Covid-19 and price indexes: Effect of expenditure shifts on CPI and ICP

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Background

- COVID-19 pandemic has been having a profound effect on the world economy; various restrictions and disruptions of supply chains affect every sector;
- COVID-19 pandemic also affects NSOs and international statistical programs, including ICP; it affects their schedules and operations;
- As a result, even price statistics, such as ICP and CPI, are affected; both price and expenditure sides are affected, which, in turn, has an effect on computed indexes;
- This paper concerns the expenditure side of the problem and its effect on the price indexes; the analysis is limited to OECD countries; the scope is Personal Consumption;

Description of data and methods

- COICOP 12 price and expenditure data for individual countries from OECD Statistics website (https://stats.oecd.org/Index.aspx?QueryId=82186);
- US detailed data from US BEA website (https://apps.bea.gov/iTable/index_nipa.cfm);
- ICP 2017 PPP and expenditure data from World Bank ICP database (https://databank.worldbank.org/source/icp-2017), and author's calculations;
- The paper studies effects of using 2020 weights vs. pre-COVID 2019 weights both in spatial and temporal indexes (i.e., the Gerschenkron effect or the Paasche-Laspeyres spread (PLS) for binary indexes).

The Paasche-Laspeyres spread (*von Bortkiewicz formula*)

Let us define $Q_L = Q_1^2$ (Laspeyres), $Q_P = Q_1^2$ (Paasche) for quantity indexes, and, correspondingly, $P_L = P_1^2$ (Laspeyres), $P_P = P_1^2$ (Paasche) for price indexes. Then we obtain:

$$P_L = \sum \frac{p_1}{p_0}\omega_0 \,, Q_L = \sum \frac{q_1}{q_0}\omega_0$$

$$\sigma_p^2 = \sum (\frac{p_1}{p_0} - P_L)^2 \omega_0 \,, \sigma_q^2 = \sum (\frac{q_1}{q_0} - Q_L)^2 \omega_0$$

hence,

$$r_{p,q} = \frac{\sum (\frac{p_1}{p_0} - P_L)(\frac{q_1}{q_0} - Q_L)\omega_0}{\sigma_p \sigma_q} = \frac{\sum (\frac{p_1 q_1}{p_0 q_0} - P_L Q_L)\omega_0}{\sigma_p \sigma_q} =$$

$$= \frac{P_P Q_L - P_L Q_L}{\sigma_p \sigma_q}$$

thus,

$$\frac{P_P}{P_L} = \frac{Q_P}{Q_L} = 1 + r_{p,q}\frac{\sigma_p}{P_L}\frac{\sigma_q}{Q_L} \textit{ (von Bortkiewicz formula)}$$

where $r_{p,q}$ -- weighted coefficient of correlation between price and quantity relatives.

σ_p , σ_q -- weighted variances in prices and quantities.

weights ω_0 are base-country weights.

The Paasche-Laspeyres spread *(von Bortkiewicz formula)*

We can rewrite the formula as:

$$PLS = \frac{Q_P}{Q_L} = 1 + r_{p,q}\,\sigma_{\frac{p}{P_L}}\,\sigma_{\frac{q}{Q_L}}$$

where $\sigma_{p/P}$, $\sigma_{q/Q}$ -- weighted variances in relative prices and quantities.

The above expression simply states that the Laspeyres index exceeds the Paasche index if correlation between relative price and quantity changes is negative, i.e., the direction of movements in price ratios en masse is opposite to those in quantity ratios [or most of the product mix are normal goods]. So, if technical change (or something else) makes products cheaper, then their consumption increases; or, when some goods experience a price shock, their consumption decreases.

Now, let’s see what is happening with the PLS during COVID times.

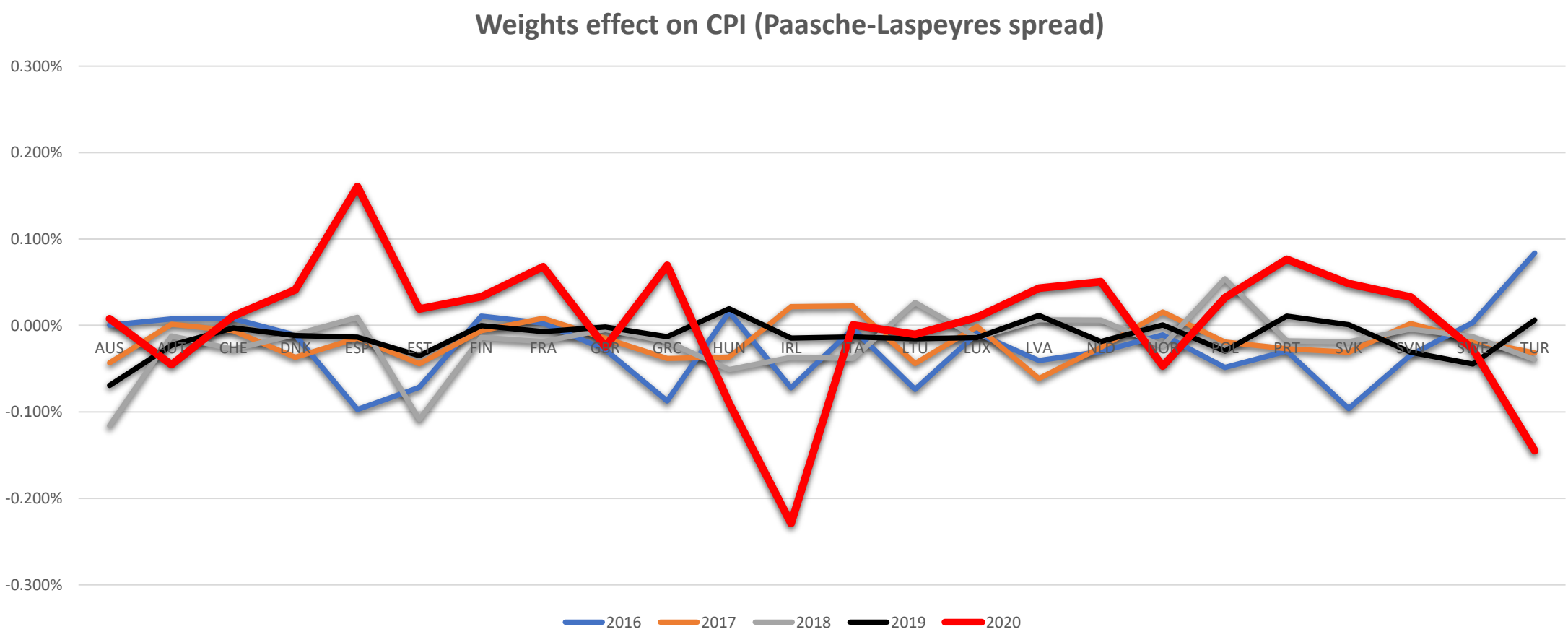
PLS as a test for updates of expenditure weights

