Infrastructure affordability in developed and developing economies: Rules of thumbs and evidence

Bagnoli, Lisa, Salvador Bertomeu-Sanchez and Antonio Estache[1]
ECARES, Université libre de Bruxelles

January 2018

Abstract

This note provides an overview of: (i) the threshold used in policy discussions to assess the extent to which users of an infrastructure service have an affordability problem or not for an acceptable level of consumption of the service as defined by international organizations or sometimes national governments; (ii) the average share of resources allocated to each infrastructure subsector for a sample of 90 countries for developing and emerging economies and for 26 European countries, as a proxy for developed countries practice; and (iii) an assessment of this share for consumption quartiles for developing economies and income quintiles for the European economies. It then produces a series of tables of regional averages which could be used to conduct rough benchmarkings of national observations. Discussions of data limitations and suggestions for additional work conclude the note.

[1]. We are grateful to E. Auriol, C. Crampes , R. Schlirf and F. Trillas for useful discussions. Any mistake in data treatment and interpretation is our responsibility only and should not be attributed to any of the institutions we are affiliated with

1. Introduction

This note summarizes the latest quantitative rules of thumbs and evidence available to assess the affordability of infrastructure services—i.e. energy, ICT, transport and water and sanitation. In policy and regulatory debates on infrastructure, the concern for the affordability of consumption is increasingly replacing the concern for the cost of investments to provide access to these services. Affordability is now an issue across regions, developed and developing, while access is now still an issue in only the poorest countries of the world, mostly in Sub-Saharan Africa (SSA) and South Asia (SA).

At the world level, access rates to electricity, improved water sources and improved sanitation facilities have now reached respectively over 85%, 91% and 68% (and this is biased downward by SSA where access rates are respectively 37.4%, 68% and 30%). Electricity and water access rates in developed economies are almost 100% on all counts. For ICT and transport, there is less agreement as to what access rates actually mean but under most definitions, access has improved significantly and is less of a concern than only a decade ago. For ICT, for instance, a common indicator focuses on internet access. In 2016, according to ITU (International Telecommunications Union) almost 1 household in 2 had access to the internet around the globe. Transport may actually be the only sector in which access issues continue to matter. The 2017 World Bank Global mobility report, unfortunately still relying on an old 2007 study, explains that in 2006 over 1 billion people did not have access to all-weather roads and transport services and that most live in rural areas.[2] This reflects a decision not to invest in quality infrastructure. But it may also be linked to the inability of authorities to rely on affordable pricing to recover the high investment costs as all-weather roads are significantly more expensive than any other type of roads.

So now that access issues are well on their way to being addressed, the next question is whether there is a match between the ability to pay for the services and the costs of an average consumption bundle for an average family. In theory, there are good reasons to worry. In most countries, the demand for infrastructure services is relatively inelastic to prices and their social impact can be quite important as it drives the effectiveness with which individuals can enjoy key dimensions of modern well-being standards, including good health, education and jobs. In most countries also, the prices of these services need to be regulated because their providers can enjoy quite significant market power. This power implies that, without regulation, they would have strong incentives to increase prices while controlling supply. The policy implication is that affordability is, at least partially, the outcome of the effectiveness with which providers are regulated in the way they deliver a service for which their clients have few alternatives. And this is why, affordability is a matter of concern in practice as much as it is in theory.

Regulating to achieve affordability is quite a technical exercise in practice. It demands the ability to design and implement complex pricing structures and subsidies to try to target those who need support the most as effectively as possible. And it also demands that this be done without imposing an unsustainable financial burden on the firms or on taxpayers. Whatever regulatory experts do, the outcome has to be that the financial burden imposed by the consumption of reasonable levels of consumption by the lowest and middle income classes is consistent with a reasonable profit or a

[2] World Bank (2017), Global Mobility Report, Washington, D.C. quoting Roberts, P., K. C. Shyam, and C. Rastogi 2006. Rural Access Index: A Key Development Indicator. Transport Papers TP-10. Washington, DC: World Bank.

fiscally sustainable level of subsidies. But before getting to decide how to design regulation to address these multiple goals, any regulator needs to get a sense of the extent to which the prevailing pricing and subsidies structures lead to affordability. And this requires some quantitative measure of affordability.

To be able to get a sense of how affordable services are, the most common approach adopted in regulatory debates at the country level is to estimate the share of its income a person or family has to allocate to a reasonable consumption level of these services. To assess whether the share observed in any given country, it is often useful to benchmark this measure internationally. But this is not an easy exercise since the demand for some services may vary significantly across countries and within countries. An individual farmer may consume more water than a civil servant working in the capital city. Any individual living in a country with long and cold winters is likely to consume more energy for heating than someone living under mild skies. But despite these limitations, which clearly need to be accounted for when comparing countries or regions, it is useful to try to come up with a rough sense of how much people actually spend on these services as a share of their income. And there is data to do so.

Without claiming to provide a definitive cross-country benchmark, the following discussion tries to use this data to produce specific estimations of the basic definition of affordability anchored. The estimation tries to rely as much as possible on internationally comparable data as possible. To do so, the note: (i) takes stock of the cross-country data available to the international community on how much people pay for energy, water, transport and ICT services across income level, (ii) highlights recurrent patterns in the characterization of the correlation between income levels on the one hand and the expenditure on the various subsectors extracted from household surveys, (iii) produces summary tables which can be used in a broad range of contexts to benchmark the affordability of infrastructure services, and, (iv) analyzes the evolution of the changes in the share of total expenditures on infrastructure to complement the widely available policy rules of thumbs on the affordability of subsectors. The discussion on total expenditure is particularly important as, even if policies specific to each subsector may be able to keep affordability for the poorest just below some reasonable thresholds for individual expenditure categories, the sum of these acceptable achievements may add up to an unacceptable situation for many families.

