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Is Living in African Cities Expensive?

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Abstract

Although several studies have examined why overall price levels are higher in richer countries, little is known about whether there is a similar relationship at the urban and city level across countries. This paper compares the price levels of cities in Sub-Saharan Africa with those of other regions by analyzing price information collected for the 2011 round of the International Comparison Program. Readjusting the calculated price levels from national to urban levels, the analysis indicates that African cities are relatively more expensive, despite having lower income levels. The price levels of goods and services consumed by households are up to 31 percent higher in Sub-Saharan Africa than in other low- and middle-income countries, relative to their income levels. Food and non-alcoholic beverages are especially expensive, with price levels around 35 percent higher than in other countries. The paper also analyzes price information collected by the Economist Intelligence Unit's Worldwide Cost of Living Survey, and obtains a similar result, indicating higher prices of goods and services in African cities.

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1. Introduction

It is widely known that richer countries tend to have higher price levels. A strand of economic theory explains this phenomenon by differences in the productivity of tradable and non-tradable goods and services (Balassa, 1964; Samuelson, 1964), difference in factor endowments (Bhagwati, 1984), and non-homothetic preferences (Bergstrand, 1991). Recent results of the 2011 International Comparison Program (ICP) clearly illustrate the positive association between price levels of household consumption excluding housing rent and gross domestic product (GDP) per capita across participating economies (Figure 1). The relationship is apparently nonlinear: price levels jump up as countries pass a certain threshold of GDP per capita, as illustrated by Organization for Economic Co-operation and Development (OECD) member countries and European countries in Figure 1. By contrast, the plateau seen in the bottom left of Figure 1 indicates that African countries face disproportionately higher price levels in comparison to other lower-income countries.[2] The regression analysis by Gelb and Diofasi (2015) finds that this "Africa effect," or the higher price levels in Africa relative to their income levels, remains statistically significant even after controlling for a variety of factors, such as fuel subsidies, geography, and institutional quality. According to their results, the price levels of GDP are 11% to 18% higher in African countries.

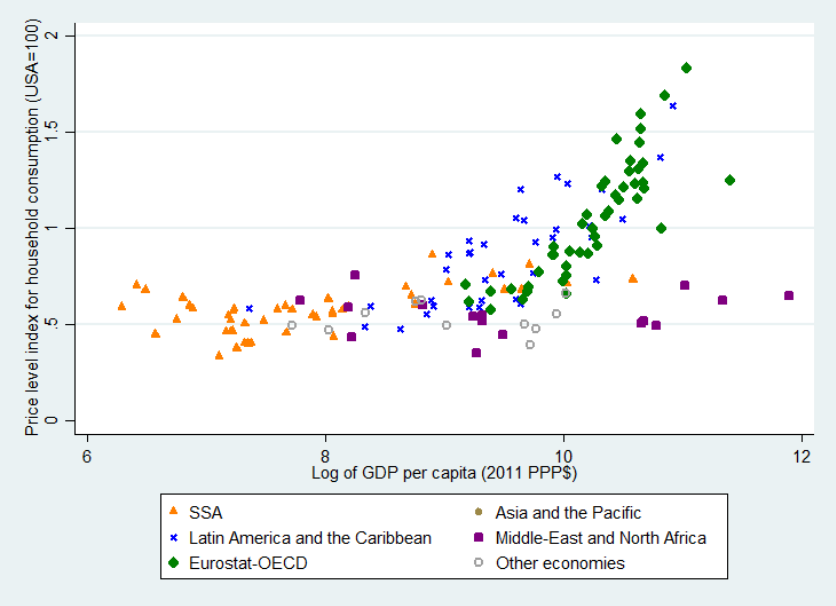

Figure 1. Price level index for household consumption and the log of GDP per capita
Note: Price level index (PLI) for household consumption except for housing rent is standardized so that the PLI of the United States equals 100.
Source: Authors' calculations are based on the 2011 ICP data.

Price levels vary not only across, but also within countries. A number of studies highlight the price differences between urban and rural areas, including Deaton and Dupriez (2011); Majmunder, Ray, and Sinha (2012); and Brandt and Holz (2006). The urban-rural price patterns are rather complex; some items may be more expensive in urban areas, while others may be more expensive in rural areas (see an example of Nigeria in Appendix A). However, it is unclear how price levels in urban areas vary across countries, and how relatively expensive it is to live in African cities. Given the rapid urbanization in Sub-Saharan Africa (SSA), clarifying this is a pressing issue. Higher prices relative to income levels, or higher costs of living, not only affect household welfare, but also the economic functions and competitiveness of

[2] "Africa" refers to Sub-Saharan Africa in this paper unless otherwise noted.

African cities. If such higher costs are evident in urban Africa, its urbanization pattern may have played a key role in this phenomenon, among other factors.

In this paper, we aim to fill an important knowledge gap and show the extent to which African cities are expensive relative to their income levels by comparing the price levels of goods and services in urban areas across countries. The main challenge is data availability. While the ICP has constructed a price level index (PLI), which indicates the relative expensiveness of goods and services at the national level, disaggregated price level data by urban and rural areas are not readily available. Our approach is to adjust the national-level PLIs of African countries in the ICP data with known capital city-to-national price ratios and then compare them with the PLIs of countries that collected price information predominantly in urban areas. Based on a comparison of 62 countries across Africa, Asia, and Latin America, our analysis shows that, controlling for their income levels, the price levels of household consumption in SSA countries are overall 31% higher than other countries. Food and non-alcoholic beverages are particularly expensive, with price levels 35% higher than in other countries. We also reach a similar conclusion by analyzing the Worldwide Cost of Living Survey data collected by the Economist Intelligence Unit (EIU).

This paper comprises three main parts: an analysis of the price levels in urban areas across countries based on the 2011 ICP data (Section 2), an analysis of the EIU data (Section 3), and a conclusion based on the summary of the findings and limitations (Section 4).

2. Comparison of price levels in urban areas

2.1 Data preparation

The ICP is a global statistical program designed to collect comparable price data and provide estimates of purchasing power parities (PPPs) of the world's economies. In order to calculate PPPs, the ICP collects price data for comparable products and services and compiles national accounts expenditure data that are used as weights. The collection of the underlying data for each economy is undertaken by its national statistical office. The ICP requires that price collection is conducted based on a nationally representative survey frame that would result in national annual average prices. However, due to the limited coverage of national consumer price index (CPI) survey frames and/or shortage in resources, some countries opted to collect in urban areas only.

Results produced by the ICP allow users to measure and compare price levels and real expenditures on GDP and its aggregates. For this paper, the indicator primarily used is the PLI for the household consumption component of GDP. This measure indicates the price level of goods and services consumed by households in each country for a given year, relative to a reference country or group of countries (see Appendix B for further explanation). We do not include the PLIs of housing rents in household consumption, because they are calculated based on data collected by different methods across regions and classified as a "comparison-resistant component" by the ICP. PLIs are calculated by dividing the PPPs by the nominal exchange rate for each country. Interpreting the PLI for a country is straightforward; for instance, when using the United States as a reference country with its PLI of 100, Country A's PLI of 50 for food items indicates that food is overall 50% cheaper in Country A relative to the United States.

Plotting the price levels of household consumption over the log of GDP per capita in 2011 PPP terms illustrates the famous Balassa-Samuelson effect (Figure 1).[3] As visually shown, richer countries tend to have relatively higher prices. The Balassa-Samuelson model (Balassa, 1964; Samuelson, 1964) explains higher price levels in more developed countries by their higher relative productivity in traded goods. Because exchange rates equate the price of tradable goods across countries, relative productivity in tradable goods leads to higher wages in the tradable sector in richer countries. This results in the rise in prices of non-tradables and the overall price levels of the countries. Another explanation by Bhagwati (1984) attributes higher price levels in richer countries to the difference in factor endowments. Higher capital-labor ratios lead to higher wages in rich countries, while poor countries—where labor is relatively cheap—have cheaper services. Finally, Bergstrand (1991) emphasizes non-homothetic tastes: as an economy develops, consumers move from consuming basic goods that are also tradable to consuming more services that are not tradable. As wage rates increase, the cost of services rises.

However, income levels alone do not fully explain the price level patterns across countries. Using the 2011 ICP data, Gelb and Diofasi (2015) show that less than 20% of the variation in price levels is explained by income. Their regression models include a variety of variables that control for subsidies, geography and scale, institutional quality, open labor markets, trade and capital inflows, and inequality.[4] No matter what control variables are incorporated, the dummy variable of SSA countries remains statistically significant in their results. Gelb and Diofasi estimate that African countries have 11% to 18% higher price levels of GDP than other countries, and 11% to 21% higher price levels than other countries at comparable levels of income.

