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Measuring inflation during the Pandemic with the benefit of hindsight.[†]

Aftab Chowdhury[‡] and Huw Dixon[§]

Abstract

This study has adopted the actual household expenditure data from the national accounts to construct a true inflation rate (using the Fisher index) and found that the official inflation rate in the 33 OECD countries was an overestimate of true inflation for 22 and underestimate in 11 countries in the first wave of the COVID-19 pandemic. The result obtained for the countries where true inflation was higher than the official rate in this study matches the results obtained by Cavallo (2020) and Reinsdorf (2020). However, a significant difference has been detected for the countries where the official inflation exceeds the true measure in this study. The core reason behind the discrepancies is in the use of appropriate expenditure weights. This suggests caution in using credit-card based expenditure data when spending behaviour has changed dramatically.

JEL codes: C43, E01, E31, I10

Keywords: Coronavirus (COVID-19), Pandemic, Inflation measurement, Household Final Consumption Expenditure (HHFCE), Consumer Price Index (CPI)

[†] We would like to thank participants at the Cardiff ONS workshop in 2021 for their comments. In addition, we are grateful to the participants at the 8th International Conference on Economics of the Turkish Economic Association (ICE-TEA 2022) and the 2nd Welsh Postgraduate Research Conference in Business, Management & Economics (WPGRC 2022) organized by the Cardiff Business School for their valuable comments. Faults remain our own.

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1. Introduction

The first documented case of Covid-19 was found in December 2019, and within three months the World Health Organization (WHO) declared Covid-19 as a Pandemic. Economies around the world experienced significant losses due to the disruption in global supply chains, temporary and permanent closures of businesses, temporary closures/limits of the production plants, restriction on international travel etc. It had a massive effect on the spending patterns within economies.

As was realized early on (see for example Dixon 2020b and Tenreyro 2020), this raised specific challenges for the measurement of CPI inflation, since the standard methods of constructing inflation statistics were not designed for periods when there were rapid and large changes in expenditure patterns. There were several attempts to use real time data such as credit card expenditures to try to understand exactly how expenditure patterns were evolving and how this might distort the official inflation figures. See for example Cavallo (2020) Chronopoulos et al. (2020), Dixon (2020a), Jaravel and O'Connell (2020b) in the UK; Chetty et al. (2020), Bachas et al. (2020), Dunn et al. (2020), Baker et al. (2020) in the US; Andersen et al. (2020) in the Denmark; Carvalho et al. (2021) in Spain; Seiler (2020) in Switzerland. We review some of the main papers published using real time data in Appendix B.

The official headline inflation of most countries uses the "Lowe" price index which is a Laspeyres-type or fixed based weight index. Moreover, the advice offered by the international agencies[1] was to keep the pre-pandemic weights. Where goods and services were unavailable due to lockdowns the advice given was to impute the missing prices on the basis of the prices that were available.[2]

As is well known, using a base weighted Laspeyres index will tend to overstate inflation (since consumers are likely to consume less of items that become more expensive), whilst a current weighted Paasche index will tend to understate inflation. The true inflation will be between these

[1] Advice from Eurostat to European Union Countries, UNCE, IMF, US Bureau of Labor Statistics.
[2] Diewert and Fox (2020) argued that the implicit price of unavailable goods was in fact very high (the price that would have driven demand to zero in normal times), so that the imputation method recommended would likely understate the real inflation.

two, and an alternative "ideal index" is the Fisher Index, which is the geometric average of the Laspeyres and Paasche indices (Fisher 1921). In this paper, we construct a Fisher index to evaluate the true inflation during the pandemic and compare to the official inflation figures with this measure. Most statistical agencies have now published the actual expenditure shares for the period 2020-2021 which we can use to answer the question of how the official measures published in 2020-21 compare with the ex-post true inflation. Real time indicators used at the time were mostly based on a limited range of consumer expenditure (mostly using credit card data[3], as in Cavallo 2020, Carvalho et al 2021, Reinsdorf 2020, and Sieler 2020) and the national statistical agencies have since published figures that are much more comprehensive and cover the whole range of consumer expenditure. We will also compare the actual data with some examples of the contemporary real time data. Hindsight is indeed an advantage when it comes to tracking what was going on in 2020-2021.

When we use the actual household expenditure data from the national accounts of the 33 OECD countries, that the official inflation figures were too high in 22 countries (including Belgium, Italy, Norway, and the UK) and too low in 11 (including the US, South Korea, and Iceland).[4]

This paper is structured as follows. Section 2 is about the measurement issues of the official inflation rate during the pandemic. Section 3 explains the methodology and the data. Section 4 has measured the impact on the UK and the US inflation rates. Section 5 illustrates the impact on the other OECD countries' inflation rates and the differences between this study's outcome with some earlier studies. Finally, we conclude the paper by mentioning the importance of appropriate data set in measuring inflation.

2. Measurement issues.

During COVID-19 Pandemic, the nationwide lockdown has produced significant challenges to the inflation measurement by the national statistical offices (NSOs) as there were large and

[3] The main exception being Jaravel and O'Connell (2020b), which used store scanner data. This is best for capturing grocery expenditure and in particular food and beverage prices.
[4] However, the results were a little mixed for 19 out of 33 countries: the bias during the 2020 Q2 was the opposite to the whole period 2020-2021. See Table 3 below.

sudden changes in the consumers' expenditure patterns. The standard method of measuring inflation measure does not consider the possibility of sudden large changes in the expenditure patterns, but rather a gradual adjustment with most NSOs updating the expenditure weights used in the official CPI annually, with lagged expenditure data from previous calendar years (Jaravel and O'Connell 2020b). Therefore, sudden large changes in the expenditure shares across different sectors, products and outlets may all create biases in the official headline inflation rate.

There are of course other issues that made measurement more challenging during the pandemic. The physical collection of prices by agents was not possible, so collection moved online. Many goods and services became unavailable during the lockdown, and hence there were no prices to be collected. Some items were completely unavailable to buy, and even when items were available, consumers were less interested in purchasing the items during lockdown.

How did the UK calculate the official price index during the pandemic? If the item was unavailable, or with limited availability (with the sample of price quotes being less than 20% of its usual size), the Office for National Statistics (ONS) decided to impute the prices, based on the method that best reflects the price behavior of the missing item. For unavailable items[5], the ONS followed the Eurostat guidelines to impute using one of three methods: firstly, imputing from the index immediately above it in the classification structure; secondly, imputing based in the price movement of a similar item; thirdly, carrying forward prices from earlier months. If the unavailable item is seasonal, the ONS will use aggregate annual growth of all available non-imputed items. However, if the unavailable item is not seasonal, the ONS will use aggregate monthly growth of all available non-imputed items.

Dixon (2020b) argued that the imputation of unavailable prices is equivalent to altering expenditure shares, since if we use the available prices to impute the unavailable prices, we are effectively increasing the weight of the available prices in the price index.

[5] ONS has identified 92 items as unavailable for April Index, where 90 items for CPIH (around 16.3% of CPIH basket), 90 items for CPI (around 20.2% of CPI basket) and 89 items for RPI (around 17.7% of RPI basket).

