Hedonic Pricing Approach for Urban Infrastructure

Guidance Note

June 2022

Alvina Erman and Ingrid Dallmann
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Background

Urban infrastructure investments often have benefits that are particularly challenging to quantify. Especially investments – such as investments in parks, recreational areas, noise reduction or streetscaping – which carry large potential positive externalities, or co-benefits. The challenge is even more prominent in data-scarce developing country environments. When the economic analysis that informs investment decisions does not incorporate the indirect and intangible benefits of investments, socially beneficial projects may not be implemented, and policy makers may end up making the wrong decisions from an economic standpoint. Financing of investment projects by the World Bank and other International Financial Institutions may also be sub-optimally allocated.

The hedonic pricing method is a data-driven decision-making tool that can be used by policy makers and researchers to quantify the benefits of urban infrastructure investments. This note is an introduction to the hedonic pricing method and provides guidance on its application to assess the benefits of urban infrastructure investments, with a focus on developing countries. The objective is to support task teams in building a value proposition of urban investments that can help inform decisions and to enhance the quality of project economic analysis of urban infrastructure investments. By enabling the monetization of the benefits of a wide range of urban investments, the hedonic pricing method is a tool particularly well-placed to support this effort. At the same time, it is also important to be aware of the method’s limitations to prevent its inappropriate application. These limitations will also be discussed in this note.

The assessment can be done ex ante, to assess the feasibility of a proposed investment, or ex post, to evaluate the benefit of existing infrastructure. Most commonly, the hedonic pricing approach is used to assess the potential benefit of a planned investment, and this will be the focus of this note. However, the approach can also be applied ex post to evaluate the value that households attribute to a given urban infrastructure.

Property pricing is a result of myriad push and pull factors. When people make decisions on where to live, they consider not only the quality of housing and services, but also access to jobs, stores, schools, personal safety, recreational opportunities, public transport, and environmental factors, such as risk of exposure to hazards (e.g., flooding and air pollution) or noise. The hedonic pricing method is a revealed preference approach, that captures the willingness to pay (WTP) for these and other “amenities” (or “disamenities”) by analyzing the drivers of property pricing, based on bundles of housing, amenities, and location characteristics (Bishop et al., 2020; Brueckner, 2011; Rosen, 1974). By estimating the WTP, the method captures the effect that each attribute has on the property value, holding other factors constant. According to consumer demand theory, the WTP equals the value that
the consumer assigns to an amenity (or the avoidance of a disamenity) and can therefore be proxied as the benefit of (avoiding) the said (dis)amenity.

The data needed to apply a hedonic model are often present in household surveys, and are thus reliable and readily available, even in data scarce environments. Data on property pricing is used to apply the hedonic pricing model. Real estate transaction data is preferred. However, other types of data can be used. For example, rent values or data from property listings. Since self-reported rent values are sometimes captured in household survey data, the hedonic model is a promising approach for developing countries, where household survey data are often readily available. The pros and cons and availability of different data options are discussed further below. Since the approach uses observed property prices (mostly), the values obtained are based on actual, rather than assumed or predicted preferences, which is common for other methods that quantify infrastructure benefits. This makes the hedonic pricing method comparatively robust.

This note provides step-by-step guidance on how to apply the hedonic pricing method, focusing particularly on considerations for developing countries. Since an almost unlimited list of urban characteristics can drive property pricing, the focus is on types of data needed to capture the most relevant variables for the purpose of project evaluation – namely, data on property values, data that capture access to the urban infrastructure being evaluated, and data for the most important control variables. The note also discusses the challenges and limitations of the hedonic pricing method.

How to apply a hedonic pricing model

The hedonic pricing method can assess the effects of a large range of urban infrastructure types on property pricing. The data used by the method typically comes from a cross-section of households, with information on property values, housing characteristics, access to public services, and other relevant location-specific characteristics that could influence property pricing and which may be correlated with the urban infrastructure being investigated.

