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Using Online Prices for Measuring Real Consumption across Countries†

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International income comparisons such as the Penn World Table (PWT) rely on data provided by the International Comparisons Program (ICP) at the World Bank, which collects prices from thousands of comparable goods and services all over the world to calculate purchasing power parities (PPPs). While ICP continually improves its methods, its reliance on traditional data collection through National Statistical Offices (NSOs) causes many problems, including the low frequency of data collection (every six years), long delays in publication (results for the 2011 round were published in 2014), issues affecting the comparability of products and methods across countries and time (see e.g., Deaton and Heston 2010, Inklaar and Rao 2017), as well as the need to rely on the efforts of individual countries that can refuse to participate (e.g., Argentina for ICP 2011) or lack transparency regarding their data and methods (see Feenstra et al. 2013).

The availability of new (big) data sources provides hope for improvements along several of these dimensions. In particular, we show that online prices can be used to construct quarterly PPPs published in real-time, with a closely-matched basket of goods and identical methodologies in a variety of developed and developing economies. At a more fundamental level, the ability to remotely collect online prices provides more control and transparency to the data and methodologies used to compute PPPs across countries.

Our data cover 11 countries in three major consumption categories, food and beverages, fuel, and electronics, from 2011 to 2017. In a validation exercise, we find that PPPs constructed with online prices are close to those reported by ICP in 2011 and the OECD in 2014. Next, we illustrate the potential of the new data to provide quarterly estimates of real consumption across countries for the fourth quarter of 2017.

While promising, we also highlight many potential problems associated with the use of online prices for PPP calculations, including the lack of representativeness and limited coverage of product categories and countries.

I. Data and Methodology

We use micro data available at the Billion Prices Project (BPP) at MIT, including daily web-scraped prices from 2010 to 2017 for all products sold by some of the largest multi-channel retailers in 11 countries: Argentina, Australia, Brazil, China, Canada, the Netherlands, Germany, Japan, South Africa, the United Kingdom, and the United States.[1]

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[1] The data were collected by PriceStats, a private company associated with the BPP, which also matched the products for 9 of the 11 countries in our sample. See Cavallo and Rigobon (2016) for details on the data and

These prices include taxes and exclude shipping costs.[2]

In constructing price comparisons across countries, one is confronted with the challenge of matching products and comparing "like-with-like." Product codes that are attached to the online goods cannot be used because they tend to be retailer or county-specific. Moreover, identical products are seldom available across countries, except for global branded products, which constitute a relatively minor share of expenditures. So to ensure sufficient coverage, local goods have to be grouped before matching is possible.

We therefore mimic the procedures followed by ICP 2011, starting with the creation of our own list of "items" (narrowly-defined product categories) to which individual products will be matched.[3] Our item list consists of 267 narrow definitions that cover all subsectors of the UN's COICOP classification system for food (and beverages), fuel, and electronics.[4] These items were chosen to strike a balance between comparability and representativeness. We have a mix of narrowly-defined global products (e.g., "decaf ground Illy coffee") and broader item definitions for unbranded products or local brands (e.g., "basmati rice" or "decaf ground coffee, all other brands"). Our item definitions tend to be more narrowly defined than those in ICP's 2011 list, particularly in electronics.[5]

The matching of individual products to each item definition is a complex process. The micro data contains detailed descriptions for millions of products. Searching this database, we find those products that best match the item descriptions in each country, and enter their package sizes so that we can calculate unit prices (e.g., price per gram).

A total of 99,028 individual products were matched, with a mean of 30 products per item in each country. Our coverage of expenditure improves considerably after 2012 because we concentrated our matching efforts in recent years, when the micro data becomes more abundant (see online Appendix Figure 1).

Once the individual products are matched, we average all unit-price observations (across products and time) for each item, country, and quarter. This implicitly assigns more weight to those products that are available to consumers for a longer time. Average prices are then aggregated to the level of a "basic heading," such as "Rice" or "Coffee, Tea, and Cocoa." Not all items within each basic heading are priced in every country, so we follow ICP and run a Country Product Dummy (CPD) regression for every quarter and basic heading. We then use the expenditure data from ICP 2011 to obtain country-level PPPs using a multilateral GEKS methodology.[6] More details on these steps are provided in the online Appendix.

Finally, to facilitate the comparison across countries and samples, we compute price level indices (PLIs), dividing the PPPs by the country's nominal exchange rate with the US dollar. PLIs are unit-free and reflect whether prices are higher (> 1) or lower (< 1) relative to the reference country.

II. Comparison to ICP

We now compare our PLIs with those of ICP for 2011, the most recent global price comparison.

In principle, there are many reasons to expect differences. First, our prices are collected online for large branded retailers selling in mostly urban locations, while ICP data is collected in physical stores in many kinds of retailers

methodologies. Alberto Cavallo is a co-founder of both the BPP and PriceStats.