3. Data and Methodology.

3.1 Methodology

Generally, CPI uses "Lowe" price index which is a Laspeyres-type or fixed based weight index. The Lowe price index measures the proportional change between 0 and t periods in the total value of a specific basket of goods and services. The basket does not necessarily have to consist of the actual quantities in same period. The formula for calculating Lowe Price Index is:

$$I^{0,t} = \frac{\sum_{i=1}^{n} p_i^t q_i^r}{\sum_{i=1}^{n} p_i^0 q_i^r} = \sum_i R_i^{0,t}.\ w_i^{0,r} \text{----------(i)}$$

Where, $I^{0,t}$= Index value for period t based on period 0

p_i^t = Price level of item i at period t

p_i^0 = Price level of item i at period 0 (base period)

q_i^r = Quantity on item I at period r (weighted reference period)

$w_i^{0,r} = \frac{p_i^0 q_i^r}{\sum_i p_i^0 q_i^r}$, is the weight or expenditure share of item i at period r (at 0 period price)

In the UK and most NSOs, the expenditure weights come from previous years and are used to weight the price relatives across months within the current calendar year. For example, in 2020 the expenditure weights used by the ONS were based on expenditure data from 2018, whilst the price relatives were between each month and January of 2020. Considering this fact, Diewert and Fox (2020) suggest using the Fisher index because the substitution bias in Laspeyres (too high) or Paasche (too low) or fixed basket index (too high) will be very large during the period of exceptional changes in the consumer expenditure pattern. More studies are also advocating the use of various superlative price indices such as the Fisher and Törnqvist indices during pandemic period, including Fox et al. (2022); Jaravel and O'Connell (2020a); Kantur et al. (2021); Alvarez and Lein (2020). Therefore, this study will adopt the Fisher price index as a pandemic/alternative price index to measure the true inflation rate during the pandemic. So, how has the pandemic/alternative price index been calculated?

Laspeyres price index: $I_L{}^{0,t} = \frac{\sum_{i=1}^{n} p_i^t q_i^0}{\sum_{i=1}^{n} p_i^0 q_i^0} = \sum_{i=1}^{n} R_i^{0,t}.\, w_i^0$----------(ii)

Paasche price index: $I_P^{0,t} = \frac{\sum_{i=1}^{n} p_i^t q_i^t}{\sum_{i=1}^{n} p_i^0 q_i^t} = \left[\sum_{i=1}^{n} \frac{1}{R_i^{0,t}}.\, w_i^t\right]^{-1}$ ----------(iii)

Fisher price index: $I_F^{0,t} = (I_L{}^{0,t} \times I_P^{0,t})$^0.5----------(iv)

Where, $I^{0,t}$= Index value for period t based on period 0

p_i^t = Price level of item i at period t

p_i^0 = Price level of item i at period 0 (base period)

q_i^t = Quantity on item i at period t

q_i^0 = Quantity on item i at period 0 (base period)

$R_i^{0,t} = \frac{p_i^t}{p_i^0}$, is the price relative

$w_i^0 = \frac{p_i^0 q_i^0}{\sum_i p_i^0 q_i^0}$, is the weight or expenditure share of item i at period 0 (at 0 period price)

$w_i^t = \frac{p_i^t q_i^t}{\sum_i p_i^t q_i^t}$, is the weight or expenditure share of item i at period t (at t period price)

The Laspeyres price index is the weighted arithmetic mean of price relatives. The basic difference between Laspeyres and Lowe price index is the calculation of the expenditure share. The Lowe price index uses a past reference period quantity, whereas Laspeyres uses base period quantity. If the reference and the base periods are the same, then both the indexes provide identical results. On the other hand, the Paasche price index is a weighted harmonic mean of price relative which is based on the current period's quantity. The Fisher price index is the geometric average of the Laspeyres and the Paasche Price Indexes, which is also known as a superlative or ideal price index.

To calculate the Laspeyres price index, the study will adopt the previous year's consumer expenditure data as the expenditure weight for the current year. For example, the expenditure weight for 2020 is the expenditure share data from 2019. We will use expenditure share data of 2020 for the expenditure weights in constructing our Paasche price index in 2020. Therefore, how frequently expenditure weights have been updated will depend on the availability of expenditure share data in each country we consider.

3.2 Data

In this study, we use (depending on availability) the annual and quarterly/monthly household final consumption expenditure (HHFCE) data from the national accounts of 33 OECD countries to directly measure the changes in spending pattern during the pandemic. In the UK, the HHFCE data is contained in Consumer Trends published by the Office for National Statistics (ONS). For the US, we have collected personal consumption expenditure (PCE) data from the U.S. Bureau of Economic Analysis (BEA), which is proxied by the consumer expenditure survey (CEX) from the U.S. Bureau of Labor Statistics (BLS) due to the significant error in collecting data directly from consumers during the pandemic period (Curtin 2022). The HHFCE data for the rest of the countries in the list are collected mostly from Eurostat, OECD Stat, and other statistical agencies, including Statistics Canada, Australian Bureau of Statistics, Statistics of Japan, Statistics Korea. In Appendix-A, we will find the full list of countries along with the frequency of the data and collecting institution.

4. Impact on the UK and the US Inflation

In this section we will look in detail at the UK and US experience to illustrate the main issues involved in measuring the effect of the pandemic on inflation. Each country has a slightly different set up for its CPI and indeed how it dealt with the pandemic.

4.1 Impact on the UK inflation

The first nationwide lockdown was enforced on the 23rd of March 2020, and it continued until the relaxing of restrictions and social distancing rules on the 23rd of June 2020. The subsequent lockdowns were the Second Lockdown (5th November 2020 to 2nd December 2020) and Third Lockdown (6th January 2021 to 12th April 2021). [6] From the literature, we have already identified that the consumers' expenditure pattern has changed significantly during the lockdown period. Table 1 has well demonstrated this concern with the help of actual household final consumption