A hedonic pricing function relates the price of a dwelling to the levels of its various attributes. A classic and straightforward specification of a hedonic model for a cross-section of households is:

$$\ln y_i = \alpha + \beta UI_i + \gamma X_i + \epsilon_i$$
The outcome variable \( y \) measures the property value. The property value \( y \) is measured in USD or local currency and should be in natural logs and \( i \) indexes the households.\(^1\). The type of data that can be used to estimate property values is described below.

**UI is a vector of the variables or a single variable of interest, which proxies or directly measures access to the urban infrastructure that is being assessed.** For example, to look at the benefit of sanitation services, variables capturing whether a household has access to piped water, sewage infrastructure, and solid waste collection could be included in UI. As a result, \( \beta \) is a vector of coefficients or a single coefficient estimating the marginal WTP for the urban infrastructure(s) of interest. If, for instance, UI is a dummy variable that equals 1 if a household has access to piped water and zero otherwise, its coefficient \( \beta \) is estimated as \( \hat{\beta} = 0.15 \), and the average rent value is 1000 LCU/month,\(^2\) the interpretation is that gaining access to piped water will increase the property price by approximately 16.2 percent,\(^3\) or 162 LCU. This means that the benefit of having access to piped water in the project area is the number of households in the area that will benefit from the investment (i.e., the number of households which will be provided with access to piped water) multiplied by 162 LCU.\(^4\) The type of data that can be used to estimate access to infrastructure is described below.

**The vector X includes control variables which are additional attributes that influence property pricing and \( y \) is a vector of the implicit prices of these attributes.** Adding control variables will not only provide insightful information on the drivers of property pricing in the area being studied, but it is also crucial for the accuracy of the estimates. Particular attention should be given to variables that are correlated with UI and impact \( y \). For instance, if the investment of interest is slum upgrading, it is important to control for tenure arrangements since the type of tenure affects property values and, at the same time, is correlated with being located in an area eligible for slum upgrading. If the benefit of the infrastructure that is being provided is correlated with other factors that themselves influence housing prices, then failure to include control variables that capture these factors, will lead to omitted variable bias (over- or under-estimation of the benefits of the infrastructure). Variables that are important drivers of property pricing and that are also generally straightforward to capture in available data include dwelling type, i.e., whether it is a house or apartment, size and quality of property, and tenure arrangement. How to obtain these data is discussed below.

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\(^1\) Implicit prices estimated in the hedonic model are assumed to be non-constant, and thus the hedonic estimation should be non-linear.

\(^2\) LCU is an acronym for Local Currency Unit.

\(^3\) The estimated marginal effect of a dummy variable in a log-linear specification is given by \((e^{\hat{\beta}}-1) \times 100\). In this case, \( \exp(0.15)-1 \times 100=16.2 \). The coefficients of continuous variables are interpreted as \( \hat{\beta} \times 100 \).

\(^4\) Data on property value should be corrected by the inflation.
Finally, the equation can be estimated using Ordinary Least Squares (OLS). The error term $\varepsilon_i$ is typically modeled using robust standard to account for heteroskedasticity.

**Measuring property value**

Property values can be measured by using either the value of the dwelling, or the rent paid by the dweller. For property value, transaction prices, asking prices, modeled property values using several inputs, or property values as recalled or “predicted” by the owner could be considered. Rent values can be measured with landlords’ asking prices, or the actual rent paid, as reported by the renter or rent values, or as “predicted” by the owner. In some cases and when relevant, commercial property prices could be used, both, property or rent values. Appendix Table A1 shows different types of data used to capture property value in hedonic model applications in different countries, including types of data sources.

**Property transaction prices, asking prices, or estimated property prices through valuation models are the most reliable measurements of property value for a hedonic application.** Among these sources, transaction prices are preferred compared to asking prices that can be potentially influenced by the sellers’ perceived valuation (Bishop et al., 2020). Property transaction and asking prices, as well as input data for property valuation models, are obtained from public records, real estate databases and websites. Ready-to-use datasets are generally not available, even in developed countries, and significant effort is usually needed to access and construct the datasets needed for analysis (e.g., bureaucracy to access public data, scraping websites for data, digitalizing paper records, etc.). Despite this, examples of hedonic applications to developing countries using these data types exist for Argentina, China, and Indonesia (see, respectively, Rabassa and Zoloa, 2016; Wen, et al., 2018; and Cobian Alvarez and Resosudarmo, 2019). Property transaction data also exist in Chile, Hungary and Poland according to a review carried out by Bishop at al. (2020) but access is more or less restricted.