Our focus is on 62 countries in Africa, Latin America, Asia, and Middle-East and North Africa (Table 1). To compare price levels in urban areas across those countries, the African price relatives are adjusted to the price relatives of capital cities in line with the methodology from the respective 2009 PPP regional updates.[5] In those updates, the prices were collected in capital cities only, and special adjustments were made to convert them to the national level. We compare their price levels with a group of countries in other regions that collected price information predominantly in urban areas.

Table 1. List of selected economies

Region (number of economies)	Economies
Sub-Saharan Africa (39)	Angola*, Benin*, Botswana, Burkina Faso*, Burundi, Cameroon, Central African Republic, Chad*, Congo, Dem. Rep., Congo, Rep.*, Equatorial Guinea, Ethiopia, Gabon*, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar*, Malawi, Mali*, Mauritania*, Mauritius, Mozambique*, Namibia*, Niger, Nigeria, Rwanda, Senegal*, Sierra Leone, South Africa*, Sudan, Swaziland, Tanzania, Togo*, Uganda, Zambia*,
Latin America (7)	Bolivia*, Brazil*, Ecuador*, Paraguay*, Peru*, Uruguay*, Venezuela, RB*
East Asia and the Pacific (5)	Brunei Darussalam*, Hong Kong SAR, China*, Macao*, Singapore*, Taiwan, China*
Middle-East and North Africa (11)	Bahrain*, Djibouti*, Egypt, Arab Rep., Iraq*, Jordan*, Kuwait*, Morocco, Oman*, Qatar*, Saudi Arabia*, Tunisia

Note: * indicates economies that collected price surveys predominantly in urban areas.

[3] The positive relationship between the log of a country's price level and the log of GDP per capita is also known as the "Penn effect."

[4] Examples of other control variables previously used include the share of government consumption over GDP (Larrain, 2010), trade openness as measured by the ratio of trade to GDP (Kravis & Lipsey, 1983), and stock market capitalization over GDP (Larrain, 2010).

[5] See African Development Bank (2012, p.4) for details.

To make it easier to interpret the PLIs for our analysis, we standardized the PLIs of the selected economies so that the average—or more precisely, the geometric mean—equals 100. The plot of the PLIs for the selected economies in Figure 2 implies that the price levels of African countries are higher relative to their income levels, which is proxied by their GDP per capita. In Figure 3, we also calculated PLIs for different categories of goods and services (for explanations of those categories, see Appendix C). Table 2 reports summary statistics of PLIs and other country characteristics, such as GDP per capita, population, and urban population rate from World Development Indicators (WDI) (World Bank, 2015c). WDI uses the urban rate reported by the United Nations World Urbanization Prospects, which is based on national statistics with some adjustments for consistency across countries (United Nations, 2015). Gross values added (GVA) per capita in capital or major cities—a proxy of city-level income (Oxford Economics, 2015) —ranges from US$276 in Democratic Republic of the Congo to US$89,400 in Qatar.[6]

Table 2. Summary statistics

	Obs.	Mean	S.D.	Min.	Max.
PLI: household consumption	62	84.27	20.11	47.72	149.3
Adjusted PLI: household consumption	62	84.32	20.14	47.13	149.3
GDP per capita (thousand US$, 2011 PPP)	62	16.6	28.62	0.537	146.5
GVA per capita in major city (thousand US$, 2011 constant)	53	10.76	17.80	0.276	89.40
Sub-Saharan Africa (1=yes; 0=no)	62	0.629	0.487	0.000	1.000
Population (in million)	62	21.74	34.35	0.393	192.4
Urban population rate (%)	62	53.34	25.31	10.91	100.0

Figure 2. Adjusted price level index of household consumption in selected economies, 2011
Note: Adjusted price level index (PLI) for household consumption except for housing rent. PLIs are standardized so that the geometric mean equals 100. The size of a circle is proportional to its GDP (2011 PPP terms).
Source: Authors' calculations are based on the 2011 ICP data.

[6] We calculate GVA per capita based on the Global Cities Historic Database (Oxford Economics, 2015). The data miss the following 9 out of 62 economies selected in this paper: Bahrain, Brunei Darussalam, Djibouti, Guinea-Bissau, Equatorial Guinea, Liberia, Mauritania, Mauritius, and Swaziland.

Figure 3. Price level index for various goods and services in selected economies, 2011
Note: x-axis indicates the log of GDP per capita; y-axis indicates the price level index for the household expenditure category in question. The triangles in orange represent SSA countries; the circles in gray represent other countries in the sample. Only countries that collected price information predominantly in urban areas are included for housing rent.
Source: Authors' calculations are based on the 2011 ICP data.

2.2 Regression analysis

We conducted a series of regression analyses to assess the extent to which price levels in African countries are higher than in other countries. Our Ordinary Least Squares (OLS) model is expressed as follows:

$$\log(\text{PLI}_i) = \alpha + \beta_1 \log(\text{GDP per capita}_i) + \beta_2 \text{SSA}_i + \beta_3 X_i + \varepsilon_i \quad (1)$$

where the dependent variable is the log of the PLI of country i; the log of GDP (or GVA) per capita controls for income levels; SSA_i is a dummy indicator (1 if country i is a SSA country; 0 otherwise); X_i is a vector of control variables; α is a constant; ε_i is an error term; and β_1 to β_3 are parameters to be estimated. We include in X_i the log of national population, urbanization rate, and their interaction term. The parameter β_2 indicates the percentage by which the PLIs of SSA countries are on average higher (or lower) than the other countries.

Household consumption except for housing rent

Table 3 reports the results of the regression analysis for household consumption except for housing rent. We first estimated the regression model in Equation (1) for the log of PLIs for household consumption with no adjustment (i.e., national level). Column (1) controls for only income levels with the log of GDP per capita. The estimated coefficient for the dummy variable of SSA countries does clearly indicate that

the PLIs for household consumption in SSA countries are higher than other economies. Once we added the log of population and urban population rate in column (2), the coefficient estimate for the SSA dummy increased to 0.229 ($p < .05$)—meaning that price levels for household consumption in SSA countries are 19% more expensive than other countries.

Columns (3) to (6) in Table 3 show the results based on PLIs adjusted by capital/major city to national price-level ratio. Thus, coefficient estimates for the SSA dummy indicate how relatively expensive urban Africa is compared with urban areas in other countries. The adjustment of PLIs only slightly changes the estimates: the estimated coefficients for the SSA dummy are 0.224 ($p < .05$) in column (3). We further added the interaction term of the log of population and urban population rate in column (4). While adjusted R-squared improves, the coefficient estimate for the SSA dummy remains almost same. In addition, we estimated the same models as in columns (4) and (5) by replacing the log of GDP per capita with the log of GVA per capita. As columns (5) and (6) show, the coefficient estimates for the SSA dummy increase to 0.276 ($p < .01$) and 0.306 ($p < .01$), respectively, while adjusted R-squared also increases to 0.400 and 482, respectively. Therefore, our best estimate indicates that when comparing with urban areas in other regions by controlling for income and other basic factors, price levels for household consumption in urban Africa are 30% more expensive.

Table 3. Estimation results for household consumption except for housing rent

	No adjustment		Adjusted			
	(1)	(2)	(3)	(4)	(5)	(6)
Log of GDP per capita	0.097***	0.047	0.049	0.049*		
	(0.026)	(0.030)	(0.030)	(0.028)		
Log of GVA per capita					0.061	0.084**
					(0.036)	(0.035)
SSA dummy	0.095	0.229**	0.224**	0.225***	0.276***	0.306***
	(0.078)	(0.089)	(0.090)	(0.084)	(0.092)	(0.086)
Log of population		0.000	-0.001	-0.116***	0.015	-0.125**
		(0.019)	(0.020)	(0.043)	(0.024)	(0.053)
Urban population rate		0.006***	0.006***	-0.026**	0.007***	-0.031**
		(0.002)	(0.002)	(0.011)	(0.002)	(0.013)
Log population × Urban rate				0.002***		0.002***
				(0.001)		(0.001)
Constant	3.511***	3.543***	3.554***	5.394***	3.110***	5.227***
	(0.259)	(0.480)	(0.482)	(0.773)	(0.535)	(0.875)
Adjusted R squared	0.220	0.309	0.308	0.389	0.400	0.482
Obs.	62	62	62	62	53	53

Note: Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variables are log of price level index (PLI). Columns (3) to (6) are based on PLIs adjusted based on capital-city-to-national price-level ratio in Africa. We also estimated models with the squared term of the log of GDP (or GVA) per capita, but obtained similar results (not reported).