[6] For details see Institute for Government Analysis, UK

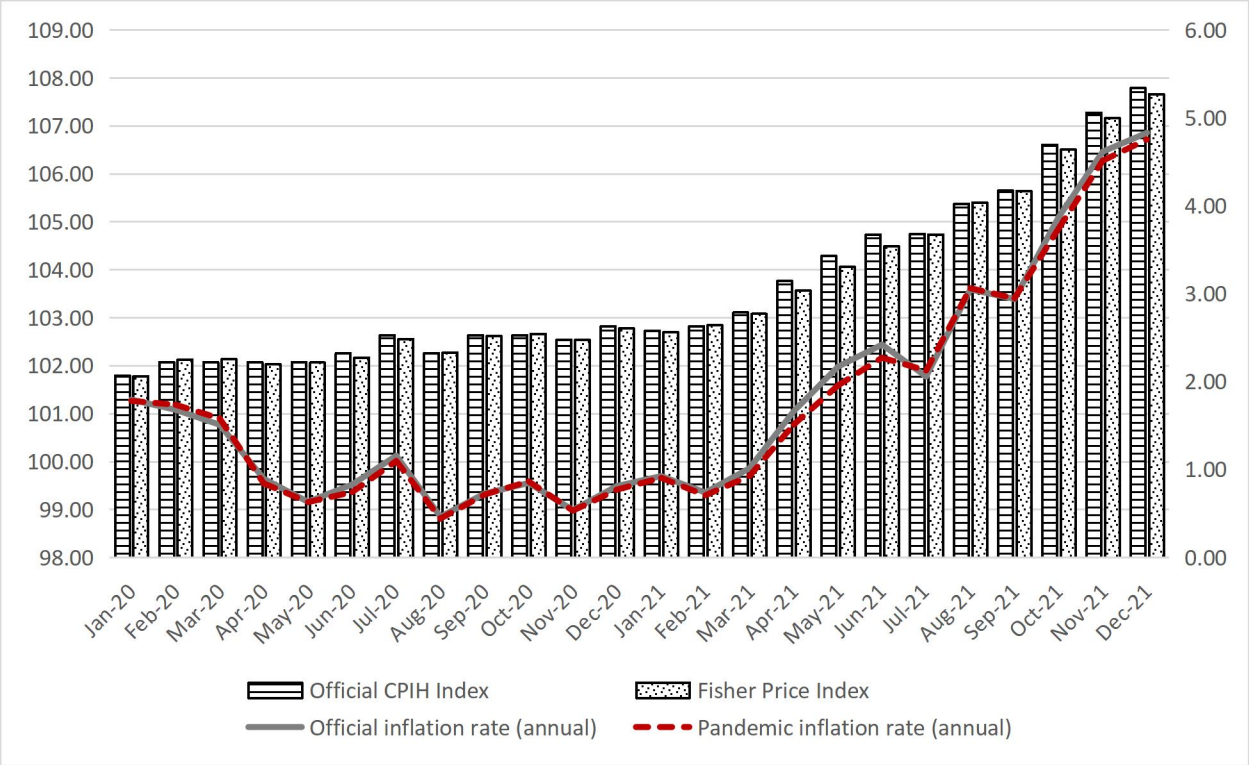
expenditure during the COVID-19 pandemic period. Major changes took place during the first lockdown. Among the 12 divisions in the COICOP category, significant changes happened in the Food and non-alcoholic beverages; Alcoholic beverages and tobacco; Housing, water, electricity, gas, and other fuels; Transport; Education; Restaurants and hotels division. However, the expenditure patterns were moving to their previous track after the end of the third lockdown in the UK. Although we have several references on the inflation measurement biases, it is time worthy to cross-check the literature with help of actual national account information rather than card-based data.

Table 1: Official expenditure weight and HHFCE in the UK

COICOP Divisions	Official Expenditure Weight		Household Final Consumption Expenditure (HHFCE)							
	2020	2021	2020Q1	**2020Q2**	2020Q3	2020Q4	2021Q1	2021Q2	2021Q3	2021Q4
01 Food and non-alcoholic beverages	79	89	87	**113**	91	93	98	87	82	81
02 Alcoholic beverages and tobacco	32	35	34	**48**	39	39	42	41	38	37
03 Clothing and footwear	51	59	49	**51**	52	53	52	53	49	50
04 Housing, water, electricity, gas and other fuels	296	328	265	**333**	277	283	297	270	259	258
05 Furniture, household equipment and maintenance	50	49	46	**54**	51	52	54	63	56	56
06 Health	22	20	20	**18**	20	22	22	18	17	17
07 Transport	120	107	128	**66**	108	101	91	110	122	126
08 Communication	17	19	17	**21**	18	18	19	20	19	19
09 Recreation and culture	136	112	115	**120**	115	120	124	107	104	104
10 Education	24	30	25	**32**	27	28	29	26	25	25
11 Restaurants and hotels	96	69	92	**13**	75	63	41	79	103	102
12 Miscellaneous goods and services	77	83	121	**131**	127	129	133	128	126	125

Source: ONS

Figure 1: UK Official and COVID Inflation



Source: Author calculation

Figure 1 shows how far the official headline inflation rate is from the pandemic inflation rate (the Fisher index). The figure depicts both the price-index level (in bars) and the Pandemic inflation rate. The two measures diverge in two periods: the official inflation rate is slightly higher than the pandemic inflation in the first lockdown period (i.e., second quarter of 2020) and after the third lockdown period (i.e., second quarter of 2021). The major contributors accounting for the differences in the second quarter of 2020 inflation were restaurant and hotels, recreation and culture, housing and household services, food and non-alcoholic beverage, clothing and footwear, and transport. As the official inflation used the earlier expenditure weight, the higher inflation in the restaurant and hotels, recreation and culture divisions have positively contributed to the overall inflation. However, the increased expenditure in the food and non-alcoholic, housing and household services divisions has also positively contributed to higher pandemic inflation but

remaining below the official headline inflation rate because of the sharp decline in the expenditure on transport where inflation rate was largely negative.

In 2021, the ONS has updated its expenditure weight significantly considering the dramatic change in the expenditure behaviour in 2020. The major contributor to the inflation in the second quarter of 2021 are housing and household services, transport, recreation and culture, other goods, and services divisions. As the actual expenditure pattern has started to return to the earlier track, the increase in housing and household services expenditure weight in the official inflation calculation is the main factor behind the difference with the pandemic inflation rate. However, the official inflation rate and the pandemic inflation rate look quite similar after the second quarter of 2021 because the increased inflation rate in the housing and household services and the transport division were cancelled out due to the expenditure weight in these two different inflation rate calculations. The official expenditure weight of the housing and household services is higher than the actual expenditure and the vice-versa for the transport after the second quarter of 2021. These are the main divisions where the change took place in the form of the inflation rate as well as the expenditure weight in the two methods of calculating the inflation rate.

The UK experience shows how the comparison of the official inflation figures with the pandemic measure depends on a detailed comparison of often offsetting effects across the expenditure categories with offsetting trends.

4.2 Impact on the US inflation

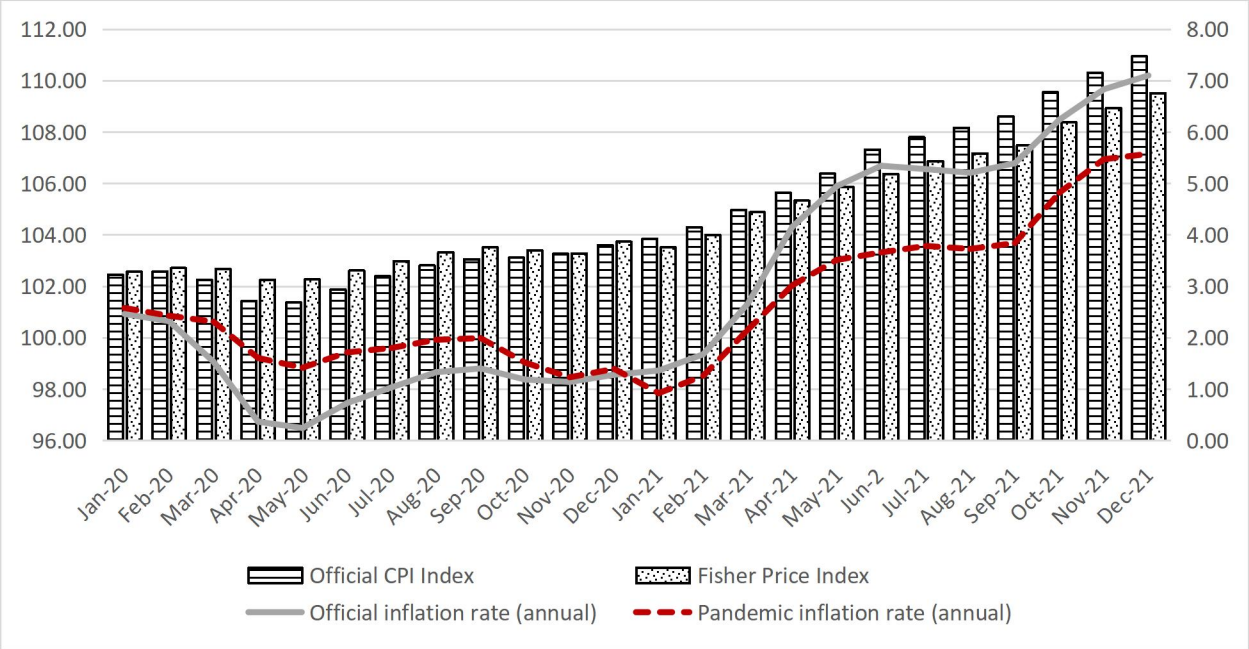
The first COVID-19 case was found in the US on the 20th of January 2020. Since then, more than one-million people have died and the US remains the top country in the world in terms of total cases and deaths. Table 2 gives us information regarding the change in the expenditure pattern by consumers during the period of the Pandemic. The expenditure pattern changed dramatically in the first wave, i.e., from March to May 2020.