The estimations are based on a synthesis, and occasionally a cleaning, of data available from various sources. *For developing countries*, the Word Bank is, for now, the best source of comparable information across countries for each subsector. It has produced a few much needed recent quantitative snapshots on electricity and transport to complement the data already available to the international community from the Joint Monitoring Program focusing on the water and sanitation subsectors.[3] The World Bank has also collected a very broad sample of household expenditure surveys and largely standardized the information. This is essentially what allows the quantitative

[3] For Energy, see for instance, World Bank (2016), The Regulatory Indicators for Sustainable Energy (RISE), available at http://documents.worldbank.org/curated/en/538181487106403375/Regulatory-indicators-for-sustainable-energy-a-global-scorecard-for-policy-makersl; for transport, see World Bank (2017) Global Mobility Report 2017, available at https://openknowledge.worldbank.org/bitstream/handle/10986/28542/120500.pdf; as for water and sanitation, see JMP (2017), Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines, available at https://washdata.org/reports.

sense of the linkage between the income levels and infrastructure expenditure levels for developing countries reported here.

For developed economies, the best equivalent and comparable data covering a large sample of countries focuses on the member of the European Union. Although not strictly comparable to the World Bank data, the data is robust enough to show that affordability is not just a developing country issue.[4] Similar observations can be made for data available on North America. And although the data from developed and developing countries is not strictly comparable, the broad insights provide solid reliable quantitative support to the recurrent and growing number of country specific claims that, quite often, the poor may not be able to afford basic infrastructure services even when they potentially have access to it, whether the countries are rich or poor.

Bringing all this data together in a single place may be on the main contributions of this paper. This is in addition to get policymakers and academics to get a concrete sense of what the affordability challenge means in practice. Despite the growing visibility of the affordability problem in academic journals and policy debates, very little of the data reported here is used in these debates. Any test of the lack of quantitative sense of the concept of affordability is to ask any audience concerned with infrastructure how much households spend on infrastructure. The question is too often likely to lead to confused and confusing answers, including among sector specialists. Moving on to ask each person in the audience to put a figure on how much they spend themselves on these services will lead to few precise answers as well. Concluding with a question on whether they expect to spend a larger share of their income of these services as their income improves, the same knowledge gaps are likely to prevail.

Increasing the dissemination and hence awareness of the evidence available thus seems like a worthwhile effort. The note should serve as a survey to be used to benchmark country specific diagnostics first. Hopefully, the awareness of the data available will also motivate additional analytical research on what makes or kills affordability. To be as detailed and short as possible and as useful as possible to a diversified audience from both develop and developing countries, the note is organized as follows. Section 2 is a reminder of the rules of thumbs used by practioners to identify affordability thresholds. Section 3 reports the evidence for developing countries. Section 4 does the same for the EU and North America. Section 5 draws some general insights from the data reported. The data is available on the following website:

http://ecares.ulb.ac.be/index.php?option=com_content&task=view&id=168&Itemid=367.

2. Defining affordability thresholds

Affordability usually refers to the match between a household income and the bills this household has to pay for consuming a basic basket of (or essential) goods and services. In most discussions of affordability, the first topic is the specification of the minimum level of consumption or the acceptable level of consumption that should be achieved by policies to ensure an acceptable match for all citizens, but in particular the poor since they are the most at risk. Unfortunately, in the context of infrastructure, there is little coherence across regions or across subsectors. The specifications of this minimum consumption level vary in details and coverage and only focus on

[4] The OECD also collects some of the data but, to our knowledge, the data available to the public does not report differences in expenditures across income classes for the various infrastructure subsectors.

electricity and water. Since transport is so dependent on location and on the nature of the physical stock of modal assets available, it makes little sense to come up with an average quantitative transport bundle approximating the basic needs of individuals and so alternative measures are needed. The number and distance of trips may indeed be much more sensitive to the context than it is for energy and water. Similarly, since ICT is such a fast changing and dynamic industry that the concept of a standardized bundle to meet the basic needs of any user is hard to imagine.

For electricity, in developing countries, the subsistence volume of electricity is usually estimated at about 1 kWh/day for residential users.[5] This is well below the expected level of consumption deemed to be desirable and acceptable in developed economies. In North America, average individual consumption is about 12-15kWh/day. In Germany or the UK it is less than half that amount while in countries such as Brazil or China, it is about 20% that amount (although it is growing fast). The heterogeneity in average consumption levels observed in developed economies can be partially explained by differences in dimensions such as climate. But they also reflect strong differences in preferences which could be categorized as cultural. Energy dependence is stronger in North America or Australia than it is in Europe in general for instance. These differences also influence what is deemed to be affordable as discussed later.

For water, the WHO suggests that a minimum of 7.5 litres per capita per day meets the very basic requirements of most people under most conditions. A quantity of about 20 litres per capita/day would cover basic hygiene needs and basic food hygiene. And with 100 litres per capita/day, most individuals should have enough to do most of what modern societies crave for. These are useful guidelines to get a sense of the consumption levels affordability for all needs to address in developing countries and to anticipate how much consumptions expectations are likely to evolve. But it is less useful for developed economies. The experience suggests that they consume much more than suggested by WHO guidelines. And to a large measure, this is simply because modern standards of living are such that many water intensive household equipments are seen as entitlements and have raised the standard of what minimum water consumption needs are in the mind of most residents od developed economies (i.e. taking a bath consumes 150-300 litres, a shower, 50-100 litres, flushing a toilet, 10 litres, washing dishes by hand or machine, 20-40 litres, laundry, 40-80 litres, Leaving the water running for 90 seconds to brush teeth, 15-20 litres). This is not to say that some countries are higher water users than others. The average individual in England uses around 150 litres/day but in Spain, she/he uses 265 litres/day.[6]

All of these "basic needs" have been priced explicitly or implicitly and turned into threshold expressed as a share of income. If anyone needs to spend more than these thresholds, the assumption built in policies is that it means that they may have to ration some other expenditure such as health or food. It may, of course, also reflect a strong preference for a specific service but this is more likely to apply to higher income classes. Rich people are more likely to be able to afford expensive individual transport modes than the poor and this would undoubtedly lead them to spend much more than the threshold. They are also more likely to invest in swimming pools and hence consume more water.