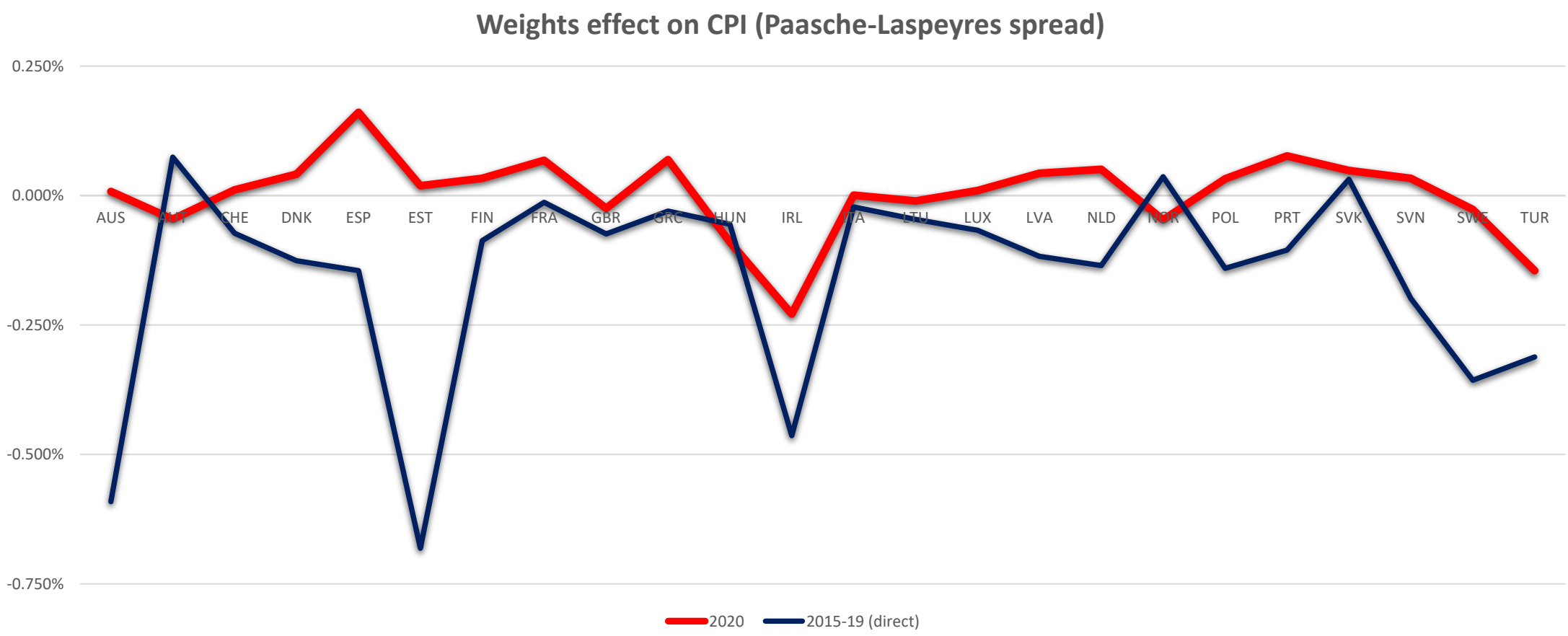
- OECD database: out of 36 countries with weights and price indexes, 26 had information on weights for 2019 and 2020, i.e., pre-COVID and COVID periods (i.e., weights for 2019 and 2020 were different, and not transferred from a previous year). However, US and Belgium had to be excluded from most of the analysis as US had their 2019 weights "price-updated" (i.e., they were really 2018 weights), and Belgium's 2020 weights were "price-updated" as well (but from 2019).
- Quite a few countries (out of the remaining 24) exhibited near-zero year-on-year PLS in one or more years: e.g., Austria, Finland, UK, Italy, but their weights don't seem to be "price-updated" (i.e., the weights cannot be arrived at by applying price index to a previous year's weights).
- As a side note, for quite a few countries, the substitution effect (PLS) over the whole 2015-2019 period was surprisingly small (less than 0.05%): e.g., for France, Greece, Italy, Lithuania, Norway, Slovakia. In fact, only a few country exhibited a significant ***measured*** substitution effect during that period (more than 0.3%): namely, Australia, Estonia, Ireland, Sweden, Turkey.
- The reasons for this phenomenon include: frequency of expenditure weights updates, incorporation of quality adjustments in technology items, various methodological differences.

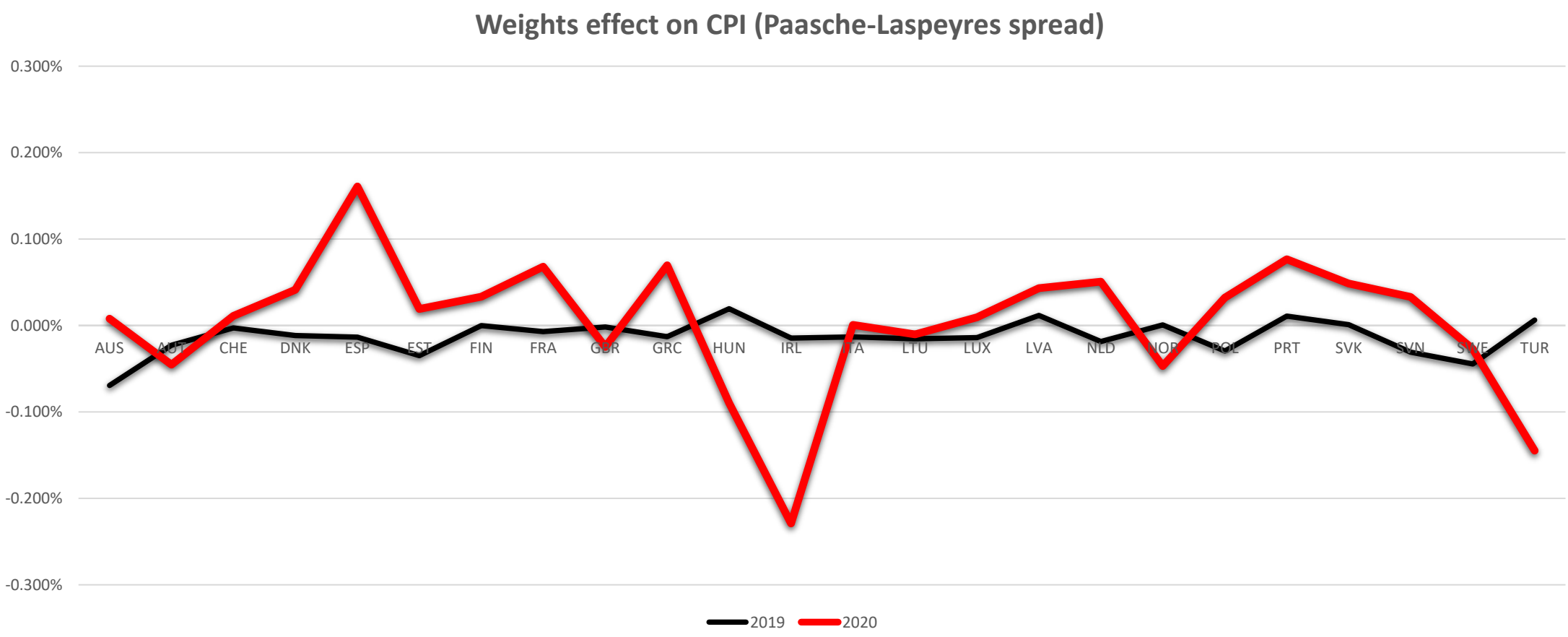
Paasche-Laspeyres Spread in CPI, OECD countries (Year-on-Year)

