating-for-vaccine-rollout/

Powell, J. 2021. "Monetary Policy in the Time of COVID," speech at "Macroeconomic Policy in an Uneven Economy," posted August 27, 2021. Accessed September 30, 2021. https://www.federalreserve.gov/newsevents/speech/powell20210827a.htm

Reinsdorf, M. 1993. "The Effect of Outlet Price Differentials on the U.S. Consumer Price Index." In *Price Measurements and Their Uses*, Chicago: University of Chicago Press.

Sherman, A. 2020. "ESPN Scrambling to Figure Out Programming While Live Sports Shut Down Indefinitely," *CNBC* online article, posted March 13th, 2020 and accessed March 20th, 2020.

Soloveichik, R. 2020. "Consumer Prices During a Stay-in-Place Policy: Theoretical Inflation for Unavailable Products" BEA Working Paper 2020-14.

Stone, L. 2020. "Lockdowns Don't Work," *Public Discourse*, April 21, 2020. Accessed April 23, 2020. https://www.aei.org/articles/lockdowns-dont-work/.

Stroebel, J. and J. Vavra. 2019. "House Prices, Local Demand, and Retail Prices," *Journal of Political Economy* 127, no. 3 (June): 1391-1436.

Takashi, P. 2020. "Even Struggling Retailers are Now Voluntarily Closing During Coronavirus Pandemic," *Houston Chronicle*, March 23, 2020. Accessed April 23, 2020. https://www.houstonchronicle.com/business/retail/article/Even-struggling-retailers-are-now-voluntarily-15151194.php.

Tognotti, E. 2013. "Lessons from the History of Quarantine, from Plague to Influenza A," *Emerging Infectious Diseases* 19, no. 2 (February): 254–259.

Vinopal, C. 2021. "A Quarter of Americans Are Worried About Inflation. Here are 4 Things to Watch" PBS Newshour, posted July 2nd 2021 and accessed September 30th, 2021. https://www.pbs.org-/newshour/economy/a-quarter-of-americans-are-worried-about-inflation-here-are-4-things-to-watch

Walsh, B. 2021. "The Global Food Price Crisis Isn't Going Away," *Axios*, posted September 15, 2021. Accessed September 30, 2021.

Appendix A. Regional Model to Calculate Theoretical Prices for a Completely Unavailable Product

The paper's model assumes that rational tourists choose a destination that maximizes utility for a given vacation budget. Tourists are generally not affected by nonprice regional factors like jobs, schools, or income taxes. Furthermore, nearby urban and rural regions typically have similar weather and travel costs. As a result, the presence of tourists in the urban region strongly suggests that tourists derive sufficient utility from amenities that are only available in urban regions to outweigh the higher urban prices (Carlino and Saiz 2019).

General Model Setup

This paper begins by setting up a general model of regional price differences in an economy with four products: one hotel product (h), one broadly available good (g), one broadly available nonhotel service (s), and one amenity (a). Next, the model assumes that there are two regions, one rural (R) and one urban (U), which each have their own prices. In order to reduce the number of coefficients, normal urban prices for each of the four products is set at 1. The prices in region R are designated (p_{hR}, p_{gR}, p_{sR}, and p_{aR}). Finally, the paper assumes that there are two types of consumers in the economy, tourists (T) and locals (L). Tourists and locals pay the same price for a particular product in a particular region, but they allocate their budgets differently. The spending share for tourists is designated as (w_{hT}, w_{gT}, w_{sT}, and w_{aT}) and the spending share for locals is designated as (w_{hL}, w_{gL}, w_{sL}, and w_{aL}). By construction, the four spending shares for tourists sum to w_T and the four spending shares for locals w_L, with $w_T + w_L = 1$.

Formulas to Calculate Regional Price Differences

If all products are available in both regions and prices are observable, then it is straightforward to calculate average rural prices for each group:

(1) Tourist Prices $=(w_{hT}*p_{hR} + w_{gT}*p_{gR} + w_{sT}*p_{s1R} + w_{aT}*p_{aR})/w_T$

(2) Local Prices $=(w_{hL}*p_{hR} + w_{g1L}*p_{g1R} + w_{sL}*p_{sR} + w_{aL}*p_{aR})/w_L$

(3) Combined Prices $=(w_{hT} + w_{hL})*p_{hR} + (w_{gT} + w_{gL})*p_{gR} + (w_{sT} + w_{sL})*p_{sR} + (w_{aT} + w_{aL})*p_{aR}$

However, the price calculations are more complicated when the rural region does not offer the amenity product. As mentioned earlier, the formula for calculating price levels requires a price for every product in the market basket—so the analyst must impute rural prices for amenity products. This imputed price is designated ip_{aR}. Average rural prices for each group are:

(4) Tourist Prices $=(w_{hT}*p_{hR} + w_{gT}*p_{gR} + w_{sT}*p_{sR} + w_{aT}*ip_{aR})/w_T$

(5) Local Prices $=[w_{hL}*p_{hR} + w_{gL}*p_{gR} + w_{sL}*p_{sR} + w_{aL}*ip_{aR})/w_L$

(6) Combined Prices $=(w_{hT} + w_{hL})*p_{hR} + (w_{gT} + w_{gL})*p_{gR} + (w_{sT} + w_{sL})*p_{1R} + (w_{aT} + w_{aL})*ip_{aR}$

BEA's general methodology uses prices for similar products as a proxy for the unavailable products. In this simplified model, available rural services are assumed to be a proxy for the unavailable rural amenity. Given that assumption, the average rural prices for each group are:

(7) Quasi-BEA Tourist Price $=(w_{hT}*p_{hR} + w_{gT}*p_{gR} + w_{sT}*p_{sR} + w_{aT}*p_{sR})/w_T$

(8) Quasi-BEA Local Price $=[w_{hL}*p_{hR} + w_{gL}*p_{gR} + w_{sL}*p_{sR} + \ldots + w_{aL}*p_{sR})/w_L$

(9) Quasi-BEA Combined Prices $=(w_{hT} + w_{hL})*p_{hR} + (w_{gT} + w_{gL})*p_{gR} + (w_{sT} + w_{sL} + w_{aT} + w_{aL}))*p_{sR}$

Calculating Theoretical Prices for Completely Unavailable Amenities

This paper uses an alternative methodology to calculate prices for the unavailable amenity. The alternative requires two additional assumptions: 1) tourists regularly visit both the rural and urban regions and 2) the rural region and the urban region have similar nonprice attributes for tourists (for example, weather and travel distance). If those two assumptions hold, then the tourist basket that can be purchased for a fixed vacation budget must be identical in both regions. In other words, theoretical prices in the rural region must be equal to prices in the urban region, which are set at 1:

(10) $1 =$ Theoretical Tourist Prices $= w_{hT}*p_{hR} + w_{gT}*p_{gR} + w_{sT}*p_{sR} + w_{aT}*ip_{aR}$

(11) So that $ip_{aR} = (1/w_{aT}) - (w_{hT}*p_{hR} + w_{gT}*p_{gR} + w_{sT}*p_{sR})/w_{aT}$

For illustrative purposes, consider the case of a tourist who is deciding whether to visit an urban or rural region in Louisiana. BEA's published regional price parities for 2018 show consistently higher prices in the New Orleans metropolitan area compared to nonmetropolitan regions of Louisiana (91.2 vs. 52.1 for housing, 97.2 vs. 92.8 for goods and 92.6 vs. 92.5 for services). Yet New Orleans earned more than ten times as much tourism revenue as nonmetropolitan regions of Louisiana (Charters 2019). Clearly, tourists must derive enough value from New Orleans amenities like Mardi Gras parades to offset its higher hotel prices. Based on BEA's published travel and tourism accounts (Franks and Osbourne 2019), this paper calculates the following product weights: w_{hT} = 0.28, w_{gT}=0.26, w_{sT}=0.21, and w_{aT}= 0.25.[12] Given those weights and Louisiana prices, equation (11) above can be solved:

(12) ip_{aR} = (1/0.25)-[0.28*(52.1/91.2)+0.26*(92.8/97.2)+0.21*(92.5/92.6)/0.33= 1.53

In other words, tourists to Louisiana value the specialized urban amenities provided by New Orleans so much that they would pay 53 percent above their current market price to keep them available. This sizable premium is sufficient to raise the average cost-of-living for tourists to nonmetropolitan Louisiana by 13 percent.

In practice, the calculation above depends on the exact regions chosen for comparison. This paper uses an ordinary least squares (OLS) regression to estimate what prices would be in each region if that region had no amenities. By design, this OLS regression holds weather, jobs, and other nonprice factors constant. This analysis then imputes region-specific amenity prices using the formula solved above for Louisiana.[13] Across all regions, the average price premium for unavailable amenities is 1.59. This paper will assume that the same price premium applies to all products that are completely unavailable during a stay-in-place policy.

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[12] Consistent with assumption 2, costs related to long distance travel are excluded from the vacation budget. Next, travel accommodations are allocated to housing, shopping is allocated to goods, intracity travel and restaurant spending are allocated to services, and finally, recreation is allocated to amenities.

[13] This coefficient is estimated using a weighted OLS regression of log prices on the share of employees working in North American Industry Classification System category 71. (The worker share data is taken from the Quarterly Census of Employment and Wages and top coded at 3 percent in order to reduce the influence of outliers). The regression is run separately for goods, housing, and services.