[5] See for instance the discussion in RiSE (2016).

[6] For more details on the European water consumption, see http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Water_use_by_households_and_the_manufacturing_industry,_from_public_water_supply_and_self_and_other_supply,_2015_(m%C2%B3_per_inhabitant)_V3.png

The current values of these thresholds are summarized in Table 1. The table reports the most common values used at the sub-sector level. It also reports a common rule of thumb used for the total expenditures on infrastructure services. This is not based on a formal analytically robust definition of affordability related to the cost of infrastructure services. But it is used in poverty diagnostics by international organization benefiting from their diversified exposure across countries. Some of these rules have actually become quite formal and built-in by international and national policy.

The most formal rule of thumb is for water supply and sanitation as it is defined by the World Health Organization. It suggests that 5% of income should be the maximum anyone should spend on her/his water and sanitation needs—3.5% for water alone. Many countries, both developed (US and Northern Ireland) and developing (e.g. Argentina Chile, Indonesia, Kenya, Lithuania or Mongolia) ranging from Mongolia to Argentina) have made an explicit commitment to adapt their water pricing policies to comply with this rule.

Table 1: Affordability threshold rules of thumb
(expenditure on service as % of income beyond which poor consumers may have to ration consumption)

	Water	Sanitation	Electricity (and gas)	Transport	Infrastructure (including communication services)
Developed economies	3-3.5%	1.5%	Up to 10%	No rule in place	No rule in place
Developing economies	3-3.5%	1.5%	4-5%	15%-20%	20-25%

Authors' compilation from various sources

For electricity, there is no such general rule. For developing and emerging countries, the upper limit is often set at 4-5% of household income for expenses on electricity and gas. For developed countries, there is more heterogeneity. In the UK for instance, this threshold had been set at 10% since the early 2000s by regulators—and is currently being revised downward. But other European countries work with lower threshold as well.

As for transport, there is no general formal rule either. The concern has been a recurring one for developing countries. Armstrong-Wright (1986) suggested for those countries that no more than 10% of the population would have to spend more than 15% of their income on transport but as mentioned earlier, many factors can explain a strong dispersion across experiences. [7] In developed economies, the concern is growing fast. In recent years, the issue has been tackled in creative ways in Australia and the US. For instance, the Australian Automobile Association has now developed a transport affordability index to be updated regularly. [8] The index considers a range of standard modal mixes and distances. The first edition (2016) finds that the most densely populated capital cities in Australia have less affordable transport costs, implying that the poor are more likely to suffer from mobility problems in these cities. With a similar concern in mind, the U.S. Department of

[7] Based on Carruthers et al. (2005), most studies looking at the affordability of transport estimate, for a set period, the percentage of income or expenditure used to make the necessary trips to work, school, health or other social services on transport by a person. Trips are usually priced at the average price.

[8] http://www.aaa.asn.au/storage/aaa-transport-affordability-index.pdf

Housing and Urban Development (HUD) has now produced a website allowing the analysis of the combined cost of housing and transport for an average household budget depending on neighbourhood characteristics and built in environment. [9] This new tool has the potential to be useful in many more countries. [10]

Finally, at the aggregate level, a global rule of thumb recognizes that infrastructure poverty may emerge from the sum of the expenditures that have to be spent on each subsector, even if individually expenditure levels are below the sector specific threshold. This rule of thumb is for now only used for developing countries and, considering only the consumption pattern of the poor, turns around 15% of income (25%. including ICT and transport equipment). There is no equivalent aggregate rule of thumb for developed countries to our knowledge.

3. How much do household actually spend on infrastructure in developing economies?

For developing and emerging economies, the analysis is based on the data reported by the World Bank Global Consumption Database on developing countries. The data corresponds to World Bank estimates of expenditure shares for a fairly detailed level of consumption categories for 90 countries.[11] It is based on national household survey consumption or expenditure survey datasets. [12] Our analysis focuses on consumption shares by country, sector, and income groups for 2010. [13]

In the database, households are categorized in four consumption segments: lowest, low, middle and higher. However, households are assigned to a consumption segment based on their relative position in the global income per capita distribution (computed in PPP$) rather than on their distribution within their country. The details are provided in Table 2. This implies that the data does not allow detailed discussion at the country level since within country groups are not divided into equally sized quartiles. The data instead only allows a discussion of the extent to which an individual within any of the consumption groups in PPP is likely to spend on average on a specific expenditure type. For the poorest countries, most people are likely to fit into the lowest consumption category and only a small share of the population is likely to fit into the higher consumption groups.

Table 2: consumption segment definitions

Consumption segment	Percentile of the global distribution	PPP$ thresholds
Lowest	≤50th percentile	Below $2.97 per capita a day
Low	51th – 75th percentile	Between $2.97 and $8.44 per capita a day
Middle	76th – 90th percentile	Between $8.44 and $23.03 per capita a day
Higher	≥91th percentile	Above $23.03 per capita a day

[9] http://www.locationaffordability.info/

[10] See for instance. Guerra, E. and M. Kirschen (2016), Housing plus transportation affordability indices: uses, opportunities, and challenges, ITF, available at https://www.itf-oecd.org/sites/default/files/docs/housing-transport-affordability.pdf

[11] The list of countries used here is provided in Annex 1.