One concern related to our methodology was that our analysis did not include Asian countries with per-capita income levels comparable to SSA countries. To address this, we estimated the same models above by adding some Asian countries (Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam). We raised the PLI of each of those Asian countries by 10% to see results in case their price levels at the urban level were 10% higher than those at the national level.[7] Figure 4 shows the relationship between the adjusted PLIs

[7] Price levels in a capital city are not necessarily higher than those in other urban areas, and the capital city-to-national price level ratio varies depending on the category of items. Our purpose of uniformly inflating PLIs of the 15 Asian countries was to estimate the lower-bound of the price premium in urban Africa. Given the results of capital city-to-national price level adjustment by the Asian Development Bank (2013), we judged that inflating PLIs by 10% was appropriate for the purpose.

and the log of GDP per capita, and Table 4 summarizes the estimation results. A notable difference from Table 3 is that the coefficient estimate for the SSA dummy increased to 0.194 ($p < .01$), because the added Asian countries have very low income levels and PLIs. Once other factors were controlled for in columns (2) to (6), coefficient estimates for the SSA dummy became lower than the results in Table 3. Nevertheless, our analysis shows that household consumption except for housing rent in urban SSA is over 20% more expensive than in other countries.

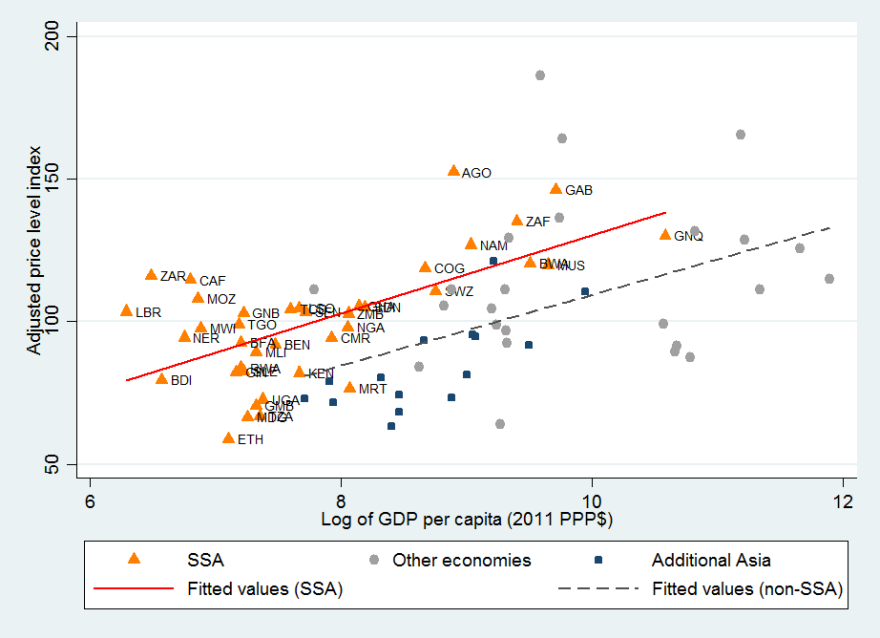

Figure 4. Adjusted price level index of household consumption with additional Asian countries, 2011
Note: Adjusted price level index (PLI) for household consumption except for housing rent. PLIs for 15 Asian countries are inflated by 10%.
Source: Authors' calculations are based on the 2011 ICP data.

Table 4. Estimation results for household consumption except for housing (with Asian countries)

	No adjustment		Adjusted			
	(1)	(2)	(3)	(4)	(5)	(6)
Log of GDP per capita	0.125***	0.051*	0.053*	0.057**		
	(0.022)	(0.027)	(0.027)	(0.025)		
Log of GVA per capita					0.070**	0.091***
					(0.031)	(0.029)
SSA dummy	0.194***	0.226***	0.225***	0.209***	0.229***	0.218***
	(0.058)	(0.058)	(0.058)	(0.055)	(0.058)	(0.053)
Log of population		0.007	0.006	-0.088***	0.009	-0.108***
		(0.014)	(0.014)	(0.032)	(0.017)	(0.037)
Urban population rate		0.006***	0.006***	-0.023**	0.006***	-0.029***
		(0.001)	(0.001)	(0.009)	(0.002)	(0.010)
Log population × Urban rate				0.002***		0.002***
				(0.001)		(0.001)
Constant	3.415***	3.630***	3.628***	5.135***	3.461***	5.271***
	(0.208)	(0.365)	(0.367)	(0.577)	(0.373)	(0.621)
Adjusted R squared	0.288	0.422	0.420	0.488	0.489	0.566
Obs.	78	78	78	78	68	68

Note: Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variables are log of price level index (PLI). Columns (3) to (6) are based on PLIs adjusted based on capital city-to-national price level ratios in Africa. PLIs for Asian countries, except for those that collected price information predominantly in urban areas, are inflated by 10%.

The results of our regression analysis also reveal which African countries are particularly expensive or less expensive for living. Relatively expensive countries include Angola, Democratic Republic of Congo, Mozambique, Malawi, and Chad. By contrast, Gambia, Mauritania, Madagascar, and Tanzania have relatively low price levels among SSA countries. The map in Figure 5 illustrates the spatial pattern in Sub-Saharan Africa by showing the residuals from column (4) of Table 3.

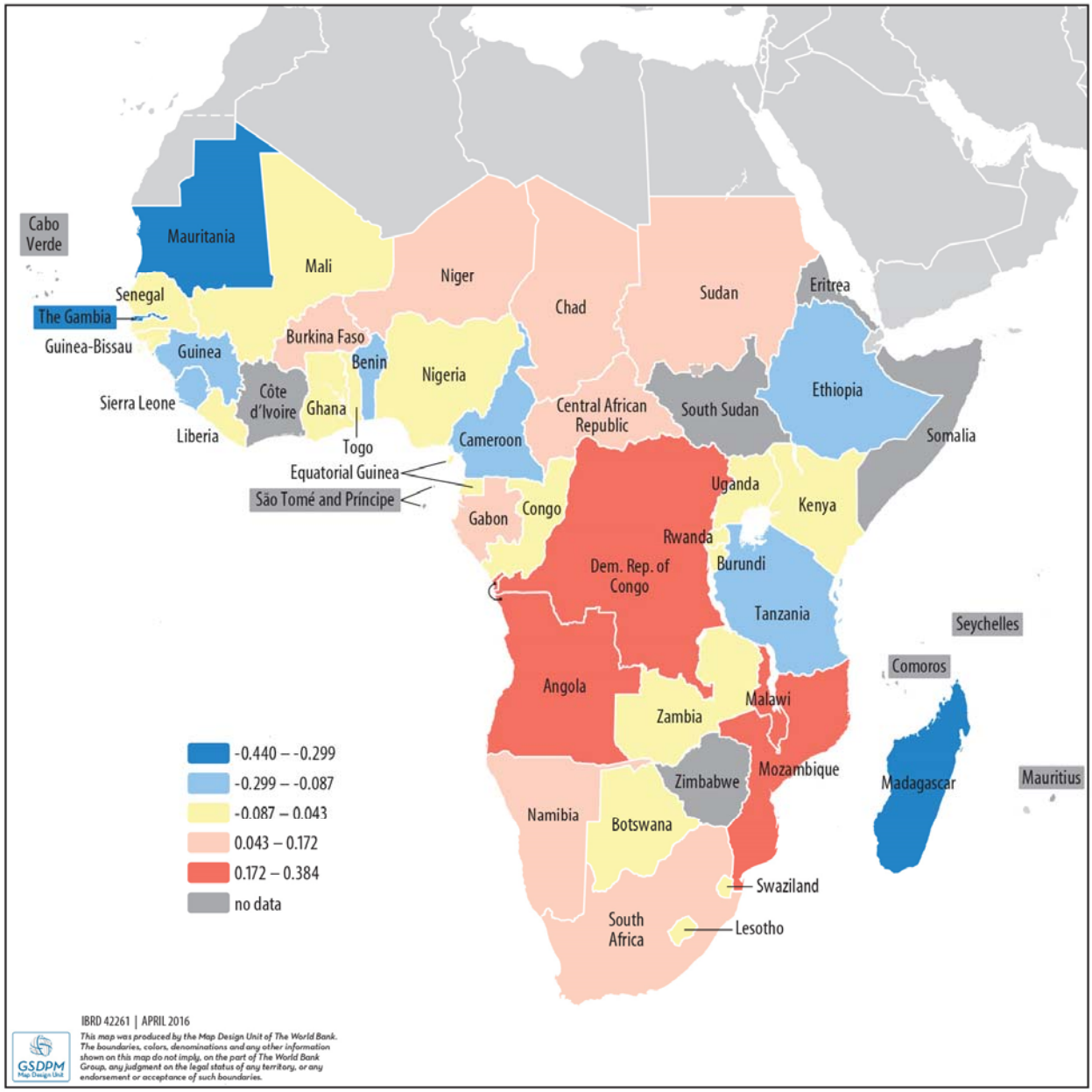

Figure 5. Map of relative expensiveness of household consumption in Sub-Saharan Africa.
Note: The map shows residuals in column (4) of Table 3 based on natural breaks: countries in red have higher residual values (i.e., are relatively expensive); countries in blue have lower residual values (i.e., are relatively less expensive). Countries in white were excluded from the analysis.
Source: Authors' calculation.