	Personal Consumption Expenditure (PCE)											
	2020 M1	2020 M2	**2020 M3**	**2020 M4**	**2020 M5**	2020 M6	2020 M7	2020 M8	2020 M9	2020 M10	2020 M11	2020 M12
Food and beverages purchased for off-premises consumption	73	73	**98**	**100**	**93**	86	85	84	83	82	83	82
Clothing, footwear, and related services	29	29	**23**	**19**	**24**	29	29	29	31	30	29	28
Housing, utilities, and fuels	183	185	**202**	**236**	**214**	200	198	196	193	193	194	197
Furnishings, household equipment, and routine household maintenance	43	43	**46**	**47**	**50**	50	49	50	49	49	49	47
Health	222	223	**214**	**199**	**212**	218	219	218	220	221	224	225
Transportation	95	94	**77**	**68**	**79**	81	83	84	86	85	84	85
Communication	19	19	**21**	**23**	**21**	20	20	20	20	20	20	20
Recreation	91	90	**85**	**79**	**83**	89	88	88	88	89	88	85
Education	22	22	**24**	**24**	**22**	21	21	21	21	21	21	20
Food services and accommodations	72	72	**56**	**42**	**49**	56	58	61	61	61	59	58
Financial services and insurance	83	83	**91**	**103**	**92**	88	87	87	86	86	87	89
Other goods and services	67	67	**64**	**59**	**60**	62	62	62	62	63	63	63

Table 2: Personal Consumption Expenditure in the US

Source: U.S. Bureau of Economic Analysis (BEA)

Figure 2: US Official and COVID Inflation



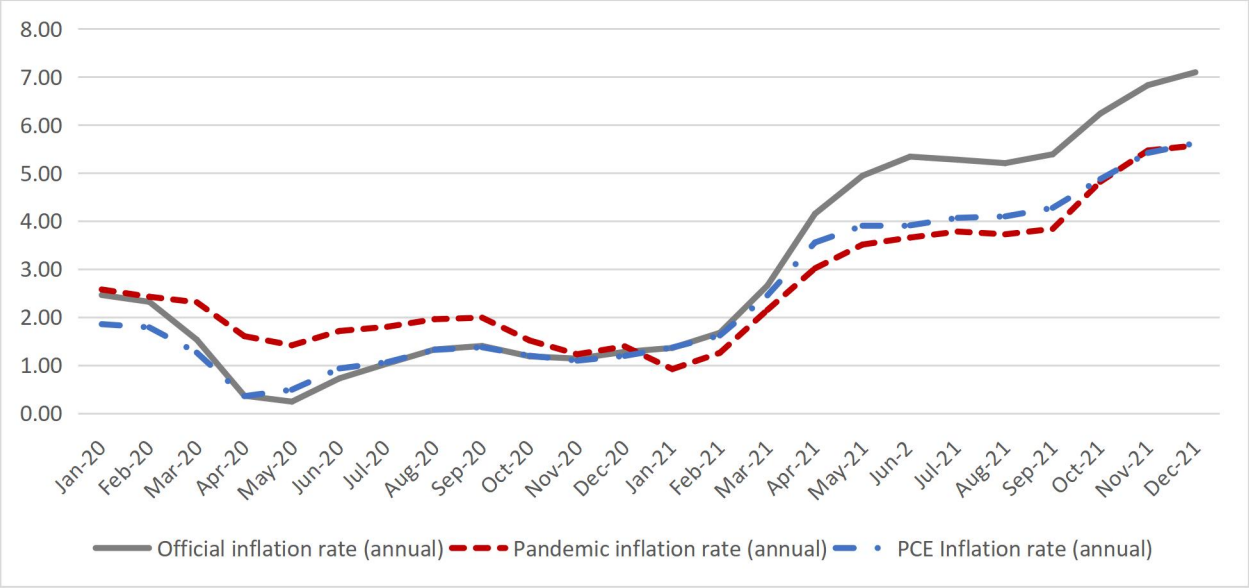
Source: Author calculation

Figure 2 depicts the official inflation rate and the Pandemic inflation rate, as well as the corresponding indices. There is a much greater divergence between the two inflation measures than in the UK. In 2020 the Pandemic inflation rate was higher, reflecting large price changes and the increased consumer expenditure in food and non-alcoholic beverage, alcoholic beverage, housing, and household services. In 2021, the situation was reversed. This is partly a result of the base effect (higher pandemic prices in 2020 tend to reduce inflation implied by prices in 2021), but also the differences in expenditure shares (the Fisher price index price levels are below the official levels).

The U.S. Bureau of Economic Analysis also calculates an alternative price index known as the Personal Consumption Expenditure (PCE) Price Index, which is calculated using the Fisher-

Index.[7] This is the measure primarily used by the FED in formulating its policy. In a report by Curtin (2022) has also confirmed that during pandemic the data quality in the CE Survey by the BLS is poor in comparison to the PCE by BE. In Figure 4 we show the PCE inflation measure in addition to the official and Pandemic rates. The PCE and Pandemic are both Fisher indices but use different expenditure data: our pandemic figure uses the final national accounts HHFCE data, whilst the PCE uses the most recent data available when it is published. Figure 3 also supports this proposition as the minimum bias is observed in the PCE Price Index. In 2020, the PCE followed the Official figure more closely (both below the pandemic measure), whilst in 2021 the PCE follows the Pandemic measure more closely (both below the official measure).

Figure 3: US Official, PCE and COVID Inflation



Source: Author calculation

5. Impact on the other OECD countries

The UK and US provide contrasting experiences of how the pandemic inflation and official figures can differ. In the UK there is a light difference, with the pandemic being slightly lower, whilst there is a more substantial difference in the US with pandemic inflation being higher in

[7] The relative weights used in the PCE index are derived from business surveys—for example, the Census Bureau's annual and monthly retail trade surveys, the Service Annual Survey, and the Quarterly Services Survey.

2020 and lower in 2021. We now go on to explore the differences across the remaining OECD countries using the same methodology, as shown in Table 3. The first two columns give the difference between the official and pandemic inflation: in column 1 we see the difference in 2020 Q2 and in column 2 we see the difference over the two years 2020-2021.

Among the rest of the OECD countries, the official inflation rate is mostly higher than the pandemic measure in the second quarter of 2020 and less over the whole COVID period of 2020-21. A common pattern in those countries is that the bias is greater in the second quarter of 2020 compared to the whole year as a result of the large change in the expenditure patterns in that quarter. An identical pattern observed in almost all the countries with a higher official rate: (i) pandemic weight is higher where the price level is decreasing; (ii) official weight is higher where the price level is increasing.