[12] http://datatopics.worldbank.org/consumption/

[13] If the survey was conducted before 2010, the estimates are obtained by extrapolation and more details on the standardization of data done by the World Bank can be found here: http://datatopics.worldbank.org/consumption/detail#datastandardization

Source: http://datatopics.worldbank.org/consumption/detail#consumptionsegments

Table 3 provides a snapshot of the ways in which the various infrastructure subsectors expenditures have been defined. [14] The data on the ICT subsector has been split to be able to disentangle the basic ICT expenditures from more sophisticated ones and the expenditure of interest her is labelled ICT main since it focuses on phones and related services. The transport subsector has been split as well to disentangle the equipment ownership, such as the ownership of expensive cars, from transport services since this is a major expenditure driver but is not as closely related to services. In many ways, buying expensive cars is often more related to the craving for status recognition than for a concern for mobility.

Table 3: Definition of sectors in the World Bank Database

Sector	Product/service
Energy	Electricity
	Gas
	Other fuels
ICT – Main	Telephone and telefax equipment
	Telephone and telefax services
ICT – Others	Audio-visual, photographic and information processing equipment
	Recording media
	Repair of audio-visual, photographic and information process. Equipment
Water	Water supply
Transport – equipment ownership	Motor cars
	Motor cycles
	Bicycles
	Animal drawn vehicles
	Fuels and lubricants for personal transport equipment
	Maintenance and repair of personal transport equipment
	Other services in respect of personal transport equipment
Transport – Services	Passenger transport by railway
	Passenger transport by road
	Passenger transport by air
	Passenger transport by sea and inland waterway
	Combined passenger transport
	Other purchase transport services

To produce the synthetic tables, we needed to clean the data somewhat. First, when no household was eligible for a certain consumption segment and when no data was available for a certain country, the observation was dropped out. Second, when the country average for a certain consumption segment is constructed with less than 5 households, the observation was left out. Finally, we also removed outliers, this includes the removal of instances for which expenditures shares for the higher group represent less than 0.01% of the total, the removal of the data for the lowest segment for the Fiji Islands for the transport sector since it is the only country above the double of the mean, the removal of the instance in which the share for water was higher than 10% in SSA, the removal of the observations for which the share of the transport sector was over 50% for the middle consumption group and the cases for the higher consumption group for which the share was over 75%.

[14] For more details, see http://databank.worldbank.org/data/download/IFCSurvey/GCD_product_sector_category_description.xlsx

The data allows two types of looks at the correlation between income and the share of income allocated to various infrastructure categories. The first, reported in Table 4, compares these shares across regions and since the regions can be ranked according to their income level, this gives a first sense of the correlation, although a weak one since the regions are all quite heterogeneous in terms of income. To make the relevance of regional income as clear as possible, Table 4 reports the data for the regions ordered according to their income per capita, with LAC enjoying the highest one and SSA the lowers one. [15]

Table 4. Average share of expenditures across sectors and regions (2010), in %

	Energy	ICT – Main	Water	Transport Equipment	Transport Services	Total	Total without transport equipment
LAC	4.6	3.1	1.1	7.4	4.5	20.7	13.3
EECA	6.9	3.4	0.7	6.00	2.9	19.8	13.9
EAP	5.1	2.9	0.7	7.0	2.9	18.6	11.6
MENA	5.4	2.9	1.5	5.1	2.8	17.7	12.5
SA	5.9	2.5	0.3	3.4	3.2	15.5	12.0
SSA	4.7	2.5	1.00	3.9	3.4	15.3	11.5

Note: LAC is Latin America and the Caribbean, EECA is Eastern Europe and Central Asia, EAP is East Asia and the Pacific, MENA is Middle East and North Africa, SA is South Asia and SSA is Sub-Saharan Africa

Source: Author's computation based on cleaned World Bank data set

Table 4 does not provide a strong picture on the correlation between income per capita and the total share of expenditures allocated to infrastructure services. For instance for none of the sectors are SSA or SA, the two poorest regions obvious outliers. [16] Their household do spend less in total (ignoring transport equipment) but there is no clear pattern for the specific subcategories. To get a more precise idea, we also ran simple linear regressions on the share of each subsector on the GDP per capital of the country and on the degree of urbanization, the results are reported in Annex 3. They are only intended to get a somewhat more precise sense of the correlation without getting into an identification of all the necessary control variables. They suggest that for ICT and transport equipment, the income level is a statistically significant determinant of the share of income allocated to these services but find not statistically significant correlation for the other subsectors. The regressions, however, suggest that the shares are also higher for urban households for all subsectors except energy. Overall, this preliminary look at the data confirms the need for a more careful analysis than the first treatment conducted here. And this is what we try to do with the data reported in Table 5. .

Table 5 illustrates the second way of linking income and expenditure shares on infrastructure. It looks at the information per consumption groups, as a proxy of income categories, within regions. Within each region, the table shows how the share of income allocated to each category of infrastructure roughly evolves with income. This alternative measure of correlation between income

[15] In 2016, the World Bank indicators suggest that the income per capita for LAC, EECA, EAP, MENA, SA and SSA was respectively US$8311, 7167, 6589, 2890, 1637 and 1464.