[2] For countries where the sales tax is not included in prices shown to customers online, we add a standard sales or VAR tax to scraped prices as follows: US food 0.952 percent, electronics 5.08 percent; Japan food and electronics 5 percent before 2014:III and 8 percent afterwards; Germany food 7 percent and electronics 19 percent; Canada electronics, chocolates, and sodas 12 percent. The Canadian average is computed from state-level rates weighted by state population.

[3] See World Bank (2014) for a description of ICP methodologies, and World Bank (2013) for an extensive motivation of why these methods are applied.

[4] See https://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=5. Our "food and beverages" sector corresponds to COICOP code 01, the "fuel" sector is COICOP 07.2.2, and "electronics" covers COICOP codes 09.1.1 to 09.1.4.

[5] See Table A2 in the online Appendix for more examples and some item counts by product category.

[6] As Argentina did not participate in ICP 2011, we use the expenditure information from ICP 2005. Expenditure information at this detailed level (for example on "potatoes" or on "beef and veal") is not readily available for all countries in published national accounts, so we assume a constant expenditure composition within our period.

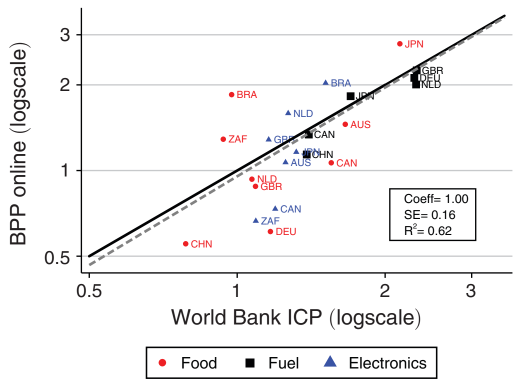

FIGURE 1. BPP VERSUS ICP PRICE LEVEL INDEXES—2011

Notes: Comparison of the ICP 2011 and BPP bilateral Fisher indices at the sector level for each country. Forty-five degree line in black, linear fit line in gray. All axes on log scale.

and geographical locations. Second, online prices are collected every day, while ICP prices are obtained once (or a few times) per year. Temporal aggregation obscures the comparison because PPPs can vary significantly within a year (particularly in high inflation countries). Third, there are methodological details in ICP that we cannot replicate. This includes the use of an "importance" weight for each item in the CPD regression, as quantity weights are only available at the basic heading level.

Despite these differences, Figure 1 shows that PLIs computed with online data align well with those calculated from ICP data (US = 1). These are results for grouped items within food, fuel, and electronics, using basic heading expenditure weights (see online Appendix Figure 1 for comparisons at basic heading level). The PLIs are closest for fuel, where the item definitions are identical across ICP and BPP. In food and electronics there is more dispersion but no evidence of PLIs being consistently higher or lower with online data.

Multilateral PLIs for each country are compared in Table 1. On average, online and ICP PLIs for 2011 differ by 15 percent in absolute value across the 11 countries. In some cases, such as Australia, the results are nearly identical, while in others, such as Japan, the difference is as high as 28 percent.

We repeat the comparison in 2014 for OECD countries, for which PPPs are published every

TABLE 1—MULTILATERAL PRICE LEVEL INDEX (PLI=PPP/E), USA=1

	2011		2014	
	BPP	ICP	BPP	OECD
Argentina	0.79	—	1.05	—
Australia	1.52	1.53	1.24	1.36
Brazil	1.44	1.20	1.17	—
Canada	1.08	1.30	1.15	1.29
China	0.71	0.93	0.97	—
Germany	1.12	1.30	1.20	1.35
Japan	2.57	2.01	1.58	1.42
Netherlands	1.21	1.29	1.22	1.27
South Africa	1.11	0.96	0.91	-
United Kingdom	1.14	1.25	1.26	1.37
United States	1.00	1.00	1.00	1.00
Mean absolute difference				
All countries		15%		
OECD		17%		9%

Notes: Multilateral GEKS PLIs covering all basic headings available in Food, Fuel, and Electronics. BPP numbers are yearly averages from quarterly PLIs excluding those quarters for which there are less than 50 percent of basic headings covered. No ICP data is available for Argentina in 2011 because the country refused to participate.

three years. The average difference is much smaller in this case, likely because our coverage of basic headings with online prices is nearly complete at this time.[7]

Beyond the comparison with ICP, a major advantage of using online data to measure PPPs is that we can provide more frequent and timely estimates of real consumption across countries. For example, the first column in Table 2 shows a cross-country comparison of the real household consumption of food, fuel, and electronics for the last quarter of 2017.