estimated from OECD database

PLS	2016	2017	2018	2019	2020	2015-19 (cum)
AUS	0.000%	-0.043%	-0.116%	-0.069%	0.008%	-0.591%
AUT	0.008%	0.001%	-0.012%	-0.023%	-0.045%	0.074%
BEL	-0.030%	0.015%	0.000%	0.000%	0.000%	-0.060%
CHE	0.008%	-0.006%	-0.027%	-0.003%	0.011%	-0.073%
DNK	-0.011%	-0.037%	-0.010%	-0.012%	0.041%	-0.126%
ESP	-0.097%	-0.015%	0.010%	-0.014%	0.161%	-0.145%
EST	-0.072%	-0.044%	-0.109%	-0.035%	0.019%	-0.681%
FIN	0.011%	-0.006%	-0.014%	0.000%	0.033%	-0.087%
FRA	0.003%	0.008%	-0.018%	-0.007%	0.068%	-0.013%
GBR	-0.028%	-0.015%	-0.005%	-0.002%	-0.025%	-0.074%
GRC	-0.087%	-0.038%	-0.018%	-0.013%	0.070%	-0.030%
HUN	0.016%	-0.036%	-0.051%	0.019%	-0.090%	-0.055%
IRL	-0.072%	0.022%	-0.037%	-0.015%	-0.229%	-0.464%
ITA	-0.004%	0.023%	-0.038%	-0.013%	0.001%	-0.022%
LTU	-0.074%	-0.044%	0.027%	-0.015%	-0.010%	-0.046%
LUX	-0.009%	-0.001%	-0.014%	-0.014%	0.009%	-0.067%
LVA	-0.041%	-0.061%	0.007%	0.012%	0.043%	-0.117%
NLD	-0.030%	-0.025%	0.006%	-0.018%	0.051%	-0.135%
NOR	-0.011%	0.016%	-0.024%	0.001%	-0.047%	0.036%
POL	-0.048%	-0.019%	0.054%	-0.030%	0.032%	-0.141%
PRT	-0.029%	-0.027%	-0.018%	0.011%	0.077%	-0.106%
SVK	-0.096%	-0.031%	-0.019%	0.001%	0.048%	0.032%
SVN	-0.034%	0.002%	-0.004%	-0.031%	0.033%	-0.198%
SWE	0.003%	-0.017%	-0.013%	-0.044%	-0.027%	-0.357%
TUR	0.084%	-0.032%	-0.039%	0.006%	-0.145%	-0.312%
USA	-0.046%	0.000%	-0.006%	0.000%	-0.001%	-0.272%


Weights effect on CPI (Paasche-Laspeyres spread)
0.300%
0.200%
0.100%
0.000%
-0.100%
-0.200%
-0.300%
AUS
AUT
CHE
DNK
ESP
EST
FIN
FRA
GBR
GRC
HUN
IRL
ITA
LTU
LUX
LVA
NLD
NOR
POL
PRT
SVK
SVN
SWE
TUR
2016
2017
2018
2019
2020


Weights effect on CPI (Paasche-Laspeyres spread)
0.250%
0.000%
-0.250%
-0.500%
-0.750%
AUS
AUT
CHE
DNK
ESP
EST
FIN
FRA
GBR
GRC
HUN
IRL
ITA
LTU
LUX
LVA
NLD
NOR
POL
PRT
SVK
SVN
SWE
TUR
2020
2015-19 (direct)


Weights effect on CPI (Paasche-Laspeyres spread)
0.300%
0.200%
0.100%
0.000%
-0.100%
-0.200%
-0.300%
AUS
AUT
CHE
DNK
ESP
EST
FIN
FRA
GBR
GRC
HUN
IRL
ITA
LTU
LUX
LVA
NLD
NOR
POL
PRT
SVK
SVN
SWE
TUR
2019
2020

Effect of COVID-related expenditure shifts in ICP context

- The OECD expenditure data were combined with ICP 2017 PPPs, extrapolated to 2020 with official CPIs for COICOP 12 categories, to simulate a 2020 ICP comparison;
- Two scenarios were estimated – one with 2019 weights and another with 2020 weights;
- Two indexes were used – EKS (Fisher) and EKS (Törnqvist);
- The effect of COVID-related expenditure shifts was found to be moderate; the results were within [-1%,1%] interval, with *s.d.* of 0.46% (0.49% for Törnqvist index), i.e., well below measurement errors in ICP; in general, as expected, EKS (Fisher) and EKS (Törnqvist) produced very similar results;
- Note that US expenditure shift was actually for two years (due to “price-updating”), and Belgium’s weights were the same in both years (again, due to “price-updating”).
- Even with these 2020 weights (from OECD database), the results still reflect a mixture of expenditure weights updated to 2020 to various degrees; however, this picture is probably not too far off from what we can expect in real life in the ICP comparison.

CPI and ICP: effect of substituting 2019 weights for 2020 weights

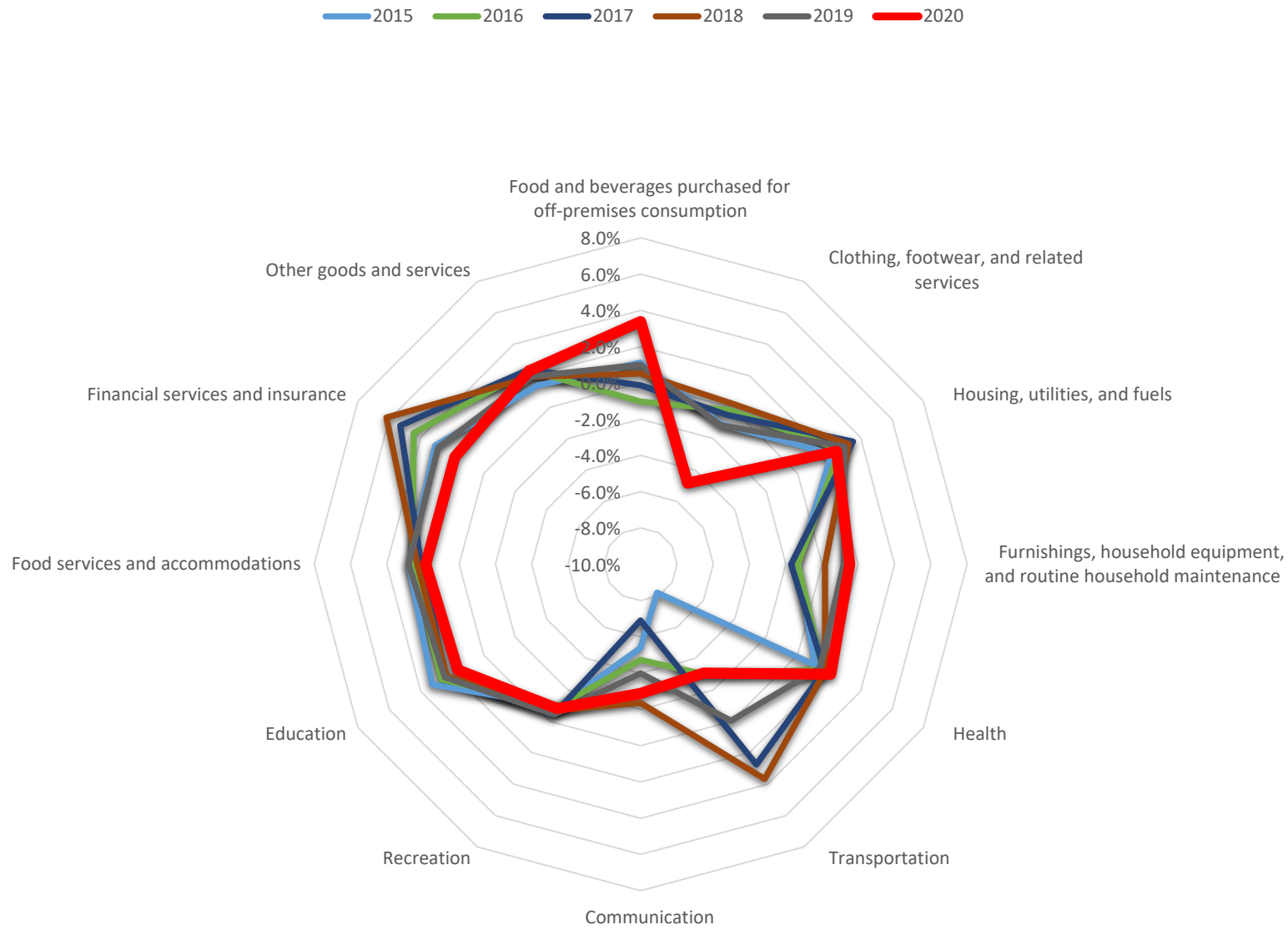
A more detailed investigation of expenditure pattern shifts in one country: *The U.S. PCE Price Index*