**Household survey data is a good source of data on property pricing, especially when measured with rent value and it is the most used data source for developing country applications.** Household survey questionnaires typically include questions on rent and since respondents are likely to know how much rent they pay; this generates a reliable estimate. Another advantage of using rent as a property value estimate is that the rental market is more transactional, and prices may therefore better reflect the currently available (dis)amenities, including urban infrastructure. A disadvantage of using reported

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5 In this case, it is important to make sure that the variables the modeled price is based on are not directly associated with the variables of interest in the hedonic model.

6 Recalled is how much the property was originally purchased for and “predicted” is how much the respondents believe the property would sell for today.

7 Some surveys ask respondents what they believe their property would rent for if rented today.
rent is that renters may not be representative of the more general population, including homeowners. Also, in many cities, renters make up a minority of the population which limits the sample size. The recalled purchase price of the property is also based on actual prices, compared to the “predicted” value, discussed below. However, it relies on the respondents’ recall capacity and, more importantly, the data points will reflect historic prices from when the property was purchased and the timing of the recalled transaction will differ across households, making the data potentially unsuited for a hedonic application.

“Predicted” property value has more uncertainty but often better coverage of the population than actual price information. Surveys often capture how much the respondent thinks his/her property will sell or rent for today. The advantage of this measure is that the question can be asked to the total survey population, regardless of their tenure status, increasing the sample size and ensuring the data is more representative. The disadvantage is that the measurement error may be larger than real prices since it is based on hypothetical questions. Furthermore, measurement error may not be random. Self-assessment of housing prices may depend on the respondent’s education level, his/her knowledge of the current housing market, and even his/her subjective attachment to his property. The pricing assessment can also be influenced by expectations of price increase if information of planned infrastructure investments is public. To reduce the bias that results from predicted property values, the hedonic model could control for characteristics of the respondent (such as education, profession, age, and gender) and location fixed effects (like neighborhood fixed effects).

In some cases, commercial rather than residential property pricing is used to assess the impact of urban infrastructure. There may be interest to evaluate the impact of urban infrastructure on commercial property pricing. For example, Berawi et al., (2020) assess how proximity to rail stations affects commercial property prices in Jakarta, Indonesia. In some cases, the use of commercial, as opposed to residential, property prices is more relevant to an evaluation. For instance, the benefits of investing in infrastructure that promotes tourism and creates jobs may be better reflected in commercial rather than residential property prices. In these cases, the model would estimate the private sector WTP to access the infrastructure, which is most likely associated with its impact on profits. This contrasts to households’ WTP to access an amenity, which is interpreted as the value households attribute to the service (welfare) and not profitability. In terms of data, commercial property price data are even more rare than data on residential prices.
Capturing the impact of urban infrastructure (co-benefits)

To select an urban infrastructure variable for the hedonic application, it is first important to understand the impact channel of the infrastructure of interest on the property value. There needs to be a direct link between the co-benefit and property pricing. Urban infrastructure can be classified into water, sanitation, and waste management; transport (overall, road and highway, and public transport); infrastructure for disaster risk reduction; housing and slum upgrading; tourism; streetscaping; and energy. While some of these investments, such as electricity access, are more directly linked to property values, for others, the link is less clear, such as for streetscaping. The data and approach used to capture the effects of urban infrastructure depends on the type of infrastructure that is being assessed.