The results of our regression analysis also hint how urbanization is linked to price levels. According to the estimation results of column (5) in Table 3, a 10% point increase in the urban population rate leads to 6.8% higher price levels, even with controls for income levels. However, as indicated in column (6), the relationship between the urban population rate and PLIs for household consumption varies depending on

the size of the country's population. Figure 6 shows four linear prediction lines for countries with the log of population being equal to 14 (i.e., with a population of 1.2 million) and the log of population equal to 18 (with a population of 65 million), respectively. As visually illustrated, when income levels are controlled for, the urban population rate is positively and more strongly associated with higher price levels for countries with larger population sizes. For smaller countries with the log of population being equal to 14, urbanization is not clearly associated with price levels. By contrast, for larger countries with the log of population being equal to 18, a 10% point increase in the urban population rate is associated with a 10.4% increase in PLIs.

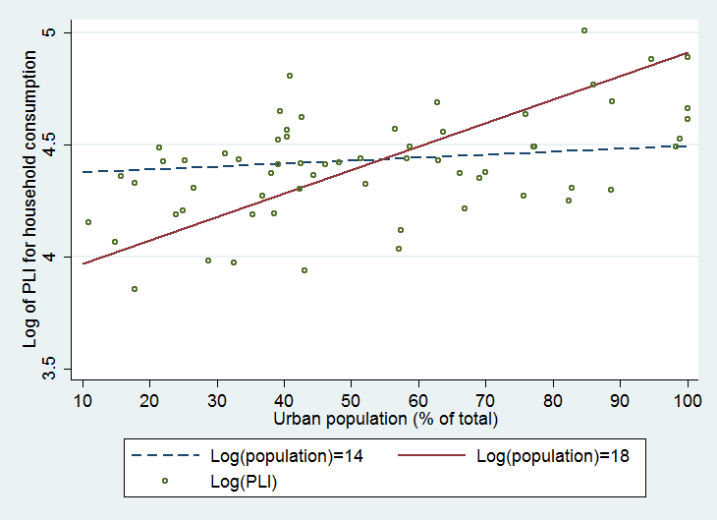

Figure 6. Urban population rate and price level index for household consumption
Note: The solid line indicates the positive relationship between the urban population rate and the log of PLI for household consumption for countries with the log of population being equal to 18. By contrast, the relationship is ambiguous for smaller countries with the log of population equal to 14.
Source: Authors' calculations.

Food and other expenditure categories

We then explored the difference in price levels between food and non-food components by estimating the same models in columns (6) of Table 3 for *household consumption except for housing and food* and *food and non-alcoholic beverages*. As summarized in Table 5, food and non-alcohol beverages are particularly expensive items in SSA countries. The estimated coefficient for the SSA dummy based on adjusted price data in column (3) is 0.348 ($p < .01$). This means that food is 35% more expensive in SSA countries relative to their income levels. Because expenditure on food accounts for a large part of household consumption, when food is excluded from household consumption, the coefficient estimate becomes lower (0.263) in column (2).

Table 5. Estimated coefficient for the dummy indicator of urban SSA for food and non-food expenditure

	Household consumption except for housing (1)	Household consumption except for housing and food (2)	Food and non-alcoholic beverages (3)
Coefficient estimate for SSA dummy	0.306***	0.263**	0.348***
	(0.086)	(0.100)	(0.086)

Note: Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable is the log of adjusted PLI; control variables include the log of GVA per capita, the log of population, urban population rate, and the interaction term of the log of population and urban population rate.

The fact that food is relatively more expensive in SSA countries demonstrates its impact on the lives of the poor population, who tend to spend a larger portion of their consumption on food. The expenditure weights of food in household consumption in the 39 SSA countries included in this analysis are exceptionally high compared to the rest of the world.[8] Figure 7 illustrates the expenditure weights of food across world economies in 2011, which are derived from national accounts and used for the calculation of PPPs by the ICP.[9] It shows that SSA countries tend to have a larger expenditure share on food. This is hardly surprising, since lower-income households are obliged to allocate a larger share of their income to the purchase of food. Urban households in Africa also allocate a large portion of their budget to food. According to household surveys collected in several African countries, urban households allocate on average 39% to 59% of their monthly spending to food (see Appendix D). Among them, the poorest—i.e., the first quintile based on the expenditure levels—spend a larger portion of money on food: 44% in Uganda to 68% in Zambia. The relative expensiveness of food-related headings results in high price levels in household consumption, because of the high expenditure shares of food.

Figure 7. Expenditure weights of food in household consumption, 2011
Note: The smooth line is based on locally weighted regression.
Source: Authors' calculations.

When looking at types of food items, their relative expensiveness in African countries varies widely. We separately estimate the regression model in Equation (1) with the PLI of each type of food as its dependent variable. Figure 8 exhibits the estimated coefficients for SSA dummies for each type of food. Relatively expensive foods are: fresh or chilled vegetables other than potatoes (68% more expensive); fresh or chilled potatoes (60%); eggs and egg-based products (56%); and fresh milk (55%).

[8] In this figure, the world is composed of 177 countries for which ICP 2011 releases full final results.
[9] A global comparison of national account-based and household survey-based food shares in household consumption shows that the former is overall lower than the latter and the gap is wider in lower-income countries (Ravallion and Chen, 2015).

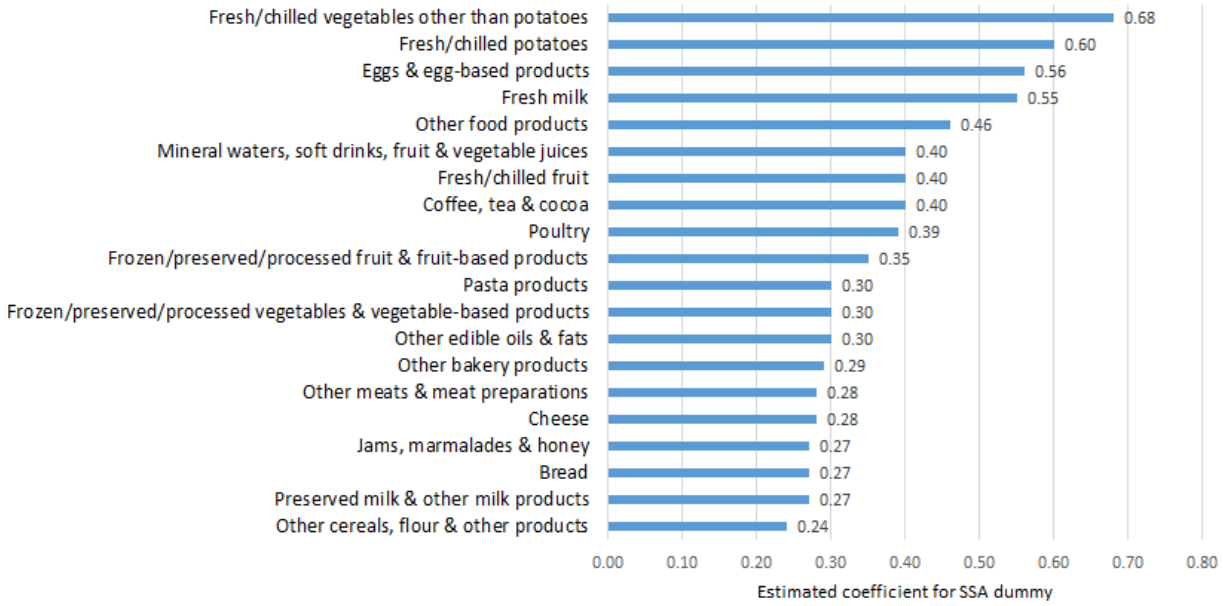

Figure 8. Estimated coefficient for the dummy indicator of urban SSA by food headings
Note: Reported are coefficient estimates for the SSA dummy in column (4) of Table 3.
Source: Authors' calculations are based on the 2011 ICP data.