[16] The unbundling of the data between urban and rural households is reported in the Annex 2.

level and expenditure produces a few simple insights, including some somewhat less intuitive than expected and which deserve to be analysed more technically than we aim at here.[17]

Table 5: Sectoral and regional shares according to consumption/income groups (2010), in %					
		Lowest	Low	Middle	Higher
Energy	LAC	6.65	5.52	4.04	2.55
	EECA	7.45	7.56	6.74	4.75
	EAP	5.64	5.23	4.39	2.82
	MENA	5.43	5.53	5.57	3.19
	SA	6.74	5.57	4.21	2.30
	SSA	4.64	4.91	4.46	2.93
ICT – Main	LAC	2.02	3.06	3.67	3.14
	EECA	2.67	3.25	3.58	3.50
	EAP	1.81	3.06	3.67	3.43
	MENA	1.78	2.73	3.60	3.63
	SA	1.89	2.95	3.40	2.35
	SSA	1.59	3.46	4.24	3.79
Transport – Equipment ownership	LAC	1.40	4.02	11.72	19.32
	EECA	1.34	3.20	6.30	13.43
	EAP	3.39	6.91	13.40	25.61
	MENA	1.52	3.11	8.59	17.96
	SA	1.06	3.50	11.09	23.81
	SSA	1.54	3.85	9.88	25.62
Transport – Services	LAC	4.46	5.19	4.34	2.37
	EECA	2.11	2.86	3.10	2.52
	EAP	1.84	3.00	2.79	3.08
	MENA	2.30	3.08	2.61	2.32
	SA	2.69	3.33	3.11	4.53
	SSA	2.74	4.47	4.30	3.73
Water	LAC	1.15	1.30	1.10	0.81
	EECA	0.65	0.75	0.68	0.53
	EAP	0.59	0.78	0.69	0.58
	MENA	1.21	1.56	1.54	1.03
	SA	0.24	0.36	0.39	0.44
	SSA	0.80	1.23	1.16	1.11
Total	LAC	15.67	19.09	24.87	28.20
	EECA	14.21	17.63	20.41	24.73
	EAP	13.27	18.98	24.94	35.52
	MENA	12.24	16.00	21.91	28.12
	SA	12.62	15.71	22.19	33.43
	SSA	11.30	17.92	24.04	37.18
Total without equipment ownership	LAC	14.27	15.06	13.15	8.88
	EECA	12.87	14.43	14.11	11.30
	EAP	9.89	12.07	11.55	9.90
	MENA	10.72	12.89	13.32	10.16
	SA	11.56	12.22	11.10	9.62
	SSA	9.76	14.07	14.16	11.56
Note: LAC is Latin America and the Caribbean, EECA is Eastern Europe and Central Asia, EAP is East Asia and the Pacific, MENA is Middle East and North Africa, SA is South Asia and SSA is Sub-Saharan Africa					
Source: Author's computation based on cleaned World Bank data set					

[17] The actual partial correlations for each infrastructure sub-category are reported in aggregate in Annex 4. They measure the correlation between the expenditure shares of each income/consumption group with the share of each of the other categories.

First, there is a clear correlation between income segments and expenditures shares. Second, the correlation can be either negative or positive. It is negative for energy and to a lesser extent water. Higher income groups clearly spend a lower share of their income on energy and lower income groups reach the affordability threshold in almost every region. The correlation is positive in every region for transport equipment ownership. Higher income classes spend much more on these private vehicles than lower income classes. Third, in almost every region (except SSA where access rates still mostly favour the rich), when transport equipment is ignored, none of the groups reaches the affordability threshold identified earlier. Latin America is however quite close to having an affordability issue for the low and middle income classes. Fourth, water seems to be particularly affordable in all regions since it represents only a very small fraction of income in all regions (at most 1.6% for the middle income classes in MENA). This may be linked to the fact that in most regions, water is highly subsidized. Fifth, the fact that affordability does not seem to be an issue for the lowest income classes may simply be the reflection of a de facto self-rationing many of them need to live with. But figuring this out would demand more detailed data on consumption and pricing than international databases allow for.

Since our main ambition for the note is to simply provide a basic sense of the importance of these expenditure categories, the analysis will not go any further at this point. But it is clear that since the data covers 90 countries, it allows for a much more detailed and robust assessment of the extent to which the allocation of income across these expenditures categories evolves over time. It would be just as useful to look at the extent to which they are influenced by pricing, regulation and other institutional arrangements characterizing the sectors.

4. How much do household actually spend on infrastructure in *developed* economies?

In developed economies, since the 2008 crisis in particular, the concern for affordability has become a recurrent concern in policy debates. In 2016, 9.4% of the EU population was unable to afford the cost of keeping their homes adequately warm, and as much as about 40% in Bulgaria and over 25% in Lithuania, Greece and Cyprus.[18] In the UK, the poorest third household have to allocate a share of their income to water bills about 2.5 times the average share of 1.6%. In the USA, between 2011 and 2013, low-income households paid over twice as much as the median household and three times as much as higher income households. [19] Based on 2014 water rates, 11.9% of all US households with incomes below US$32,000 allocate more than 4.5% of their income to pay for water services. [20]

To have a sense of the levels of expenditure for a large sample of developed economies for which the data is comparable across countries, we rely on the data on the member of the European Union because it is available for each infrastructure service across income groups. The data has been retrieved from *Eurostat,* and compiled by the United Nations Statistic Division in the Classification of Individual Consumption according to Purpose (COICOP). It covers 26 countries (Austria, Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Cyprus, Latvia, Lithuania, Hungary, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, and United Kingdom).

[18] Pye et al. (2015)
[19] Energy Efficiency for All, American Council for an Energy-Efficient Economy (2016),
[20] Mack and Wrase (2017)

The subcategories cover largely the same items as for developing countries although not precisely. More specifically, Water and sanitation covers maintenance and repair of the dwelling (CP043 in the Eurostat database), water supply and miscellaneous services relating to the dwelling (CP044); Electricity, gas and other fuels covers electricity (CP0451), gas (CP0452), liquid fuels (CP0453), solid fuels (CP0454), and heat energy (CP0455) (disaggregated data not available); Transport covers the purchase of vehicles (CP071), operation of personal transport equipment (CP072), transport services (CP073) and ICT covers postal services (CP081), telephone and telefax equipment (CP082), telephone and telefax services (CP083). Table 6 reports the average share per income quintile for the year 2010, the latest one for which all the required data is available to the public. And as for developing economies, the total column is computed as the sum of % values for a specific quintile. The average row is computed as the average of quintiles for a specific category to ease the comparison with Table 5.