The impact of urban infrastructure is measured with level of access to the service provided by the infrastructure. If the urban investment of interest is a proposed investment (ex ante) then the variable used in the model will reflect access to similar existing infrastructure in the city of interest. If the objective of the application is to assess the impact of an already existing infrastructure (ex post), then the variable used will capture access to that particular infrastructure. Data sources and approaches are similar for the two scenarios. However, in special cases, when the investment planned is for an infrastructure that doesn’t already exist in the city or when the data needed for the analysis is not available, results from hedonic pricing model applications in comparable cities could be exploited to shed some light on the potential impact of the planned investment. Naturally, such extrapolation of results incurs lot of uncertainties. Not only do the cities need to be comparable, but the investments (the infrastructure assessed and the one proposed) also need to be similar (type, location, type of beneficiaries, etc.). To take into account some of the uncertainty in the cost-benefit analysis, the team could use a range, such as 10 percent higher and lower than the point estimate, to assess sensitivity.
Information on access to infrastructure can be obtained in most household survey datasets, especially for amenities that are supplied directly to households, such as water and sanitation, and electricity. Household survey data sometimes also include information on access to services that are more public by nature, such as access to waste management, quality of road and drainage outside dwelling and information on exposure to disasters (whether the household has been affected by or has a perceived risk of future exposure). The latter could be used to capture the benefit of risk reduction investments. Boxes 1 and 2 detail hedonic price model applications in Kinshasa, Democratic Republic of the Congo (DRC) and Guatemala, respectively, that use household survey data to evaluate the benefit of different urban infrastructure. The application in Kinshasa evaluates the benefits of a World Bank-financed urban resilience project, including improved access to services, such water, and electricity and flood protection. The application in Guatemala assessed the benefit of having access to solid waste collection and sewer infrastructure. Some household survey instruments, such as the World Bank’s Living Standards Measurement Survey (LSMS), include community level surveys that capture information on the quality of, and access to, services at the community level and therefore tend to contain more information on services that are more public by nature than household surveys.


**The objective of the project** was to improve institutional capacity for urban management and access to select infrastructure and services in Kinshasa.

**The valuation of economic benefits of the project** relied on hedonic regression using data from a household survey conducted in 2018-2019 in Kinshasa. The analysis was limited to renters only. The specification was as follows:

\[
\ln y_i = \alpha + \beta U_i + \gamma X_i + \varepsilon_i
\]

where \(y\) measures the self-reported rent value for each household \(i\). \(U\) is a set of categorical and dummy variables that measure access to different types of water sources, sanitation systems, solid waste management, electricity, as well as risk of flooding (captured by whether a household had previously been exposed to a flood) as a proxy for access to risk reduction infrastructure. \(X\) is a set of control variables, which contain housing and location characteristics.

**The results showed** that having access to improved piped water, sanitation, excreta disposals, solid waste management, flood risk reduction and electricity are associated with higher rents. For example, it was found that households that had not been exposed to floods pay between 17 to 22 percent higher rents, indicating that households are willing to pay a premium to live in safer areas. By applying the estimated marginal WTP for each type of urban infrastructure to the average rent value, considering the number of beneficiaries by infrastructure type, the assessment showed that the project has a net present value of US$ 247.5 million.

**Box 2. A hedonic valuation of sanitation services in Guatemala (Vasquez and Beaudin, 2020)**

The objective of the paper was to estimate the benefits of having access to solid waste collection and sewer infrastructure in Guatemala.

The analysis used a subsample of households from the Living Standards Measurement Surveys (LSMS) 2006, 2011 and 2014, composed of urban renters. A hedonic analysis was applied to estimate the value that urban renters assign to sanitation services. The following specification was used:

\[
\ln y_i = \beta U_i + \gamma X_i + \varepsilon_i
\]

where \(y\) is a self-reported rent value for each household \(i\), located in department \(j\), in year \(t\). \(U\) is a set of dummy variables that capture access to municipal solid waste management and private solid waste management, respectively, as well as whether the property is hooked up to a sewer system. \(X\) is a set of control variables, including access to other services (piped water, electricity, and landline communication), number of rooms, and other dwelling features. \(D\) and \(Y\) are department and time fixed effects, respectively. The estimation was done using OLS with pooled data.

The results showed that having access to municipal solid waste services was associated with about 23 percent higher rent. Having access to a private provider was valued even higher, 32 percent and 26 percent higher rent for solid waste and sewer infrastructure, respectively.
Most household survey data can be accessed on the Microdata Library\(^8\) or via the National Statistical Office in the country. In case the team is using non-household survey property value data, the data most likely also contain information on access to services that are more private by nature, such as water and electricity. For information on other services, spatial data may be leveraged.