The following investigation is based on the U.S. BEA detailed data. Price indexes are reconstructed from 12, 89 and 214 categories. The indexes exclude Net purchases abroad and NPISH to be comparable to the ones reconstructed from the OECD database.

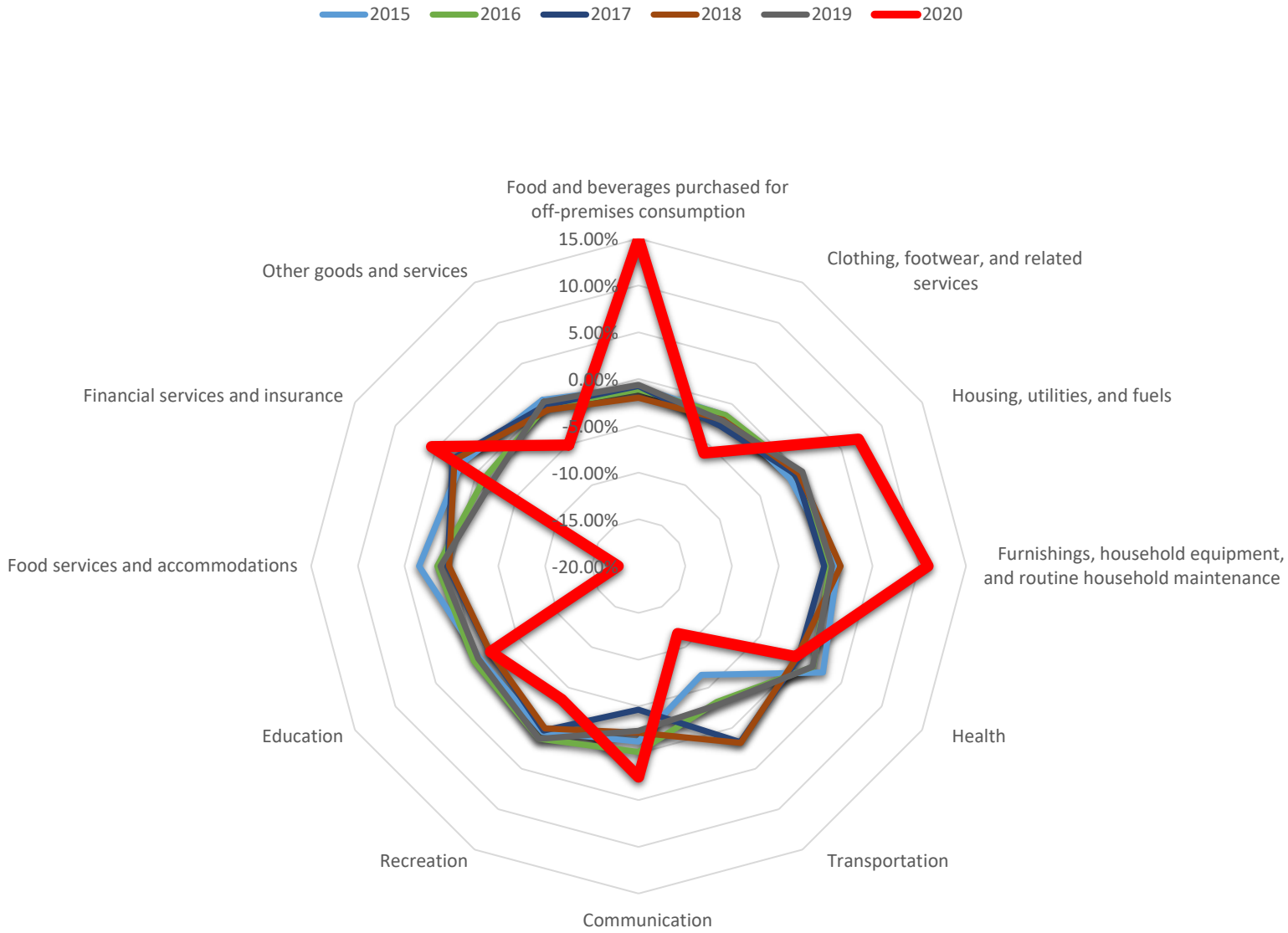
As a check, a full recomputation using all details (i.e., including Net purchases abroad and NPISH) was carried out, and the results matched the official computations.

- The tables and graphs that follow will show price and expenditure evolution of 12 COICOP categories during 2015-2020.

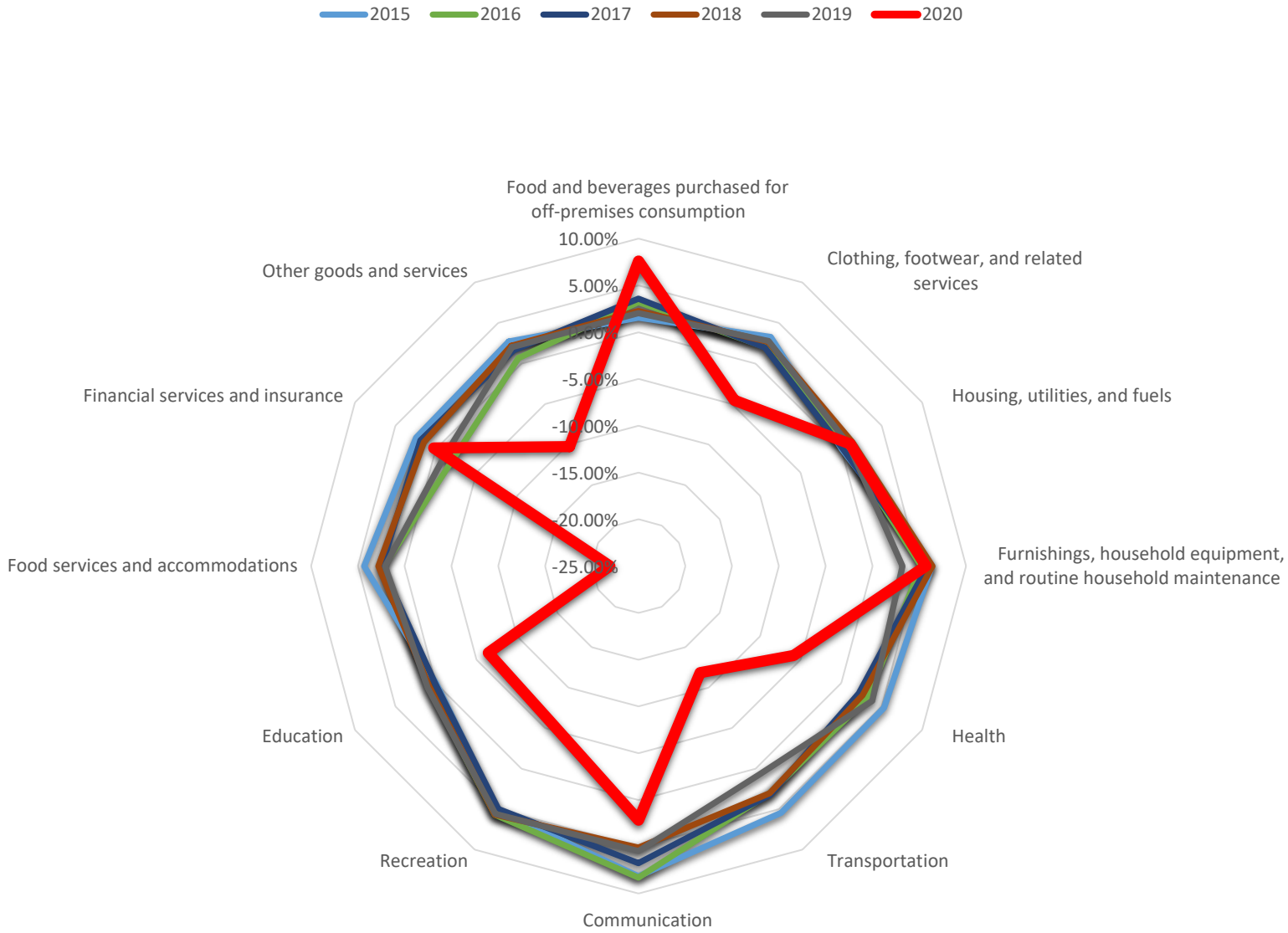
U.S. PCE: Price change by category, Year-on-Year, %