The measurement of PPPs on a quarterly basis can replace current nowcasting procedures that rely on extrapolation of benchmark PPPs with relative CPI movements. These extrapolations are prone to cause biases that distort the PLIs (Deaton and Aten 2017). In fact, online PPPs could help avoid extrapolation "surprises," particularly in countries where CPI data and methods do not match well with the ICP comparisons framework. Comparing column 2 (based on extrapolated 2011 PPPs) with column

[7] See online Appendix Figure A1 for basic heading coverage in every country over time.

Table 2—Real Household Consumption per Capita of Food, Fuel, and Electronics Based on BPP Data for 2017:IV (USA=1)

	Actual	Extrapolated with CPIs
Argentina	0.41	0.70
Australia	0.76	0.74
Brazil	0.20	0.22
Canada	0.61	0.89
China	0.11	0.18
Germany	0.60	0.76
Japan	0.45	0.40
Netherlands	0.57	0.70
South Africa	0.18	0.20
United Kingdom	0.72	0.76
United States	1.00	1.00

Notes: "Extrapolated" figures are based on the 2011 BPP price level index, extrapolated to 2017:IV using the difference in (overall) consumer price inflation from 2011 to 2017:IV between each country and the United States minus the change in the exchange rate. Estimates for Argentina, Brazil, China, and South Africa are for 2017 as a whole, rather than the fourth quarter of 2017. The "Actual" figures are based on the BPP prices for 2017:IV.

Sources: Total household consumption expenditure in local currency units, total population, the consumer price index, and the exchange relative to the US dollar is taken from the OECD *Main Economic Outlook*, no. 102 (November 2017). For China, household consumption expenditure is from the UN National Accounts Official Country Data for 2015, extrapolated to 2017 using the growth of GDP at constant prices and the consumer inflation rate for 2016 and 2017 from the IMF World Economic Outlook of October 2017. The share of food, fuel, and electronics in total household consumption is from ICP 2011.

1 reveals that these surprises can be large and occasionally more than 50 percent (as for China, Argentina, and Canada).

III. Limitations

While helpful, online data have many limitations. First, given that prices are mostly from large retailers with an online presence, the resulting PPPs may not be representative for national averages, especially in countries with a fragmented retail sector or (for food) where the local diet relies heavily on regional products. Furthermore, the prices on retailers' websites can be different from the prices found in their physical stores, where most retail transactions take place (at least for now). Cavallo (2017) shows these differences are small on average, but they could still meaningfully affect price-level comparisons in some countries.[8]

Second, most retailers that sell online tend to have a single price for all locations within a country. This seems at odds with existing ICP data that shows significant regional price dispersion (such as urban areas having higher prices of food, especially in poorer countries).[9] This lack of spatial price differences can be resolved by scraping more localized retailers, whose online presence is improving over time.

Third, online data do not have expenditure weights for individual products, so it is hard to know which products are more important for the comparison. In ICP this is decided upon by the NSO data collectors, who arguably have more information to make the choice. While scanner or other expenditure data sources could potentially be used as a complement in some categories, the question of which matched individual products are more representative of actual consumption remains.

Fourth, online data only cover a limited number of product categories and countries. The three sectors included in this paper represent only between 13 percent and 23 percent of the share of household consumption in these countries. While more categories with online prices can be potentially added, there are hard-to-compare areas of consumption, such as housing, personal services or health services, that will likely remain a challenge until more data are available online. Similarly, online prices are currently available in a small number of countries. We have matched data in 11 countries out of approximately 60 for which the BPP has some price information. While matching can improve, our approach is not yet viable in countries where there is still little price data online.

IV. Conclusions

We have shown that online prices can be used to enhance ICP data, dramatically improving the

[8] To control for persistent online-offline differences, ICP can periodically estimate an average difference and adjust local prices accordingly. See Cavallo (2017) for a discussion.

[9] Some of this price dispersion could be explained by data collected from different retailers, as there is growing evidence that firms use uniform pricing policies within countries. See DellaVigna and Gentzkow (2017) for the United States, and Cavallo (2017) for some other countries.

frequency and transparency of PPPs compared with traditional data collection methods. We have also identified many challenges and limitations of online data.

We further note that the process of selecting ("matching") products across countries remains a challenge, even with "Big Data." Online data enlarge the universe of products from which comparable goods are chosen, and potentially improve the transparency and similarity in methods used across countries, but selecting individual goods continues to be a labor-intensive task that cannot be easily performed by automated procedures due to the lack of standardization in product identification numbers and descriptions.

Future work could address some of these issues, as well as explore other potential uses of online prices in the context of PPP measurement, such as the computations of standard errors for national average prices, the use of retailer dummies and other product characteristics in CPD regressions, and better ways to account for entering and exiting products and items across countries.

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