Table 6: Structure of consumption expenditure by income quintile
2010 EU Average, in %

	Quintile					
	First	Second	Third	Fourth	Fifth	Average
Electricity, gas and other fuels	9.49	8.32	7.55	6.70	5.61	7.53
ICT	3.70	3.68	3.73	3.69	3.36	3.63
Transport vehicle ownership	5.13	7.48	9.24	11.05	12.34	9.05
Transport services alone	1.52	1.41	1.37	1.40	1.57	1.45
Water and sanitation	4.07	4.13	4.05	3.94	3.80	4.00
Total	23.91	25.02	25.94	26.79	26.67	25.67
Total without transport vehicle ownership	18.78	17.54	16.7	15.73	14.34	16.61

Source: Authors' compilation based on data from EUROSTAT: http://ec.europa.eu/eurostat

Table 6 illustrates why the concern for the affordability of infrastructure services is justified in Europe. For the first four quintiles, the total share of expenditure to be allocated to these services is above the threshold discussed earlier (ignoring for now the cost of vehicle ownership). Even if there is no subsector for which the threshold used as a rule of thumb is violated, the sum of the subsector shares seems to cause a problem. Energy and water expenditure for the bottom 40% of the population in terms of income are the two categories most at risk of leading to affordability issues in Europe.

What is surprising is that to some extent, the concern for affordability may be more justified than in developing countries. Although the data for the developed and developing countries sample are not strictly comparable, they jointly provide the following rough insights. First, energy, ICT and water related expenditures represent a higher share of income in Europe than they do in any of the developing and emerging economies covered by the sample. ICT expenditures shares are however not too different and water related expenditures in developed countries include sanitation for which no data is available for the developing country sample. Second, the share of income allocated to transport services is much lower in Europe than in the developing country sample. This is partially linked to the large subsidies allocated to the transport sector in Europe. Once more, these observations beg for a more detailed follow up. However, they are already quite useful in that they illustrate the challenges of trying to benchmark expenditure shares across country groups. The key is to keep in mind that expenditure shares are related to both consumption and policy decisions and

without information on policy characteristics (e.g. tariff design, subsidies, quality choices,…) , any benchmarking will be subject to limitations.

5. Concluding comments

Besides the data cleaning and dissemination, the paper provides two main groups of insights. First, at the pure policy level, the latest data available suggests that there are some reasons to be concerned with the lack of affordability of reasonable levels of consumption bundles for the poor in both developed and developing regions. The data also shows that affordability is often a stronger concern for the middle income groups than they are for the poor. Maybe because the poor are more rationed, the issue does not appear as aggressively but the fact is that the share of income to be allocated to basic infrastructure services appears to be a growing matter of concern to be accounted for in policy diagnostics. This suggests that there is some work to be done at the regulatory level to come up with more precise diagnostics of pricing and subsidies incidence on a much more systematic basis. This has been done at the country level in some detail but there is seldom much coherence across country studies unless they are conducted as part of a multi-country diagnostic anchored in a common methodology (e.g. Waddams and Deller (2015) for Europe or Estache, Foster and Wodon (2002) for Latin America and Estache and Wodon (2014) for Sub-Saharan Africa). For now, these incidence analyses are still mainly done mostly for academic purposes than for a strict policy purpose. A simple look at the web site of regulators across the world illustrates the low interest in these types of diagnostics despite their tremendous social, and hence political, relevance.

The second take-away is more technical and focuses on the limitations of the affordability measures reported here. First, as illustrated by the differences in approaches we had to rely on for developed and developing countries, data reporting continues to be imperfect. This introduces some uncertainty on the robustness of benchmarking efforts. At the very aggregate level, the information is certainly useful but it is not ready yet to be used at a precise level. The lack of comparability of the data across countries makes international benchmarking too loose to use it for instance to set prices or subsidy levels. Second, measurement issues are not only linked to differences in definitions, they are also linked to the fact that there is a lot of illegal use of many of the services reported here. This implies that actual consumption may be underestimated. Illegal water and electricity connections continue to be quite common in developed countries and allow free riding by many. For many of the poor, this is often the only way to limit rationing. But from a benchmarking perspective, free riding leading to the underestimation of consumption levels is an issue. And it is not only a developing country issue. A 2016 report by the French Government Auditing Office (Cour des Comptes) detailed the level and fraud in the use of public transportation in the French capital in 2013 and estimated that for some lines, this reaches 27% of the use of the service. That was about 244 million trips consumed but not paid for.

From a conceptual perspective, a final of caution is also needed. Indeed, trying to come up with policy readings from simple or fancy correlations between expenditure shares and income implies a fairly naïve assumption on the relation between welfare and expenditure shares. Indeed, it essentially implies a monotonic relation between welfare and the expenditure on any activity as a percentage of income as hinted at by Estupinan et al (2007). The assumption is very tempting but it can be misleading. In practice, the data reported here should convince the reader that this relation may be less monotonic and certainly less predictable than implicitly assumed in some policy and

academic discussions of the uses of affordability measures. The data suggests that there is no reason to assume systematically that households that spend less than a threshold of income or expenditure on a service are necessarily better off than people that spend more. The data on the transport sector is quite clear on this. For instance, rich people are happier to be able to rely on expensive vehicles consuming a lot of energy rather than relying on cheaper public transport. Alternatively, very poor people either walk or do not make many trips because they cannot afford the relatively high price of public transport in their city. They are below the threshold indeed, but not by choice. In sum, benchmarking affordability is certainly a useful exercise, but the details on both the demand and the supply side of this market matter. As often is the case in country specific diagnostics, these details on preferences may actually be the most important driver of what affordability means in practice and this will not be picked up from a very rough benchmarking exercise.