U.S. PCE: Weight change by category, Year-on-Year, %

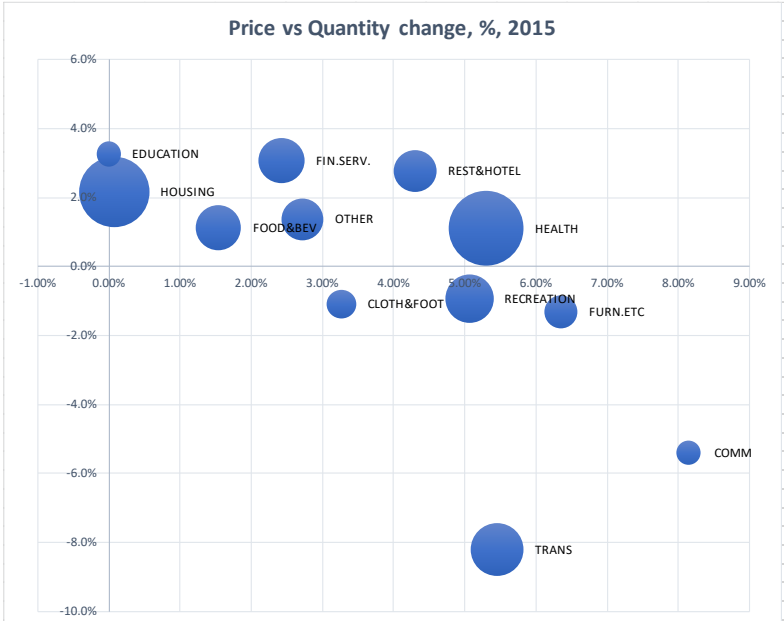


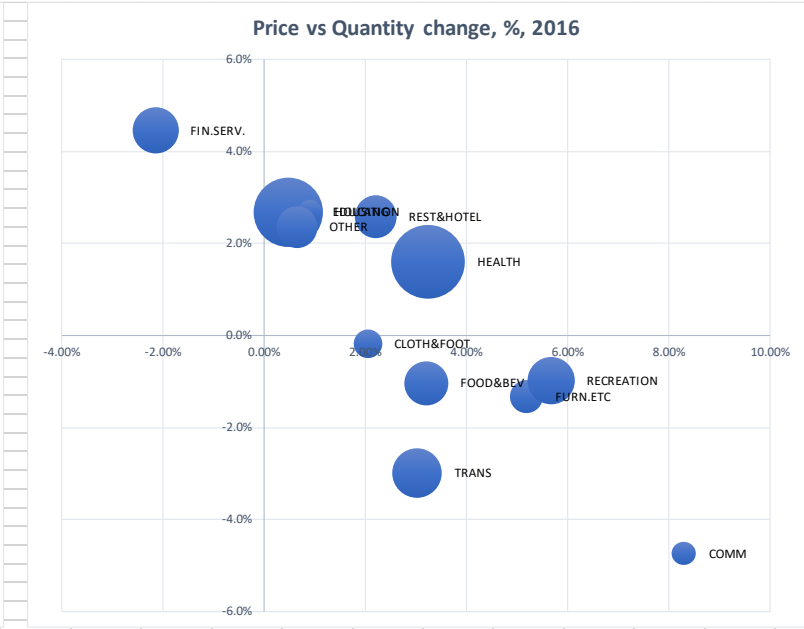
U.S. PCE: Quantity change by category, Year-on-Year, %