In three countries out of the sample (Iceland, Poland and South Korea), the official inflation rate was lower than the pandemic inflation in both the second quarter of 2020 and the whole COVID period of 2020-21. Among these three, the changes in the expenditure pattern were quite similar except in South Korea where the pattern changed earlier i.e., in the first quarter of 2020. In these countries, pandemic weights have increased in food and non-alcoholic beverage, alcoholic beverage, housing and household services, furniture, health, communication, and education. In addition, the price level has increased in food and non-alcoholic beverage, alcoholic beverage, housing and household services, furniture, health, recreation and culture, education, restaurant, and hotels; and the price level has decreased in clothing and footwear, transport, and communication. Again, a similar pattern has also been observed in those countries where the official inflation rate is higher, they are: (i) pandemic weight is higher where the price level is increasing; (ii) official weight is higher where the price level is decreasing.

For most countries, there are mixed results, meaning the bias during 2020 Q2 was the opposite to the whole period 2020-2021. In Norway, the official inflation rate was significantly higher than the pandemic in 2020 and lower over the whole period. The opposite scenario was seen the Czech Republic where the official inflation rate was lower in the second quarter of 2020 and higher for the whole. Clearly, the differences can be very small (smaller than 0.1 pp in absolute

terms) ranging to over 1 pp in absolute terms in 2020 Q2 (Norway and the US). There is great heterogeneity in how the pandemic impacted om the inflation experience in different countries, reflecting different expenditure patterns, government policies and the behavior of households and firms.

In columns 3 and 4, we show the earlier results obtained by Cavallo (2020) and Reinsdorf (2020) using real time debit and credit card-based expenditure data. Whereas study is based on the actual data from the national accounts with the benefit of hindsight, these studies were attempts to measure the effects as they were happening. Both Cavallo and Reinsdorf used credit card data from one country and applied it to several other countries: Cavallo used US card data, Reinsdorf Canadian and US data. Even when applied to the US or Canadian data, the credit card data can be misleading. For example, Reinsdorf (2020) and Cavallo (2020) use 37.12 and 35.80 respectively for the COICOP category 04 housing and household services in Canada, but the actual data from Statistics Canada gives us 32.59 for this COICOP category. In the case of the UK, the official expenditure share for the COICOP category 01 food and non-alcoholic beverage in the second quarter of 2020 is 11.3 whereas the expenditure share for the similar category in Cavallo (2020) is estimated as 29.5 in April 2020.[8] The difference is quite high and the potential source of bias in the inflation measurement. Whilst using card data provides real time information, it can be significantly different to the real expenditure behavior since it only captures a part of expenditure.

[8] Cavallo (2020) used Spanish card-based expenditure data to estimate the weight for the European countries in his sample.

Table 3: CPI and Pandemic CPI in OECD countries

	OECD Countries	Annual Official inflation rate minus Pandemic inflation rate for **2020Q2**	Annual Official inflation rate minus Pandemic inflation rate for the **Pandemic Period (2020-2021)**	**Cavallo (2020)** (CPI-Pandemic CPI, YoY, Sept 2020)	**Reinsdorf (2020)** (CPI-Pandemic CPI, 3-month growth, March-May 2020)	
					Canada Weight	US Weight
Official Inflation > Pandemic Inflation	Canada	0.03	0.10	**-0.15**	**-0.36**	**-0.36**
	Hungary	0.22	0.45	…	**-0.72**	**-0.95**
	Ireland	0.67	0.02	0.32	0.22	0.18
	Israel	0.2	0.14	…	**-0.14**	**-0.27**
	Italy	0.75	0.00	0.15	…	…
	Japan	0.09	0.05	**-0.24**	**-0.08**	**-0.17**
	Latvia	0.01	0.13	…	**-0.08**	**-0.54**
	Lithuania	0.43	0.07	…	**-0.09**	**-0.52**
	Netherlands	0.49	0.07	0.34	**-0.01**	**-0.1**
	United Kingdom	0.05	0.04	0.06	**-0.09**	**-0.14**
Mixed result in 2020Q2 and Pandemic Period	Australia	-0.08	0.18	…	…	…
	Austria	-0.15	0.08	…	-0.09	-0.33
	Belgium	0.66	-0.02	…	**-0.39**	**-0.45**
	Czech Republic	-0.01	0.33	…	-0.59	-0.64
	Denmark	0.08	-0.08	…	**-0.17**	**-0.25**
	Estonia	0.09	-0.09	…	**-0.38**	**-0.51**
	Finland	-0.17	0.03	…	-0.2	-0.19
	France	0.06	-0.09	**-0.46**	…	…
	Germany	-0.04	0.03	0.58	0.17	-0.03
	Greece	0.65	-0.04	**-0.06**	1.28	0.34
	Luxembourg	-0.16	0.00	…	-0.16	-0.33
	Mexico	0.21	-0.04	…	**-0.63**	**-0.69**
	Norway	1.63	-0.44	…	0.47	0.42
	Portugal	0.16	-0.01	…	0.64	**-0.04**
	Slovakia	-0.37	0.30	…	-0.26	-0.38
	Slovenia	0.65	-0.10	…	0.32	0
	Spain	0.78	-0.09	**-0.32**	0.26	**-0.36**
	Sweden	0.31	-0.05	…	**-0.2**	**-0.3**
	Turkey	0.18	-0.01	0.44	**-0.08**	**-0.27**
	United States	-1.13	0.31	-0.48	-0.68	-0.77
Official Inflation < Pandemic Inflation	Iceland	-1.07	-0.39	…	-0.17	-0.18
	Poland	-0.06	-0.06	…	-0.57	-0.77
	South Korea	-0.01	-0.09	-0.52	-0.38	-0.5

Source: Author calculation

7. Conclusion

During the coronavirus pandemic, specifically the first wave (second quarter of 2020) of the pandemic, the official Consumer Price Index (CPI) inflation figure wasn't as informative as usual about the balance of supply and demand in the economy. The reason behind that is the conceptual challenges that have affected price measurement during the lockdown period. The major change was that the large shifts in spending patterns due to the stringent lockdown policies adopted by the government across the world, which changed the representative household consumption basket.

The aim of this study is to identify whether the official inflation rate was higher or lower than the true inflation rate (using the Fisher index) during the COVID-19 pandemic. Adopting the actual household expenditure data from the national accounts, this study found that the official inflation rate in the 33 OECD countries was an overestimate of true inflation for 22 and underestimate in 11 countries in the first wave of the COVID-19 pandemic. The result obtained for the underestimating countries in this study has matched the result obtained by Cavallo (2020) and Reinsdorf (2020). However, a significant difference has been detected for the countries where the official inflation rate was higher than the true inflation rate in this study. The core reason behind the discrepancies in the use of appropriate expenditure weight. Finally, this study suggests caution while adopting card-based expenditure data in calculating any superlative price indexes for measuring general price levels when spending behaviour has changed dramatically.