Although results for the categories of household consumption except for housing rent, household consumption except for housing rent and food, and food would be more robust than the ones for smaller components, we also examined other groups of items. Our estimation for housing rent is based on non-adjusted PLIs for countries that collected price data predominantly in urban areas because national-to-capital city price ratios for housing rent are not available. The estimation result shows that housing rent is 55% more expensive in urban SSA (Table 6).[10] Other groups of relatively expensive items include transport (42%), communication (46%), and restaurants and hotels (41%). Transport items include household expenditure on purchase of vehicles, operation of personal transport equipment, and transport services (see Appendix C). Figure 9 summarizes our results.

Table 6. Estimated coefficient for the indicator of urban SSA for non-food expenditures

	Housing rent	Transport	Communication	Restaurants & hotels
Coefficient estimate	0.546***	0.424**	0.457*	0.413**
for SSA dummy	(0.188)	(0.183)	(0.225)	(0.168)

Note: Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Only countries that collected price information predominantly in urban areas are included. The dependent variable is the log of adjusted PLI; control variables include the log of GVA per capita, the log of population, the urban population rate, and the interaction term of the log of population and urban population rate.

[10] In its broadest category in the ICP data, the PLI of housing includes not only household expenditure on actual and imputed housing rent, but also maintenance and repair of the dwelling and utilities (see Appendix C). We focus on only PLI for housing rent in the present paper.

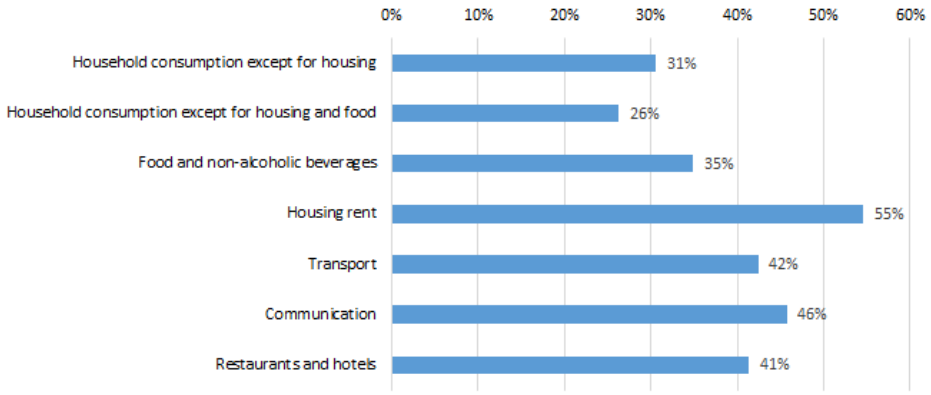

Figure 9. To what extent price levels in urban SSA are higher than other countries?
Note: Figures are based on the results reported in Tables 3, 5, and 6.
Source: Authors' calculations.

3. Analysis of alternative data: Worldwide Cost of Living Survey

Another data source useful for the global comparison of price levels is the EIU's World Cost of Living survey.[11] The EIU collects data for the survey in 140 cities in nearly 90 countries every year (see Figure 10 and Appendix E for the list of cities used for our analysis). Survey prices of more than 160 items are gathered from supermarkets, medium-priced retailers, and more expensive specialty shops (see Appendix E for the list of food items in the EIU data). The EIU's data contains price information for nine cities in eight SSA countries: Abidjan, Dakar, Douala, Harare, Johannesburg, Pretoria, Lagos, Lusaka, and Nairobi.

Figure 10. Cities in EIU data
Source: Authors' work based on DeLorme Publishing Company, Inc. (2015).

Because the EIU data records prices in local currency units, they are not directly comparable across cities in different countries. We calculated a price level index for each category of goods and services as of 2011 as follows: first, we calculated elementary, or basic heading, PPPs based on local current unit prices, which were then combined with the expenditure weights for aggregation following the ICP methodology (see Appendix G for details). The resulting aggregated PPPs were subsequently converted to PLIs using exchange rates.

[11] An example of a previous study that uses the EIU data is Crucini and Yilmazkuday (2014), which investigates long-term price dispersion patterns across cities between 1995 and 2005.

There is a cautionary note about our use of EIU data for our analysis. The EIU collects price information for a different purpose. Its main objective is to compare the cost of living for expatriates traveling from developed countries for business, and its price survey collects data on items typically consumed by expatriates. As a result, the price levels calculated based on the EIU data do not necessarily reflect the costs of living for local people. Nevertheless, with this point in mind, the analysis of such data can be useful for our purpose.

The plot of the PLI for household consumption except for housing rents and the log of GVA per capita demonstrates that all the SSA countries lie above the fitted line (Panel (a) in Figure 11). However, some SSA cities, such as Lusaka, Nairobi, Johannesburg, and Pretoria, have price levels of food and non-alcoholic beverages comparable to other low-income cities (Panel (b) in Figure 11).

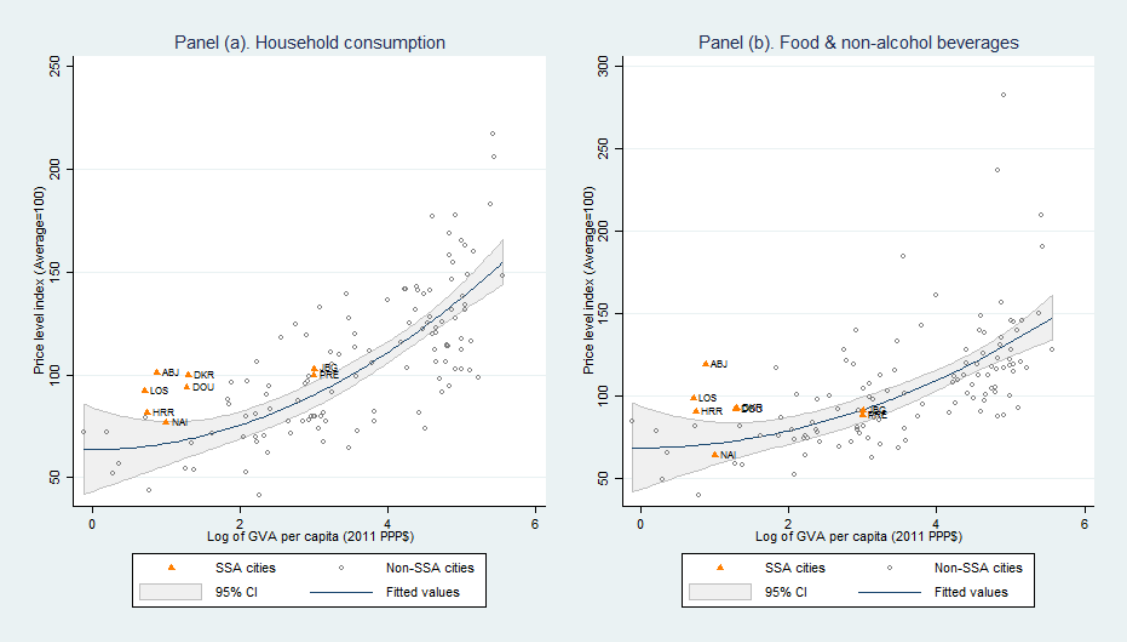

Figure 11. Price levels for household consumption and food items in world cities, 2011
Note: PLIs for household consumption are calculated without housing rent.
Source: Authors' calculations are based on EIU data

We estimated the expensiveness of SSA cities by regressing the log of the PLIs against income and other control variables. We estimated regression models with PLIs for household consumption and food separately. Table 7 reports the results of our regression analysis. The results overall indicate that the PLIs for household consumption are about 30% higher in SSA cities. Column (1) is the baseline model that controls for only income levels. The estimated coefficient for the SSA dummy is 0.276 ($p < .01$). Adding the log of population and population density in column (2) and the Europe-OECD dummy in column (3) does not substantially change the estimates: 0.307 ($p < .01$) and 0.322 ($p < .01$), respectively. Excluding cities in European and OECD member countries does not significantly change the result either (0.301, $p < .01$). These estimates are slightly higher than the results based on adjusted PLIs in the ICP data, most likely because items in the EIU survey tend to be those typically consumed by higher-income households.

By contrast, the estimated price premiums for food and non-alcoholic beverages in columns (5) to (8) in Table 7 are modest, compared with the results based on the ICP data. Column (8) shows that food is 21% more expensive than other lower- and middle-income cities. Despite the difference in the choice of basket items and the list of cities and countries, an analysis of the EIU data reaches similar results to the previous section based on ICP data.