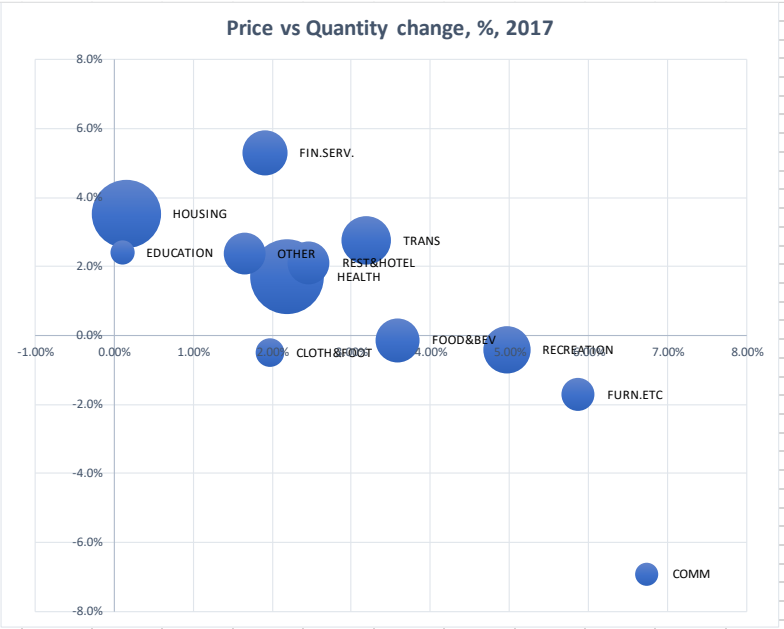


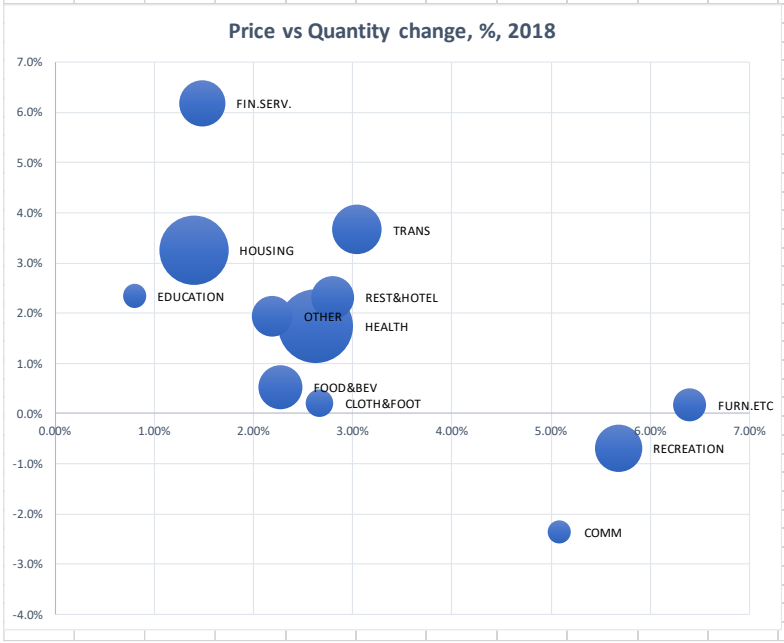
U.S. PCE: Price changes vs. Quantity changes, Year-on-Year, 2015-2020

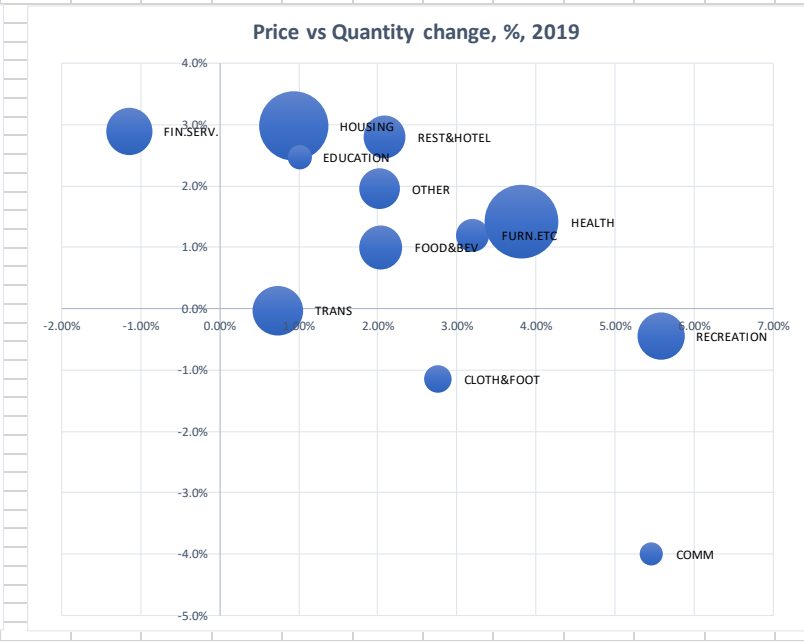
- Contrasting price and quantity changes helps see correlation between the two. This is shown in next two slides and is essentially a visualization of *von Bortkiewicz* formula;
- Slope of the regression line would be proportional to 1-PLS.


Price vs Quantity change, %, 2015
EDUCATION
FIN.SERV.
REST&HOTEL
HOUSING
FOOD&BEV
OTHER
HEALTH
CLOTH&FOOT
RECREATION
FURN.ETC
COMM
TRANS


Price vs Quantity change, %, 2016
FIN.SERV.
REST&HOTEL
HEALTH
CLOTH&FOOT
FOOD&BEV
RECREATION
FURN.ETC
TRANS
COMM

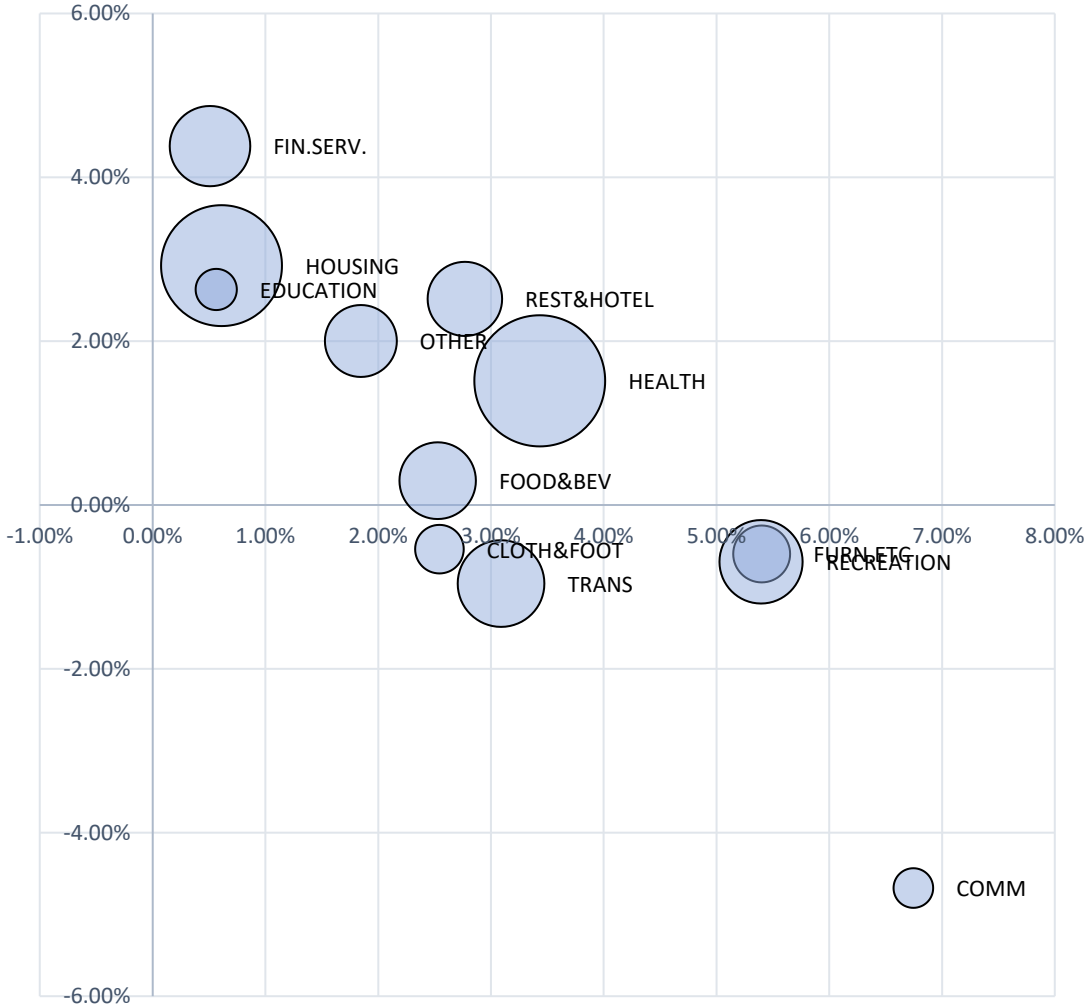

Price vs Quantity change, %, 2017
FIN.SERV.
HOUSING
EDUCATION
TRANS
OTHER
REST&HOTEL
HEALTH
FOOD&BEV
RECREATION
FURN.ETC
COMM


Price vs Quantity change, %, 2018
FIN.SERV.
TRANS
HOUSING
EDUCATION
REST&HOTEL
OTHER
HEALTH
FOOD&BEV
CLOTH&FOOT
FURN.ETC
RECREATION
COMM