Overall, despite the various limitations of the exercise, the benchmarking reported here should have been useful to help some reader recognize the significant relative importance of the sector in the families' budget. But it is essential to keep in mind that its use should be cautious. There is a clear case to complement the basic correlation analysis reported to her with a more refined and hence robust treatment of the data. Hopefully, this analysis will be conducted in a set of follow-up papers now that the data has been collected and processed.

References

Armstrong-Wright, A. (1986). Urban Transport Systems: Guidelines for Examining Options,.Washington, D.C.: World Bank Technical Paper, Urban Series No. 52

Carruthers, R., M. Dick and A. Saurkar (2005), Affordability of Public Transport in Developing Countries, Transport Papers TP-3, The World Bank Group, Washington D.C., January.

Cours des Comptes (2016), La lutte contre la fraude dans les transports urbains en Île-de-France : un échec collectif, chapter 4 in Rapport Annuel, Paris, available at https://www.ccomptes.fr/sites/default/files/EzPublish/15-lutte-contre-fraude-transports-idf-RPA2016-Tome-1.pdf

Energy Efficiency for All, American Council for an Energy-Efficient Economy (2016), Lifting the High Energy Burden in America's Largest Cities, http://energyefficiencyforall.org/resources/lifting-high-energy-burden-americas-largest-cities

Estache, A. and Q.Wodon (2014), **Infrastructure and Poverty in Sub-Saharan Africa**, Palgrave-Mac-Millan, New York

Estache, A., V. Foster and Q. Wodon (2002), **Accounting for Poverty in Infrastructure Reform – Learning from Latin America's Experience,** World Bank Institute Publications, Studies in Development Series

Estupinan, N.; A. Gomez-Lobo; R. Munoz-Raskin and T. Serebrisky (2007), Affordability and subsidies in public urban transport : what do we mean, what can be done?, World Bank, Policy Research

Mack E.A. and S. Wrase (2017), "A Burgeoning Crisis? A Nationwide Assessment of the Geography of Water Affordability in the United States", PLoS ONE12(1): e0169488. https://doi.org/10.1371/journal.pone.0169488

OFWAT (2016), Affordable for all- How can we help those who struggle to pay their water bills?, London, UK

Pye, S. et al. (2015), Energy poverty and vulnerable consumers in the energy sector across the EU: analysis of policies and measures, INSIGHT_E

Reynaud, A. (2016), "Assessing the impact of full cost recovery of water services on European households", Water Resources and Economics, Volume 14, pp 65-78

Waddams, C. and D. Deller (2015) Affordability of Utilities' Services: Extent, Practice, Policy, University of East Anglia Working Paper 4440

Annex 1: List of countries used in Section 3

Latin America and the Caribbean
Bolivia
Brazil
Colombia
El Salvador
Guatemala
Honduras
Jamaica
Mexico
Nicaragua
Peru

Eastern Europe and Central Asia
Albania
Armenia
Azerbaijan
Belarus
Bosnia and Herzegovina
Bulgaria
Kazakhstan
Kyrgyz Republic
Latvia
Lithuania
Macedonia, FYR
Moldova
Montenegro
Romania
Russian Federation
Serbia
Tajikistan
Turkey
Ukraine

East Asia and the Pacific
Cambodia
China
Fiji
Indonesia
Lao PDR
Mongolia
Papua New Guinea
Philippines
Thailand
Timor Leste
Vietnam

Middle East and North Africa
Djibouti
Egypt, Arab Rep.
Iraq
Jordan
Morocco
Yemen, Rep.
South Asia
Afghanistan
Bangladesh
Bhutan
India
Maldives
Nepal
Pakistan
Sri Lanka

Sub-Saharan Africa
Benin
Burkina Faso
Burundi
Cabo Verde
Cameroon
Chad
Congo, Dem. Rep.
Congo, Rep.
Cote d'Ivoire
Ethiopia
Gabon
Gambia, The
Ghana
Guinea
Kenya
Lesotho
Liberia
Madagascar
Malawi
Mali
Mauritania
Mauritius
Mozambique
Namibia
Niger
Nigeria
Rwanda
Tome and Principe
Senegal
Sierra Leone
South Africa
Swaziland
Tanzania
Togo
Uganda
Zambia

Annex 2: Unbundling of expenditures in developing countries into urban and rural, in %