Table 7. Summary of regression analysis with EIU data

	Household consumption				Food and non-alcohol beverages			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log of GVA per capita	0.072	0.098*	0.189***	0.147***	0.042	0.067	0.169***	0.103***
	(0.060)	(0.058)	(0.026)	(0.033)	(0.064)	(0.061)	(0.027)	(0.031)
Log of GVA per capita squared	0.018*	0.021**			0.018*	0.022**		
	(0.009)	(0.009)			(0.010)	(0.009)		
SSA dummy	0.268***	0.296***	0.307***	0.284***	0.192**	0.228***	0.242***	0.200**
	(0.084)	(0.081)	(0.080)	(0.090)	(0.090)	(0.084)	(0.084)	(0.084)
Log of population		0.013	0.006	0.043		0.045**	0.039*	0.058**
		(0.020)	(0.021)	(0.029)		(0.021)	(0.021)	(0.028)
Log of population density		0.102***	0.098***	0.005		0.107***	0.103***	-0.041
		(0.034)	(0.034)	(0.057)		(0.035)	(0.035)	(0.053)
Euro-OECD dummy			0.132**				0.124**	
			(0.058)				(0.061)	
Constant	4.104***	3.012***	3.017***	3.630***	4.204***	2.783***	2.777***	4.049***
	(0.090)	(0.327)	(0.327)	(0.507)	(0.097)	(0.340)	(0.343)	(0.475)
Adjusted R^2	0.578	0.617	0.616	0.339	0.461	0.540	0.534	0.282
Obs.	125	125	125	70	125	125	125	70

Note: Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variables are the log of price level index. Columns (4) and (8) exclude high-income cities. Control variables include log of GVA per capita (Oxford Economics, 2015), log of population (Oxford Economics, 2015), log of population density (Demographida, 2015), and a dummy indicator about Euro-OECD countries.

4. Concluding remarks

This paper shows that goods and services consumed by urban households in SSA countries are very expensive relative to their incomes. Readjusting national-level PLIs to reflect price levels in capital or major cities, we find that the price level of household consumption in Sub-Saharan Africa is up to 31% higher than in comparable countries. In particular, food and non-alcoholic beverages are 35% more expensive. The results of our analysis of EIU data also corroborate higher price levels in urban Africa.

Our estimates are higher than those of Gelb and Diofasi (2015), who use the same ICP 2011 data and find that price levels in Africa are 11 to 18% more expensive than other countries, with controls for income and other factors. This difference is mainly due to the methodology used. We analyzed price levels at the city and urban level by adjusting PLIs and choosing countries that collected price information predominantly in urban areas. In addition, Geld and Diofasi (2015) analyzed the PLIs for GDP, which includes not only household consumption but also other components, such as collective consumption expenditure by government. By contrast, we focused specifically on PLIs for household consumption.

Finally, there are three limitations to our approach that must be clarified. First, like any other statistical indicators, PPPs are statistical constructs rather than precise measures—that is, they are point estimates that fall within some margin of error of the unknown true values. The margins of error around PPPs are the result of sampling and non-sampling errors plus the inherent variability in price and economic structures between economies. Second, our analysis is cross-sectional only. We avoided directly comparing the 2005 and 2011 ICP data because of methodological changes (see Ravallion, 2014). Third, because our aim was to show the relative expensiveness of SSA countries, we did not test many factors that potentially influence their price levels. In contrast, Gelb and Diofasi (2015) examined a variety of factors, and still confirmed that Africa is expensive even when those factors are controlled. This paper intends to clarify *how* relatively expensive it is to live in African cities, and leaves the question open of *why* they are so costly. This question of why will be addressed in the World Bank's forthcoming report, *Opening Doors to the World: Building African Cities that Work*, which discusses extensively how urban forms contribute to the relatively high costs of living in urban Africa.

Appendices

Appendix A. Urban-rural price gap in Nigeria

Price collection is a vital part of the overall matter of measuring poverty because it necessitates adjusting nominal consumption into a real value of consumption. Many price indices reflect the prices and quantities of urban consumers because price data are often collected only in urban areas. That is acceptable when most of a country's population lives in urban areas and markets are highly integrated, as in the United States. For Africa, however, this could create an urban bias: even though Africa is urbanizing heavily, its population remains predominantly rural. Obtaining spatial price comparisons is not easy, posing different demands on the data collection and sampling methodology. This is especially the case for large countries, where regional consumption baskets overlap only partially and where product characteristics may be highly variable across regions.

Empirical evidence shows that food prices can differ significantly between urban and rural areas because of the high cost of transport and limited market integration. Rural prices are expected to be lower for unprocessed raw foodstuffs, which are typically transported from rural to urban areas, while they may be higher for processed packaged goods that are transported in the reverse direction (Gaddis, 2015). This is confirmed by Nigeria price data from 2012. The items that have the largest gap in price are presented in Figure B1 below. Rural prices seem to be higher for processed food, such as cake, croissants, and imported meat; and cheaper for raw food, such as local beef, pork, chicken, etc.

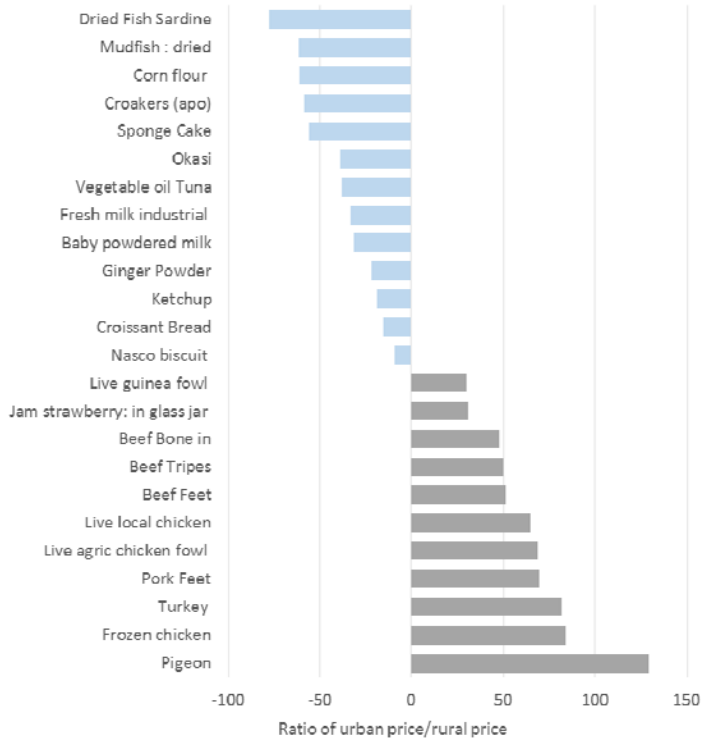

Figure B1. Urban-rural price gap in Nigeria, 2012
Source: Nigeria Statistical Office

Appendix B. Terminology

Purchasing power parity (PPP)

The spatial deflator and currency converter eliminate the effects of the differences in price levels between economies, thereby allowing volume comparisons of GDP and GDP component expenditures.
PPPs are calculated in three stages: (1) for individual products, (2) for groups of products or basic headings, and (3) for groups of basic headings or aggregates. The PPPs for individual products are the ratios of national prices in national currencies for the same good or service. The PPPs for basic headings are the unweighted averages of the PPPs for individual products. And the PPPs for aggregates are the weighted averages of the PPPs for basic headings. The weights used are the expenditures on the basic headings. At all stages, PPPs are price relatives. They show how many units of currency A need to be spent in economy A to obtain the same volume of a product or a basic heading or an aggregate that X units of currency B purchases in economy B. In the case of a single product, the same volume means an identical volume. But in the case of the complex assortment of goods and services that make up an aggregate such as GDP, the same volume does not mean an identical basket of goods and services. The composition of the basket will vary among economies according to their economic, social, and cultural differences, but each basket will provide equivalent satisfaction or utility.

Price level index (PLI)

PLIs are the ratio of PPPs to exchange rates. They provide a measure of the differences in price levels between economies by indicating for a given aggregation level the number of units of the common currency needed to buy the same volume of the aggregation level in each economy. At the level of GDP, they provide a measure of the differences in the general price levels of economies.

Balassa-Samuelson or Penn effect

The overstatement of the economic size of high-income economies with high price levels and the understatement of the economic size of low-income economies with low price levels that result when exchange rate-converted GDPs are used to establish the relative sizes of economies. It arises because exchange rates do not take into account price level differences between economies when used to convert their GDPs to a common currency.