Price vs Quantity change, %, 2019
FIN.SERV.
HOUSING
REST&HOTEL
EDUCATION
OTHER
HEALTH
FURN.ETC
FOOD&BEV
TRANS
RECREATION
CLOTH&FOOT
COMM


Price vs Quantity change, %, 2020
FOOD&BEV
HOUSING
OTHER
HEALTH
REST&HOTEL
FIN.SERV.
EDUCATION
FURN.ETC
RECREATION
COMM
TRANS
CLOTH&FOOT

U.S. PCE: Price vs Quantity change, % average 2015-19



U.S. PCE: Price vs Quantity change, % 2020

U.S. PCE: Paasche, Laspeyres and Fisher Price indexes by level of disaggregation

	2014	2015	2016	2017	2018	2019	2020	2014-19 cum
12 categories								
Fisher	101.448	100.163	100.967	101.779	102.127	101.447	101.172	108.189
Paasche	101.428	100.143	100.948	101.765	102.118	101.439	101.198	107.677
Lapeyres	101.468	100.183	100.986	101.793	102.136	101.455	101.147	108.703
PLS	-0.039%	-0.039%	-0.038%	-0.027%	-0.018%	-0.015%	0.050%	-0.944%
89 categories								
Fisher	101.448	100.163	100.967	101.779	102.127	101.447	101.170	108.121
Paasche	101.411	100.136	100.935	101.745	102.095	101.424	101.210	107.201
Lapeyres	101.484	100.190	100.998	101.813	102.159	101.470	101.130	109.050
PLS	-0.071%	-0.054%	-0.062%	-0.066%	-0.063%	-0.045%	0.079%	-1.695%
Difference (89-12)								
Fisher	0.000	0.000	0.000	0.000	0.000	0.000	-0.003	-0.067
Paasche	-0.016	-0.007	-0.012	-0.020	-0.023	-0.015	0.012	-0.475
Lapeyres	0.016	0.007	0.012	0.020	0.023	0.015	-0.017	0.346
PLS	-0.032%	-0.014%	-0.024%	-0.039%	-0.045%	-0.030%	0.029%	-0.750%
214 categories								
Fisher	101.448	100.154	100.969	101.781	102.130	101.444	101.172	108.076
Paasche	101.401	100.114	100.926	101.737	102.092	101.413	101.192	106.956
Lapeyres	101.495	100.194	101.011	101.825	102.168	101.475	101.153	109.209
PLS	-0.092%	-0.080%	-0.084%	-0.086%	-0.074%	-0.061%	0.039%	-2.063%
Difference (214-12)								
Fisher	0.000	-0.009	0.002	0.002	0.004	-0.003	0.000	-0.112
Paasche	-0.027	-0.029	-0.021	-0.028	-0.025	-0.026	-0.005	-0.721
Lapeyres	0.027	0.012	0.025	0.032	0.033	0.020	0.005	0.506
PLS	-0.053%	-0.040%	-0.046%	-0.059%	-0.057%	-0.046%	-0.011%	-1.119%

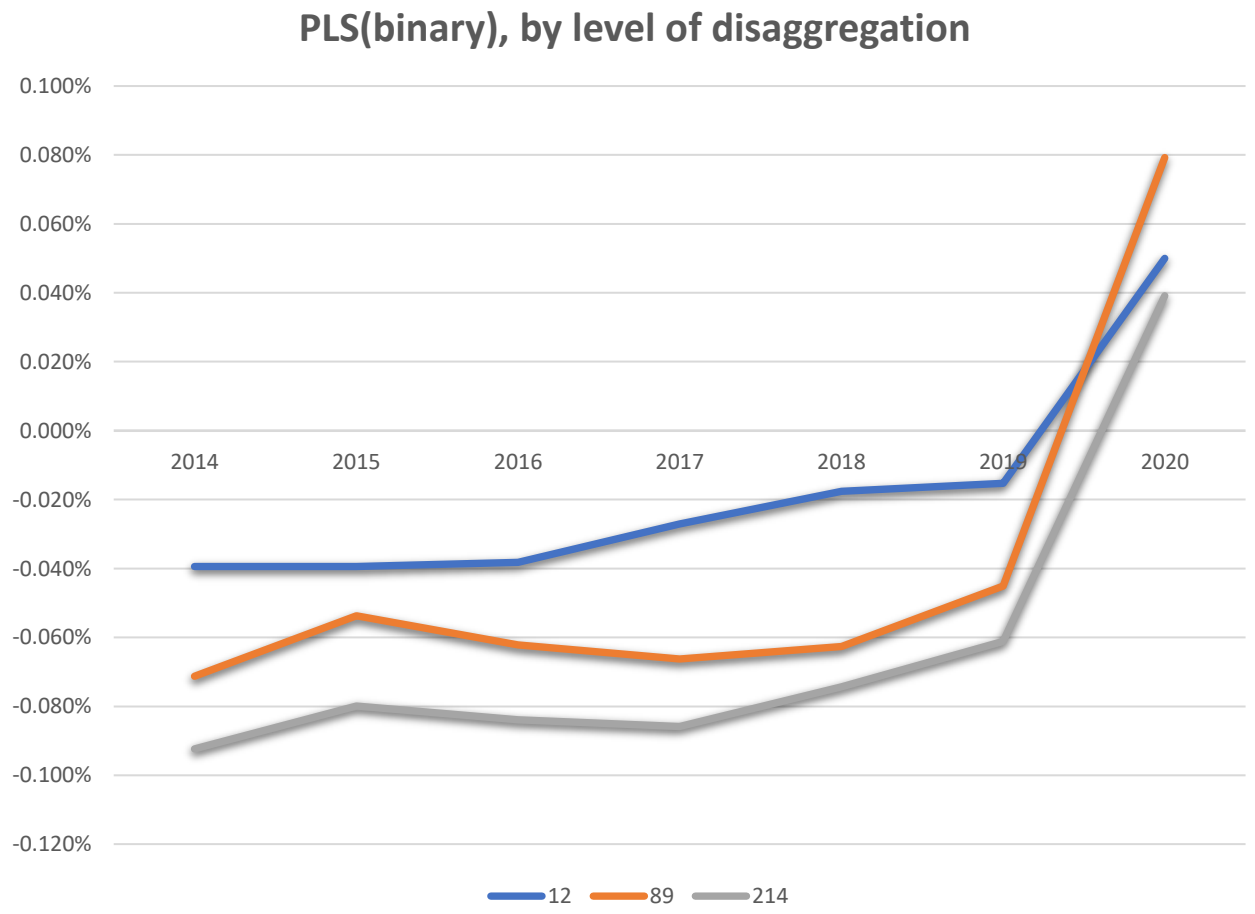
Comparing PLS estimates from different sources (OECD and BEA)

- If we compare our previous results (CPI from OECD database) to BEA PCE results, we can see quite a bit of difference due to the weights in CPI being updated once in two years, and different sources of data:

PLS, Year-on-Year	2016	2017	2018	2019	2020
PCE Price index, 12 cat.	-0.038%	-0.027%	-0.018%	-0.015%	0.050%
CPI (OECD database), 12 cat.	-0.046%	0.000%	-0.006%	0.000%	-0.001%

PLS, by level of disaggregation

#Categories	2014	2015	2016	2017	2018	2019	2020	2013-19 direct
12	-0.039%	-0.039%	-0.038%	-0.027%	-0.018%	-0.015%	0.050%	-0.944%
89	-0.071%	-0.054%	-0.062%	-0.066%	-0.063%	-0.045%	0.079%	-1.695%
214	-0.092%	-0.080%	-0.084%	-0.086%	-0.074%	-0.061%	0.039%	-2.063%



- The 89-category computation reproduces most of the PLS of the full 214-category one. [89-categoty breakdown is not too far off from the ICP's 100+ BHs for Individual Consumption].
- The PLS effect produced by the 89-category computation is in general larger than the one in the 12-category computation. Still, it seems that 12-categories may be adequate for our PPP simulations for actual spatial comparisons as many countries may not be able to properly update all 100+ BHs for ICP 2021 exercise; it's more likely that, due to various COVID related issues, updates will happen at a higher level in those countries, and BHs structures within those higher-level categories will be replicated from some prior period.