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Appendix-A: Selected countries, Frequency and Sources of HHFCE data

OECD Countries	Frequency of HHFCE Data	Source of HHFCE
Australia	Quarterly	Australian Bureau of Statistics
Austria	Annually	Eurostat
Belgium	Annually	Eurostat
Canada	Quarterly	Statistics Canada/OECD
Czech Republic	Annually	Eurostat
Denmark	Annually	Eurostat
Estonia	Annually	Eurostat
Finland	Annually	Eurostat
France	Annually	Eurostat
Germany	Annually	Eurostat
Greece	Annually	Eurostat
Hungary	Annually	Eurostat
Iceland	Annually	Eurostat
Ireland	Annually	Eurostat
Israel	Annually	OECD Stat
Italy	Annually	Eurostat
Japan	Annually	Statistics of Japan
Latvia	Annually	Eurostat
Lithuania	Annually	Eurostat
Luxembourg	Annually	Eurostat
Mexico	Annually	OECD Stat
Netherlands	Annually	Eurostat
Norway	Annually	Eurostat
Poland	Annually	Eurostat
Portugal	Annually	Eurostat
Slovakia	Annually	Eurostat
Slovenia	Annually	Eurostat
South Korea	Quarterly	Statistics Korea/Eurostat
Spain	Annually	Eurostat
Sweden	Annually	Eurostat
Turkey	Annually	Eurostat
United Kingdom	Monthly	Office For National Statistics

United States	Monthly	Bureau of Economic Analysis

Appendix B: Review of real time indicator papers published in 2020.

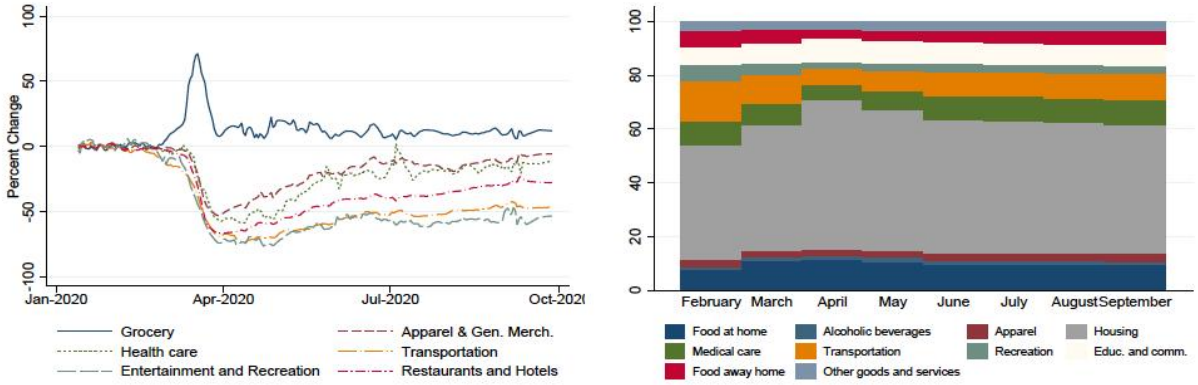
CPI measures inflation with reference to a fixed basket of goods and services, which is constructed based on the weighted average of prices using the budget shares of a reference "base" period. These weights are based on the expenditure patterns taken from well before the index calculation period (one or two years old). During the first wave of coronavirus, expenditure share has been changed significantly around the world that might made official inflation rate biased. Over the last two year, several studies were conducted across the world for identifying the expenditure pattern and measurement error in the headline inflation rate during the COVID-19 Pandemic. Therefore, the continuous development in this topic has been categorized as (1) the expenditure pattern and (2) the measurement issues of the inflation rate during the Pandemic.

The expenditure pattern during COVID-19 Pandemic

The Covid-19 Pandemic has brought a dramatical change in consumer expenditure pattern in many countries due to the lockdowns, social-distancing rules, and mobility restrictions.[9] Cavallo (2020) mentioned that consumers were spending less on transportation, hotels, restaurants, recreation, and spending more on food and groceries.

Figure 4: Consumer Spending and CPI Basket Weights During the Pandemic

[9] Andersen et al (2020), Bachas et al (2020), Baker et al. (2020), Carvalho et al (2020), Chetty et al (2020), Chronopoulos et al (2020), Dunn et al (2020).



(a) Consumer Spending (Opportunity Insights) (b) Covid Basket Weights

Source: Cavallo (2020)

Chronopoulos et al. (2020) found that discretionary spending remains relatively stable throughout the incubation, outbreak, and most of the fever phases. However, the discretionary spending has declined significantly during the lockdown phase as the government imposed strict lockdown restrictions. [10] After the announcement of Covid-19 as a pandemic by WHO, there was a strong increase in the groceries spending which is consistent with the panic-buying and stockpiling behaviour reported by the UK media. Further, grocery spending has declined noticeably at the beginning of the Lockdown period. Moreover, spending on dining and drinking has increased during the outbreak and the early weeks of fever period before declining. The study also identified heterogeneity in consumer spending based on demographically and geographically across the nation. For example, consumer based in Scotland appears to spend more in the early stage of the outbreak period. Moreover, those consumers also appear to reduce spending in dining and drinking before counterpart located in England and Wales. Furthermore, the males spend significantly more than females, younger individual spends more than older and high-income individual spend more than low-income counterpart. Overall, the study suggests that consumer spending has declined significantly since the beginning of the Covid-19 outbreak.

[10] Discretionary spending is the sum of spending in groceries, dining and drinking, alcohol, gambling, games and gaming and other related items. The study categorized different phases as: Incubation (Jan 1 to Jan 17), Outbreak (Jan18 to Feb 21), Fever (Feb 22 to March 22), Lockdown (March 23 to May 10) and Stay Alert (May11 to onwards).

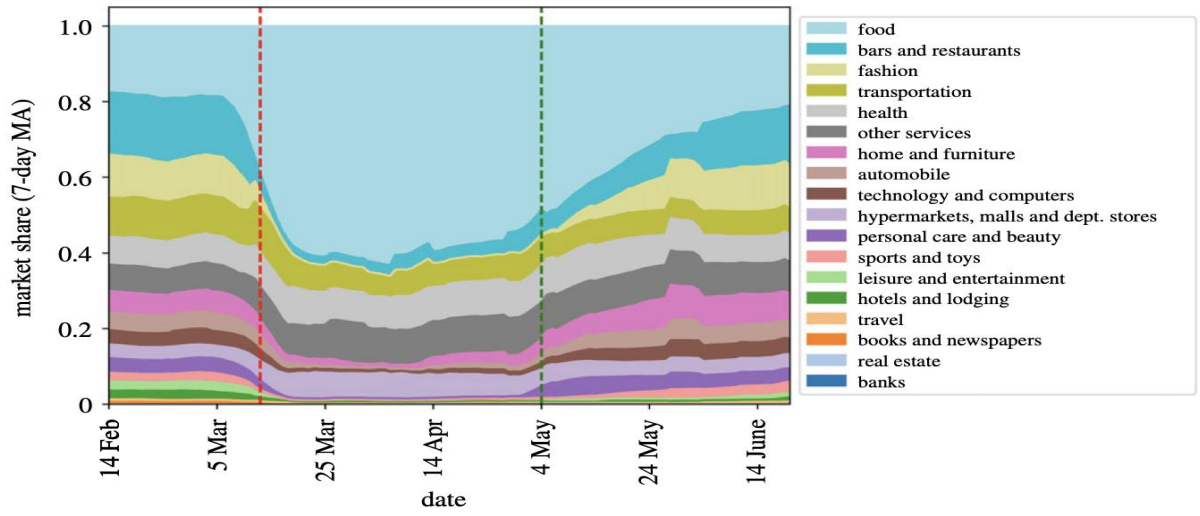
Moreover, Barclays (2020) identified that the non-essential spending in the UK has declined significantly after the government announcement of initial lockdown on 23rd March 2020.[11] The study also identified an initial rise of spending in essential items after the WHO announcement of Covid-19 as global pandemic. In overall, the consumer spending has declined significantly after the announcement of lockdown. However, the spending growth is showing signs of recovery since relaxation of government lockdown policy, which is basically led by the online retail and home deliveries. The study also found a dramatic change in online shopping in UK after the spread of virus. The online spending has grown by around 10.6%, whereas a decline in in-store spending by around 6.7%.