Source: World Bank (2015a)

Appendix C. List of item categories in household consumption

Category	Description
Food and nonalcoholic beverages	Household expenditure on food products and nonalcoholic beverages purchased for consumption at home (excludes food products and nonalcoholic beverages sold for immediate consumption away from home by hotels, restaurants, cafés, bars, kiosks, street vendors, automatic vending machines, etc.; cooked dishes prepared by restaurants for consumption off their premises; cooked dishes prepared by catering contractors, whether collected by the customer or delivered to the customer's home; and products sold specifically as pet foods).
Alcoholic beverages, tobacco, and narcotics	Household expenditure on alcoholic beverages purchased for consumption at home (includes low or nonalcoholic beverages that are generally alcoholic such as nonalcoholic beer, and excludes alcoholic beverages sold for immediate consumption away from the home by hotels, restaurants, cafés, bars, kiosks, street vendors, automatic vending machines, etc.) and household expenditure on tobacco (covers all purchases of tobacco, including purchases of tobacco in cafés, bars, restaurants, service stations, etc).
Clothing and footwear	Household expenditure on clothing materials; garments for men, women, children, and infants; other articles of clothing and clothing accessories; cleaning, repair, and hire of clothing; all footwear for men, women, children, and infants; and repair and hire of footwear.
Housing, water, electricity, gas and other fuels	Household expenditure on actual and imputed rentals for housing; maintenance and repair of the dwelling; water supply and services related to the dwelling; and electricity, gas and other fuels. Also includes expenditure of Non-Profit Institutions Serving Households (NPISHs) on housing, and general government expenditure on housing services provided to individuals.
Furnishings, household equipment and maintenance	Household expenditure on furniture and furnishings; carpets and other floor coverings; household textiles; household appliances; glassware, tableware, and household utensils; tools and equipment for house and garden; and goods and services for routine household maintenance.
Health	Household expenditure on pharmaceuticals; medical products, appliances, and equipment; outpatient services; and hospital services. Also includes expenditure of NPISHs on health, plus general government expenditure on health benefits and reimbursements and the production of health services.
Transport	Household expenditure on purchase of vehicles, operation of personal transport equipment, and transport services.
Communication	Household expenditure on postal services, telephone and telefax equipment, and telephone and telefax services.
Recreation and culture	Household expenditure on audiovisual, photographic, and information processing equipment; other major durables for recreation and culture; other recreational items and equipment; gardens and pets; recreational and cultural services; newspapers, books, and stationery; and package holidays. Includes expenditure of NPISHs on recreation and culture, plus general government expenditure on recreation and culture.
Education	Household expenditure on pre-primary, primary, secondary, postsecondary, and tertiary education. Includes expenditure of NPISHs on education plus general government expenditure on education benefits and reimbursements and the production of education services.
Restaurants and hotels	Household expenditure on food products and beverages sold for immediate consumption away from the home by hotels, restaurants, cafés, bars, kiosks, street vendors, automatic vending machines, etc. (includes cooked dishes prepared by restaurants for consumption off their premises; cooked dishes prepared by catering contractors, whether collected by the customer or delivered to the customer's home); and household expenditure on accommodation services provided by hotels and similar establishments.
Miscellaneous goods and services	Household expenditure on personal care, personal effects, social protection, insurance, and financial and other services. Includess expenditure by NPISHs on social protection and other services plus general government expenditure on social protection.
Individual consumption expenditure by households	Total value of actual and imputed final consumption expenditures incurred by households on individual goods and services; also includes expenditure on individual goods and services sold at prices that are not economically significant.

Source: World Bank (2015a). *Note: Education* is not included.

Appendix D. Share of household expenditures on food in urban Africa

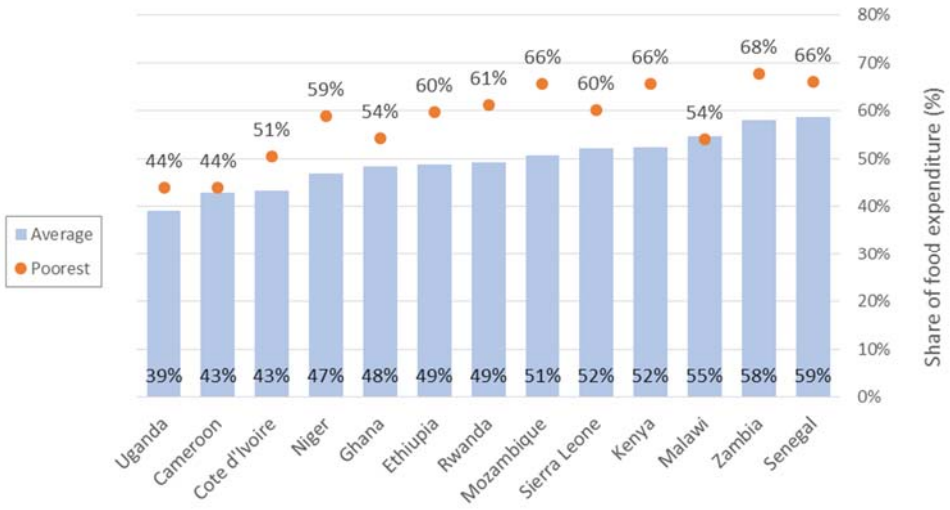

Figure D1. Share of food in household expenditure in urban Africa

Note: Poorest refers to the group of households at the first quintile in income distribution in each country's urban area.

Sources: Côte d'Ivoire, Enquête sur le Niveau de Vie des Ménages (ENV) 2008; Cameroon, Enquête Camerounaise Anprés des Ménages (ECAM-3) 2007; Ethiopia, Welfare Monitoring Survey and Household Income, Consumption, and Expenditure Survey (WMS-HICES) 2004; Ghana, Ghana Living Standards Survey (GLSS) 2005; Kenya, Kenya Integrated Household Budget Survey (KIHBS) 2005; Mozambique, Inquérito ao Orçamento Familiar (IOF) 2008; Malawi, Integrated Household Survey (IHS-3) 2010; Niger, National Survey on Household Budget and Consumption (ENBC) 2007; Rwanda, Integrated Household Living Conditions Survey (EICV2) 2005; Senegal, Enquête Sénégalaise sur les Priorités (ESP) 2005; Sierra Leone, Sierra Leone Integrated Household Survey (SLIHS) 2003; Uganda, National Panel Survey (NPS) 2010; and Zambia, Living Conditions Monitoring Survey (LCMS VI) 2010.

Appendix E. List of cities in EIU data used for this paper

Region	City (countries/economies)
Sub-Saharan Africa (8)	Abidjan (Côte d'Ivoire), Dakar (Senegal), Douala (Cameroon), Harare (Zimbabwe), Johannesburg and Pretoria (South Africa), Lagos (Nigeria), Nairobi (Kenya)
Europe-OECD (58)	Auckland and Wellington (New Zealand); Adelaide, Brisbane, Melbourne, Perth, and Sydney (Australia); Amsterdam (Netherlands); Athens (Greece); Atlanta, Boston, Chicago, Cleveland, Detroit, Honolulu, Houston, Los Angeles, Miami, Minneapolis, New York, Pittsburgh, San Francisco, Seattle, and Washington DC (United States of America); Barcelona and Madrid (Spain); Berlin, Düsseldorf, Frankfurt, Hamburg, and Munich (Germany); Bratislava (Slovakia); Brussels (Belgium); Budapest (Hungary); Calgary, Montreal, Toronto, and Vancouver (Canada); Dublin (Ireland); Geneva and Zurich (Switzerland); Helsinki (Finland); Copenhagen (Denmark); London and Manchester (United Kingdom); Lisbon (Portugal); Lyon and Paris (France); Milan and Rome (Italy); Osaka and Tokyo (Japan); Oslo (Norway); Prague (Czech Republic); Seoul (Republic of Korea); Singapore (Singapore); Stockholm (Sweden); Taipei (Taiwan, China)
Middle East and North Africa (14)	Abu Dhabi and Dubai (United Arab Emirates), Algiers (Algeria), Amman (Jordan), Cairo (Egypt), Casablanca (Morocco), Doha (Qatar), Jeddah and Riyadh (Saudi Arabia), Kuwait City (Kuwait), Muscat (Oman), Tel Aviv (Israel), Tehran (Iran), Tunis (Tunisia)
Eastern Europe and Central Asia (11)	Almaty (Kazakhstan), Baku (Azerbaijan), Belgrade (Serbia), Bucharest (Romania), Istanbul (Turkey), Kiev (Ukraine), Moscow (Russia), Sofia (Bulgaria), St Petersburg (Russia), Tashkent (Uzbekistan), Warsaw (Poland)
Latin America (14)	Asunción (Paraguay), Buenos Aires (Argentina), Bogotá (Colombia), Caracas (Venezuela), Guatemala City (Guatemala), Lima (Peru), Montevideo (Uruguay), Mexico City (Mexico), Panama City (Panama), Quito (Ecuador), Rio de Janeiro, São Paulo (Brazil), San Jose (Costa Rica), Santiago (Chile)
East Asia and the Pacific (16)	Bangkok (Thailand); Beijing, Dalian, Guangzhou, Qingdao, Shanghai, Shenzhen, Suzhou, and Tianjin (China); Ho Chi Minh City and Hanoi (Vietnam); Hong Kong (Hong Kong SAR, China); Jakarta (Indonesia); Kuala Lumpur (Malaysia); Manila (Philippines); Phnom Pen (Cambodia)
South Asia (6)	Colombo (Sri Lanka), Dhaka (Bangladesh), Kathmandu (Nepal), Karachi (Pakistan), Mumbai and New Delhi (India)