Conclusions

Effects due to COVID-19-related expenditure shifts on *measured* CPI are not significant (perhaps, due to incomplete incorporation of the shifts into national CPIs);

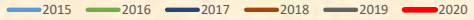
On ICP side, the PPPs will be affected more, but still the effect will be well below ICP measurement errors (within one per cent);

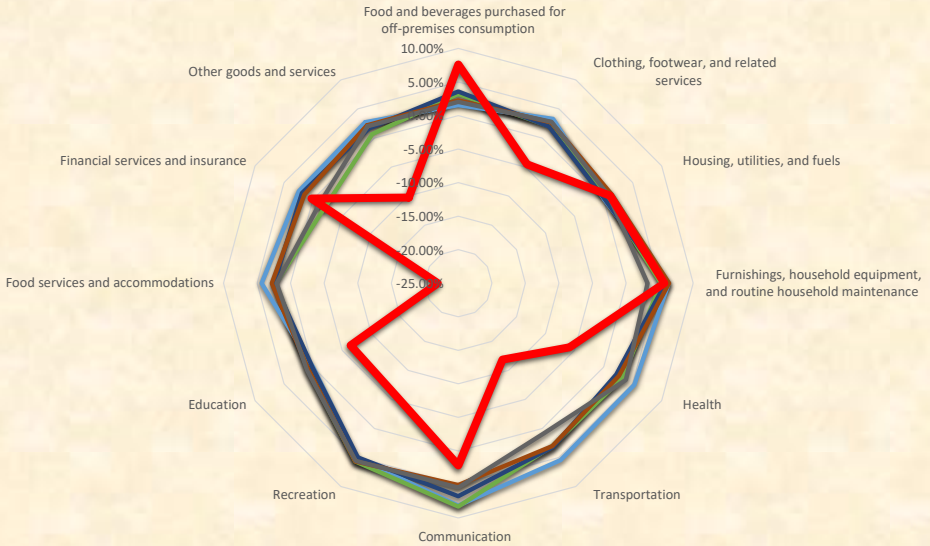
However, the expenditure pattern shifts (or, rather their uneven incorporation into the ICP comparison, such as using 2019 or some other year's weights instead of 2020 ones) will affect real expenditures much more than PPPs;

In addition, the current analysis was carried out on OECD countries. Countries in other regions may be affected differently;

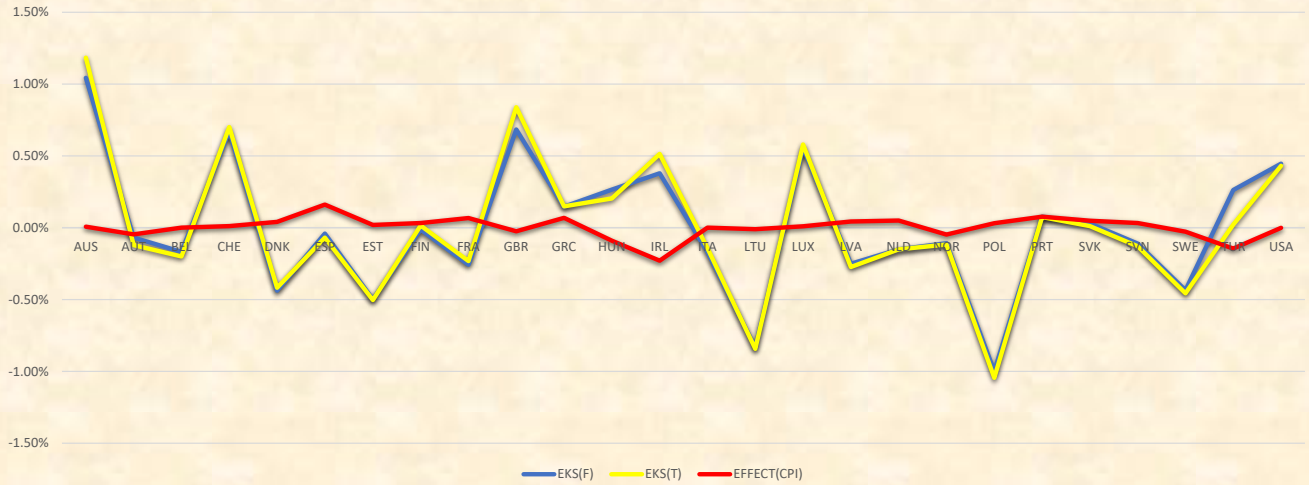
12 COICOP categories is quite enough to simulate national Fisher CPI and direction of the PLS, given updated data.

U.S. PCE: Quantity change by category, Year-on-Year, %

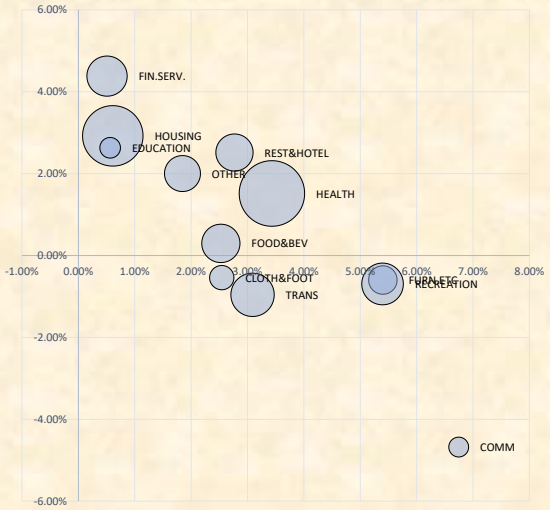




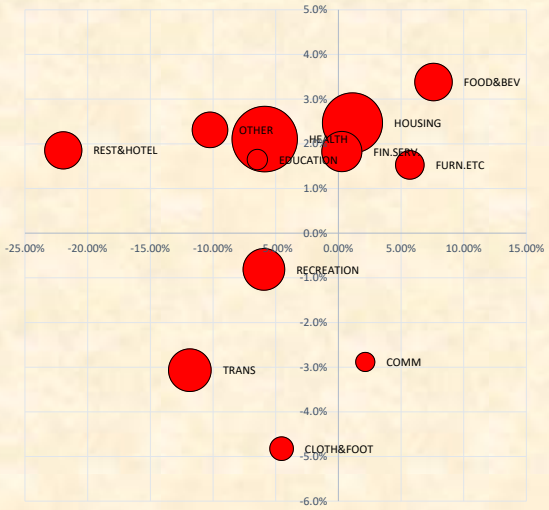
Weights effect



U.S. PCE: Price vs Quantity change, % average 2015-19



U.S. PCE: Price vs Quantity change, % 2020



PLS(binary), by level of disaggregation