Carvalho et al. (2021) has studied the evolution of aggregate expenditure across the provinces in Spain and the postal codes within Madrid during the Covid-19 crisis using the high frequency transaction data as a proxy to traditional data collected by the national statistical office.[12] The expenditure has declined dramatically in Spain after the implementation of strong lockdown and social distancing policy and afterwards the expenditure seems fast recovery (more V than L-like) due to the relaxation of public health measures. The expenditure share in Spain has experienced a clear re-allocation due to the national lockdown. The spending on food (small stores), tobacco stores, mobile phone credit, supermarket, hypermarkets (large surface supermarket), pharmacy and para pharmacy has grown significantly. On the contrary, the spending on fashion, pubs and disco clubs, furniture, restaurant, leather shops, shoe shops, toys, massage, and personal care has collapsed dramatically. In fact, the expenditure categories that suffered most mainly come from the lockdown / the state of alert.

Figure 5: COVID-19 and evolution of market share in Spain

[11] The study is based on the Barclays debit card and Barclays credit card transitions in the UK

[12] Credit and debit card transaction data collected from Banco Bilbao Vizcaya Argentina, S.A. (BBVA), the second-largest bank in Spain. The dataset contains 6 billion transactions collected from BBVA cardholders and the study used 2.1 billion card transactions. The timeline of data collection is 1st January 2019 to 29th June 2020.



Source: Carvalho et al. (2021)

Similar outcome has also observed in the Danish economy in a study by Andersen et al. (2020). The study was based on the transaction data of about 760,000 individuals at Danske Bank, the largest retail bank in Denmark with a customer base which is a good approximation of the Danish economy. The study addressed the strong cyclicality of spending over the week, the month, and the year by comparing consumer spending on each day in 2020 to consumer spending on a reference day 364 days earlier. The study first aimed to calculate the excess spending[13], then compute the crisis-induced change in spending as the difference between excess spending in the post-lockdown period (March 11 to May 3) and excess spending in the pre-lockdown period (January 2 to February 15). The study has come up with two findings. First, aggregate spending has dropped by 27% relative to the counterfactual trajectory. This reveals that excess spending was slightly positive in the pre-lockdown period and strongly negative in the post-lockdown period. Second, the changes in consumer expenditure across categories have been strongly correlated with the extent of supply restrictions. In overall, the spending increased by more than 10% in the open sector (around half of the economy) and dropped by almost 70% in the constrained sector (around one quarter of the economy).

[13] Excess spending is the difference between spending on a given day in 2020 and spending on the reference day in 2019.

In USA, government statistics reveal that the Covid-19 pandemic led to a sharp reduction in GDP and an extraordinary surge in unemployment. However, the national accounts data published that most of the reduction in GDP came from a reduction in consumer spending rather than business investment, government purchases, or exports. Chetty et al. (2020) has studied the nature consumer spending during pandemic using the credit and debit card spending of consumer.[14] The study found that the major reduction in consumer spending in the U.S. has come from the reduces spending by the high-income households. Moreover, most of the reduction in consumer spending has been accounted for by reduced spending on goods and services that requires in-person physical interaction, such as hotels, transportations, and food services, which is completely consistent with the findings of other studies. The consumption pattern has noticeably difference from the previous financial crisis. In the current pandemic, a large reduction in services sector has been more apparent, whereas spending in service sector has remain unchanged and spending in durable goods has fall sharply during previous financial crisis. The study further identified that spending on luxury goods (that do not require physical contact, such as landscaping services or home swimming pools) did not fall, while spending at salons and restaurant plunged. Moreover, Financial, and professional services firms (that offer fewer in person services) has faced less losses compare to other businesses. The income of the rich has fallen less compared to the poor as the high-income individual can self-isolated more easily (i.e., work from home).

In line with the other literature, Baker et al. (2020) has also identified the sharp increase in the retail, credit card spending and food items in the early stage of the pandemic, later it has followed by a dramatic decline in overall spending as the lockdown has stringent in the U.S. The study further explored the heterogeneity among partisan affiliations and demographics, which are closely related to stated beliefs about the influence of the Covid-19 pandemic. The study found that Republican were less concerned about the new virus. An Axios Poll between March 5 and 9 found that 62% of Republican were less concern (thought that the virus was largely exaggerated), while 31% of Democrats and 35% of Independents thought the same. Moreover, a Quinnnipac

[14] Consumer spending data were collected from Affinity Solutions Inc., a company that aggregates consumer credit and debit card spending information. The raw data were collected at the country-by-ZIP code income quartile-by-industry-by-day level starting from January 1, 2019. Small business transactions and revenues were collected from Womply, a company that aggregates data from several credit card processors to provide insights to small business and other clients. Employment and earning data for low-income workers were collected from Earnin and Homebase.

Poll between March 5 and 8 also found that 68% of Democrats were concerned, while only 35% of Republican were concerned. Despite lower concern about the new virus, Republican spent more than Democrats in the early days of the pandemic. Additionally, the more spending by Republicans at the restaurant and in retail shops also reveals the lower concern about the infection of the virus.

The measurement issues of the inflation rate during COVID-19 Pandemic

The COVID-19 pandemic has forced almost all the nations across the world to implement lockdowns, which brought a worldwide economic downturn. To formulate a national policy to confront the economic crisis, it is essential to measure the changes in the price level accurately during the crisis period. However, the nationwide lockdown has produced significant challenges to the inflation measurement by the national statistical offices (NSOs) as there were large and sudden changes in the consumers' expenditure patterns. The standard method of inflation measure has not considered the sudden changes in the expenditure patterns because most NSOs update the expenditure weights used in the official CPI annually, usually with lagged expenditure data Jaravel and O'Connell (2020b). Therefore, changes in the expenditure share across different sectors, products and outlets may all create biases in calculating the headline inflation rate.

Most of the NSOs use the "Lowe" price index which is a Laspeyres-type or fixed based weight index to calculate official CPI. Diewert and Fox (2020) states that fixed basket indexes, such as Lowe Index to construct the CPI, are inadequate when there are dramatic changes in consumer expenditure. Moreover, they also stated that the advice from the international agencies to calculate the price index during lockdown leads to a Downward Bias in estimating changes in the cost of living and an Upward Bias in estimating changes in real consumption. However, the study suggests using the Fisher index when the consumption pattern has changed a lot during the lockdown, as the amount of substitution bias in a Laspeyres (too high) or Paasche (too low) or fixed basket index (too high) will be very large.

Dixon (2020a) has proposed guesstimate, a trial calculation of inflation during lockdown using new (lockdown) expenditure weight and identified that CPIH would trend to overstate the fall in inflation because it gives excessive weight to items in the basket which may have falling prices

(petrol, clothing, and footwear) and very little demand in lockdown. For example, during lockdown the prices of clothing and footwear were falling as well as the consumption of those items. But the official CPIH has applied 2019 expenditure weights to calculate the inflation figure and hence understates the inflation. Similar result also obtained by the Jaravel and O'Connell (2020b) using UK scanner monthly data of 30,000 household (purchase record)[15]. They measured that the month-on-month (MoM) inflation rate was 2.4% in the first month of lockdown. The study identified that the distribution of inflation rates across product categories has shifted rightwards compared with previous year. In overall, they have identified that the lockdown coincides with unusually high inflation, which was experienced by almost all households and in almost all product categories.