Appendix F. List of non-alcohol food items in the EIU data

Apples (1 kg) (supermarket)	Margarine, 500g (supermarket)
Apples (1 kg) (mid-priced store)	Milk, pasteurized (1 l) (supermarket)
Bacon (1 kg) (supermarket)	Milk, pasteurized (1 l) (mid-priced store)
Bacon (1 kg) (mid-priced store)	Mineral water (1 l) (supermarket)
Bananas (1 kg) (supermarket)	Mineral water (1 l) (mid-priced store)
Bananas (1 kg) (mid-priced store)	Mushrooms (1 kg) (supermarket)
Beef: filet mignon (1 kg) (mid-priced store)	Mushrooms (1 kg) (mid-priced store)
Beef: filet mignon (1 kg) (supermarket)	Olive oil (1 l) (supermarket)
Beef: ground or minced (1 kg) (supermarket)	Olive oil (1 l) (mid-priced store)
Beef: ground or minced (1 kg) (mid-priced store)	Onions (1 kg) (supermarket)
Beef: roast (1 kg) (supermarket)	Onions (1 kg) (mid-priced store)
Beef: roast (1 kg) (mid-priced store)	Orange juice (1 l) (mid-priced store)
Beef: steak, entrecote (1 kg) (supermarket)	Orange juice (1 l) (supermarket)
Beef: steak, entrecote (1 kg) (mid-priced store)	Oranges (1 kg) (supermarket)
Beef: stewing, shoulder (1 kg) (supermarket)	Oranges (1 kg) (mid-priced store)
Beef: stewing, shoulder (1 kg) (mid-priced store)	Peaches, canned (500 g) (supermarket)
Butter, 500 g (mid-priced store)	Peaches, canned (500 g) (mid-priced store)
Butter, 500 g (supermarket)	Peanut or corn oil (1 l) (supermarket)
Carrots (1 kg) (supermarket)	Peanut or corn oil (1 l) (mid-priced store)
Carrots (1 kg) (mid-priced store)	Peas, canned (250 g) (supermarket)
Chicken: fresh (1 kg) (supermarket)	Peas, canned (250 g) (mid-priced store)
Chicken: fresh (1 kg) (mid-priced store)	Pork: chops (1 kg) (supermarket)
Chicken: frozen (1 kg) (supermarket)	Pork: chops (1 kg) (mid-priced store)
Chicken: frozen (1 kg) (mid-priced store)	Pork: loin (1 kg) (supermarket)
Coca-Cola (1 l) (supermarket)	Pork: loin (1 kg) (mid-priced store)
Coca-Cola (1 l) (mid-priced store)	Potatoes (2 kg) (mid-priced store)
Cocoa (250 g) (supermarket)	Potatoes (2 kg) (supermarket)
Cocoa (250 g) (mid-priced store)	Sliced pineapples, canned (500 g) (supermarket)
Cornflakes (375 g) (supermarket)	Sliced pineapples, canned (500 g) (mid-priced store)
Cornflakes (375 g) (mid-priced store)	Spaghetti (1 kg) (supermarket)
Drinking chocolate (500 g) (supermarket)	Spaghetti (1 kg) (mid-priced store)
Drinking chocolate (500 g) (mid-priced store)	Sugar, white (1 kg) (supermarket)
Eggs (12) (supermarket)	Sugar, white (1 kg) (mid-priced store)
Eggs (12) (mid-priced store)	Tea bags (25 bags) (supermarket)
Flour, white (1 kg) (supermarket)	Tea bags (25 bags) (mid-priced store)
Flour, white (1 kg) (mid-priced store)	Tomatoes (1 kg) (supermarket)
Fresh fish (1 kg) (supermarket)	Tomatoes (1 kg) (mid-priced store)
Fresh fish (1 kg) (mid-priced store)	Tomatoes, canned (250 g) (supermarket)
Frozen fish fingers (1 kg) (supermarket)	Tomatoes, canned (250 g) (mid-priced store)
Frozen fish fingers (1 kg) (mid-priced store)	Tonic water (200 ml) (supermarket)
Ground coffee (500 g) (supermarket)	Tonic water (200 ml) (mid-priced store)
Ground coffee (500 g) (mid-priced store)	Veal: chops (1 kg) (supermarket)
Ham: whole (1 kg) (supermarket)	Veal: chops (1 kg) (mid-priced store)
Ham: whole (1 kg) (mid-priced store)	Veal: fillet (1 kg) (supermarket)
Instant coffee (125 g) (supermarket)	Veal: fillet (1 kg) (mid-priced store)
Instant coffee (125 g) (mid-priced store)	Veal: roast (1 kg) (supermarket)
Lamb: chops (1 kg) (supermarket)	Veal: roast (1 kg) (mid-priced store)
Lamb: chops (1 kg) (mid-priced store)	White bread, 1 kg (mid-priced store)
Lamb: leg (1 kg) (supermarket)	White bread, 1 kg (supermarket)
Lamb: leg (1 kg) (mid-priced store)	White rice, 1 kg (mid-priced store)
Lamb: Stewing (1 kg) (mid-priced store)	White rice, 1 kg (supermarket)
Lamb: Stewing (1 kg) (supermarket)	Yoghurt, natural (150 g) (supermarket)
Lemons (1 kg) (supermarket)	Yoghurt, natural (150 g) (mid-priced store)
Lemons (1 kg) (mid-priced store)	
Lettuce (one) (supermarket)	
Lettuce (one) (mid-priced store)	
Margarine, 500g (mid-priced store)	

Appendix G: Calculation of PLIs for EIU data

The calculation of purchasing power parities (PPPs), and subsequently price level indices (PLIs), was carried out based on the standard ICP methodology; see World Bank (2015b) for details. At the first stage, elementary PPPs were calculated based on the local currency unit prices[12] from the Economist Intelligence Unit's Worldwide Cost of Living survey, using the Country Product Dummy (CPD) method. The regression equation for the CPD can be written as:

$$\ln p_{cp} = y_{cp} = x_{cp}\beta + \varepsilon_{cp}$$

where P_{cp} is the price of product p in country[13] c; Dc_j and Dp_i are country and product dummies, respectively; Np and Nc are number of products and countries, respectively; and

$$x_{cp} = \left[Dc_2 \ldots Dc_{Nc} Dp_1 Dp_2 \ldots Dp_{Np} \right]$$
$$\beta = \left[\alpha_2 \ldots \alpha_{Nc} \gamma_1 \gamma_2 \ldots \gamma_{Np} \right]^T$$

At the second stage elementary PPPs were aggregated using the using the Gini-Éltetö-Köves-Szulc (GEKS) method. This method is non-additive and consists of two stages. First, the basic heading PPPs were aggregated using the national accounts expenditure structures[14] to obtain the bilateral Fisher PPPs (F-PPPs) for all pairs of countries. For any two economies j and k, the binary F-PPP was computed as:

$$P_{F\,j,k} = \left(\left(\frac{\sum_i p^i_j q^i_k}{\sum_i p^i_k q^i_k} \right) \left(\frac{\sum_i p^i_j q^i_j}{\sum_i p^i_k q^i_j} \right) \right)^{1/2}$$

Second, all direct and indirect F-PPPs were averaged geometrically to obtain the transitive GEKS-PPPs. The GEKS-PPPs were computed as:

$$P_{GEKS\,j,k} = \left(\prod_l P_{F\,j,l} \,/\, P_{F\,k,l} \right)^{1/K}$$

where K is the total number of economies.

Finally, the PLIs were calculated as the ratio of the PPP to the exchange rate, and expressed as a percentage.

[12] Each city was treated separately.
[13] Cities were treated as countries.
[14] National expenditure structures were used as a proxy for city-level expenditure structures.

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