URBAN		All	Lowest	Low	Middle	Higher
Energy	LAC	4.72	8.03	5.74	4.06	2.59
	EECA	6.59	7.48	7.57	6.45	4.67
	EAP	5.25	6.45	5.56	4.54	2.87
	MENA	5.30	5.46	5.52	5.55	3.42
	SA	5.76	7.36	5.81	4.39	2.43
	SSA	5.18	5.73	5.17	4.51	3.10
ICT –	LAC	3.41	3.41	3.28	3.73	3.19
Main	EECA	3.73	3.30	3.75	3.85	3.80
	EAP	3.44	2.56	3.42	3.88	3.54
	MENA	3.28	2.06	3.02	3.72	3.68
	SA	3.13	2.29	3.22	3.63	2.56
	SSA	3.29	2.27	3.73	4.34	3.93
Transport -	LAC	7.92	1.30	3.77	11.38	18.92
Equipment	EECA	5.81	1.49	2.75	5.89	12.04
ownership	EAP	7.73	3.33	6.01	12.45	24.55
	MENA	5.35	1.16	2.65	7.86	17.17
	SA	4.61	1.11	3.22	10.02	27.74
	SSA	4.91	1.40	3.70	9.86	26.70
Transport -	LAC	4.32	4.19	5.06	4.37	2.34
Services	EECA	3.02	2.14	2.92	3.14	2.50
	EAP	3.05	2.27	3.07	2.90	3.23
	MENA	2.97	2.32	3.18	2.71	2.47
	SA	3.19	2.53	2.53	3.00	4.84
	SSA	4.15	3.44	4.81	4.34	3.76
Water	LAC	1.22	1.74	1.52	1.12	0.82
	EECA	0.80	0.93	1.04	0.77	0.55
	EAP	0.86	1.02	0.99	0.75	0.60
	MENA	1.69	1.84	1.81	1.61	1.11
	SA	0.55	0.48	0.60	0.52	0.45
	SSA	1.31	1.39	1.35	1.23	1.17
Total	LAC	21.59	18.67	19.38	24.66	27.85
	EECA	19.95	15.35	18.03	20.09	23.56
	EAP	20.33	15.64	19.04	24.52	34.77
	MENA	18.60	12.83	16.18	21.44	27.84
	SA	17.24	13.76	15.38	21.56	38.03
	SSA	18.84	14.22	18.75	24.28	38.65

RURAL		All	Lowest	Low	Middle	Higher
Energy	LAC	4.37	5.21	4.59	3.95	2.42
	EECA	7.16	7.15	7.24	7.13	6.07
	EAP	4.80	5.13	4.58	3.25	2.84
	MENA	4.91	5.33	5.07	5.32	2.81
	SA	6.16	6.74	5.53	3.99	1.05
	SSA	4.04	4.04	4.04	4.27	2.36
ICT – Main	LAC	1.85	1.27	2.02	2.70	2.36
	EECA	2.85	2.14	2.77	3.00	2.89
	EAP	2.02	1.52	2.48	2.31	3.21
	MENA	2.18	1.55	2.23	2.77	3.94
	SA	2.19	1.82	2.74	2.76	1.27
	SSA	1.48	1.18	2.63	3.40	6.18
Transport - Equipment ownership	LAC	6.23	1.60	5.61	13.56	34.73
	EECA	6.16	1.37	3.57	7.09	17.74
	EAP	6.49	3.95	8.61	11.96	9.39
	MENA	5.16	1.76	4.10	11.64	31.33
	SA	2.71	1.03	3.86	15.23	61.36
	SSA	2.71	1.65	4.65	11.37	21.23
Transport - Services	LAC	4.83	4.65	5.41	4.07	2.37
	EECA	2.69	1.97	2.70	2.81	2.12
	EAP	2.62	1.62	2.80	2.15	3.20
	MENA	2.45	2.22	3.18	1.73	1.09
	SA	3.21	2.70	3.52	3.67	2.19
	SSA	2.63	2.33	3.48	4.10	4.80
Water	LAC	0.53	0.52	0.54	0.63	0.33
	EECA	0.50	0.64	0.56	0.48	0.39
	EAP	0.36	0.38	0.41	0.38	0.35
	MENA	0.72	0.80	0.77	0.72	0.94
	SA	0.17	0.18	0.16	0.07	0.07
	SSA	0.50	0.48	0.86	0.59	0.68
Total	LAC	17.80	13.25	18.17	24.90	42.21
	EECA	19.35	13.28	16.84	20.51	29.20
	EAP	16.29	12.59	18.87	20.04	18.99
	MENA	15.41	11.66	15.36	22.18	40.11
	SA	14.43	12.48	15.82	25.73	65.94
	SSA	11.36	9.68	15.66	23.73	35.24

Note: LAC is Latin America and the Caribbean, EECA is Eastern Europe and Central Asia, EAP is East Asia and the Pacific, MENA is Middle East and North Africa, SA is South Asia and SSA is Sub-Saharan Africa

Source: Author's computation based on cleaned World Bank data set

Annex 3:

	Energy	ICT	Transport equipment	Transport services	Water
GDP/Capita	0.0000003151 (1.36)	0.00000117***	0.00000266*** (5.30)	-2.71e-08 (-0.10)	-5.84e-09 (-0.06)
Urban household	0.00216 (0.85)	0.0141***	0.0133*** (2.44)	0.0071** (2.32)	0.00626*** (6.10)
Constant	0.0241 *** (10.13)	0.012 *** (5.01)	0.0267*** (5.21)	0.0294*** (10.28)	0.0047*** (4.92)
Number of countries	85	87	88	90	83
Note: t statistic in parentheses and * p<0.1, ** p<00.5 and *** p<0.01					

Annex 4: Correlation of shares per infrastructure categories across income classes

Energy	*Lowest*	*Low Middle*	*High Middle*	*Highest*
Lowest	1			
Low Middle	0.930777	1		
High Middle	0.53503	0.768232	1	
Highest	0.233598	0.314532	0.598373	1

ICT	*Lowest*	*Low Middle*	*High Middle*	*Highest*
Lowest	1			
Low Middle	0.556599	1		
High Middle	0.026192	0.804721	1	
Highest	0.133256	0.382136	0.500112	1

Transport services	*Lowest*	*Low Middle*	*High Middle*	*Highest*
Lowest	1			
Low Middle	0.957088	1		
High Middle	0.864051	0.954176	1	
Highest	0.101035	0.211683	0.33874	1

Water	*Lowest*	*Low Middle*	*High Middle*	*Highest*
Lowest	1			
Low Middle	0.99018	1		
High Middle	0.93305	0.967866	1	
Highest	0.842855	0.867888	0.94287	1