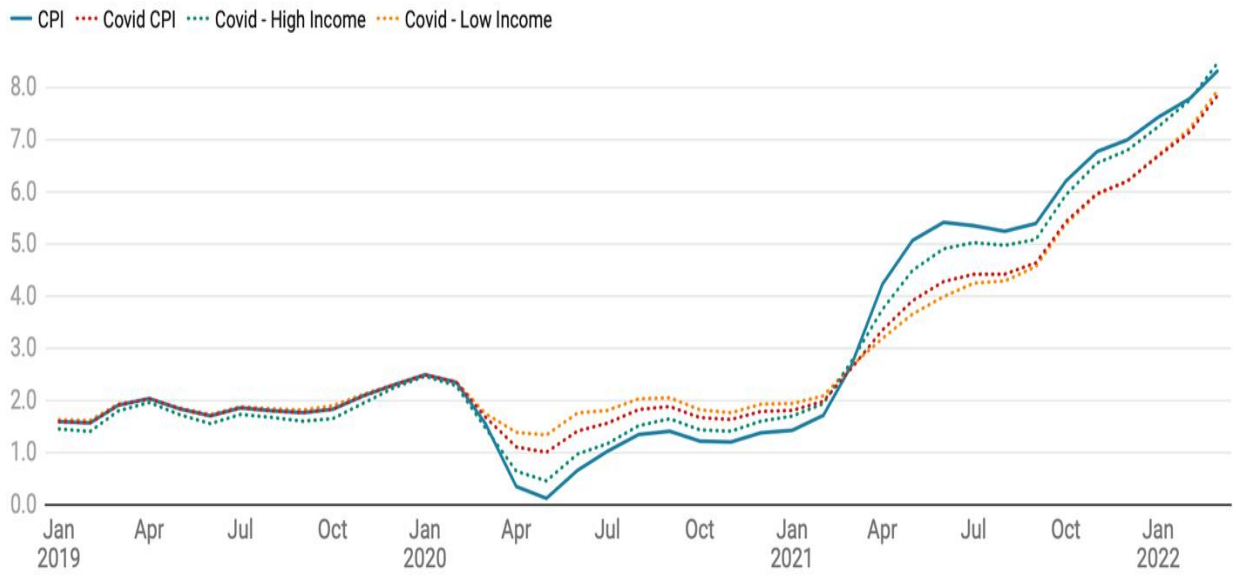
Similar evidence has been found in Switzerland by Seiler (2020). Using public data from debit card transaction, the study constructs an alternative price index to measure the effect of the Covid-induced weighting bias on the Swiss consumer price index. Therefore, the study found that inflation was higher during the lockdown than the official CPI inflation. Basically, this is a consequence of the relative increase in consumption of "Food & Alcoholic Beverage", which are more inflationary than other spending categories. The annual inflation rate of the Covid price index was -0.4% by April 2020 compared to -1.1%of the equivalent CPI. However, the monthly inflation rate has been recovered by the end of April due to the government policy changes.[16] In addition, the study also identified a persistent change in consumer behavior which is mainly driven by "Low Touch" considerations due to new working habits, prolong uncertainty and the lifestyle adopted during the lockdown period. The study predicts that this low touch consideration keeps underestimating short to medium-term inflation through-out the year by more than a quarter of a percentage point.

In absence of the national account information, most of the studies in measuring inflation bias use card-based expenditure data. One of the pioneer study in this area was conducted by Cavallo (2020) based on the card-based U.S. expenditure data[17]. The study was conducted on the impact

[15] The data has been collected by the market research firm Kantar FMCG Purchase Panel. The periods start from December 30, through to May 17.
[16] In Switzerland, the initial Lockdown measure has been started on 16th March 2020. The first relaxation of lockdown happened on 27th April 2020 and further relaxation took place on 11th May 2020.
[17] Data are publicly available as part of the Opportunity Insights Economic Tracker at Harvard and Brown University.

of changes in expenditure patterns on the measurement of CPI inflation in 17 countries. The study found that out of 17 countries 10 countries have higher inflation than that of the official CPI. In case of US, Covid-CPI is greater than official CPI in both monthly and annual inflation rate. In April, the annual inflation rate in US is 1.06% for Covid-CPI and 0.35% for official CPI. The study also mentioned that Covid basket bias presents in the core index that excludes food and energy. The Covid core deflation in April was only half of the core CPI, while the annual inflation rate is at 1.73% compared to the 1.43% in the official core index.

Figure 6: US Covid Inflation (All-items, 12-month changes)



Source: Cavallo (2020)

Diewert and Fox (2020) has mentioned that the out-of-stock products are likely to have higher market clearing prices than those of continuing goods, which potentially introduces an additional downward bias in the CPI measurement. Moreover, Cavallo (2020) has also identified that some retailer's online delivery has soared during pandemic in US, where most of the retailer in this platform tend to have higher prices than in their physical stores. Therefore, if this is not accounted for in the collection methodology used by the national statistical office, the change in spending outlets could cause another downward bias in the official CPI. The study found greater

Covid-CPI than Official CPI annual inflation in the following countries: Argentina, Brazil, Canada, Chili, France, Japan, Korea, Spain, Turkey, Uruguay, and US. whereas annual inflation by Covid-CPI is smaller than official CPI for: Germany, Greece, Ireland, Italy, Netherlands, and UK. The study identified that most of the countries experienced higher Covid inflation rate is driven by an increase in spending in "Food and Beverages" and a decrease in the weight of "Transportations". In contrast, closures of firms due to lockdown policy of government has induced deflationary pressure rather than inflation Balleer et al. (2020).[18]

Reinsdorf (2020) has done a similar exercise based in 83 countries in 09 different regions. The study proxied the card-based expenditure data on US and Canada as expenditure weights for the rest of the countries. The study found that out of 83 economies where official CPI is underestimated in 65 countries during Feb-May 2020. Similarly, Kantur et al. (2021) conducted a study in Turkey using the credit and debit card total expenditure data from January 2020 to February 2021. They found that pandemic inflation is higher than the official inflation rate during the first lockdown, suggesting a behavioral change in consumption.[19] In contrast to the above-mentioned studies, Benchimol et al. (2021) following Cavallo (2020) methodology and using credit card spending data found that the bias in the overall inflation rate is relatively marginal in Israel.

In terms of methodology, almost all the studies emphasized the importance of using superlative indexes in the time of dramatic changes in the spending behaviour of the consumer. However, it is a matter of debate whether to use a superlative index or a simple Laspeyres type price index as the availability of current expenditure data timely is quite challenging. Therefore, the core motivation of this study is to identify whether card-based/home scanner/online data can be used as a substitution for the actual household expenditure data from national accounts.

[18] The reason behind deflationary pressure is that the strongly negatively affected firms in manufacturing that experience closures are 11% more likely to decrease prices than comparable firms that do not experience closure. However, similar, and significant effects are exhibited for very strongly negatively affected firms in wholesale/retail. Positively exposed firms that experience closures in service are less likely to increase prices.

[19] Pandemic inflation as a geometric average of these two inflation figures Chained and Paasche.