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\[
\ln y_{ijt} = \beta U_{ijt} + \gamma X_{ijt} + \delta D_j + \mu Y_y + \varepsilon_{ijt}
\]

where \(y\) is a self-reported rent value for each household \(i\), located in department \(j\), in year \(t\). \(U\) is a set of dummy variables that capture access to municipal solid waste management and private solid waste management, respectively, as well as whether the property is hooked up to a sewer system. \(X\) is a set of control variables, including access to other services (piped water, electricity, and landline communication), number of rooms, and other dwelling features. \(D\) and \(Y\) are department and time fixed effects, respectively. The estimation was done using OLS with pooled data.

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**Spatial data is a powerful source of information on city amenities that can be used to capture the co-benefits of different urban infrastructures, especially the ones that are more public by nature.** To capture the effect of more types of infrastructure, such as transport, slum upgrading, disaster risk reduction or streetscaping, complementary data, and in particular spatial data, can be leveraged. For instance, Open Street Map (OSM)\(^9\) has information on the locations of health and education facilities, parks, bus stations, road networks, etc. The benefit of having access to these different amenities, as well as the benefit of the transport network itself, can be captured by, for example, measuring a household’s distance or travel time to the amenity. Hazard risk maps or spatial disaster data based on historic events can be matched with household or property location data to assess the role of disaster risk exposure on property values. The risk level can be captured either using a binary variable (e.g.,

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\(^8\) [https://microdata.worldbank.org/](https://microdata.worldbank.org/)

\(^9\) [https://www.openstreetmap.org/](https://www.openstreetmap.org/)
located in high risk or low risk area) or categorical (not affected, affected once, affected multiple times in the past, if using historical disaster data) or continuous variables (e.g., predicted flood depth) depending on the type of hazard map used.

Table A2 in Appendix includes examples of measurements used to capture the effect of more public urban infrastructure in hedonic applications in developing countries.

**Resources needed to apply a hedonic pricing model**

While the hedonic pricing model itself is straightforward and quick to implement, the effort required to collect and manage the data can be considerable and depends largely on the data that is available (see table 1 for a matrix that indicates the time and effort required for each data type scenario).

- **Effort: Easy.** If household survey data from the study area is available and it contains both a property value variable and information on access to relevant urban infrastructures, as well as control variables, then the analysis can be done in less than a week by a junior analyst with familiarity with household survey and regression analysis.

- **Effort: Medium.** If access to the urban infrastructure of interest is not captured in the household survey data, but publicly available spatial data, such as OSM data or hazard maps are readily available online, they could be leveraged to compute the variables of interest. This requires that the household data disclose information on the location of households. To create the variables, additional support from a geospatial specialist, with strong knowledge of geographic information system (GIS) techniques, is needed. This computational work, plus the analysis, should not take more than 2-3 weeks.

- **Effort: Significant.** When using asking or transaction price data, things are not as straightforward. In a best-case scenario, processed data are available and minimum work is needed to make it fit for use. If the data are geo-located, it will be easy to merge with urban infrastructure variables of interest. For this special case, processing and analysis may only take a few weeks. However, as discussed above, observed property price data is rarely readily available. When data are obtained from websites, which is the case primarily with asking prices, expertise in extracting information off websites (data/web scraping) and deep knowledge of the housing market in the area studied are needed. If data is owned by the government administration, as often is the case with transaction data, obtaining records may require making an official request which can take several weeks or months. Once data is obtained, whether from the web or from public records, significant data cleaning will most likely be needed. It is difficult to predict how much effort is required to be able to map out the property data spatially to be able to link them with the spatial infrastructure data. Obtaining
and processing asking or transaction price data is estimated to take months and the length will depend on country specific factors. Beyond a junior economist and geospatial specialist, obtaining and processing the data may require more advanced programming and data science skills. While this type of data is more challenging to obtain and use, they are the preferred options in terms of robustness of the analysis.

- **Effort: Significant.** When the urban infrastructure variables of interest cannot be computed using readily available data, further work will be required. This will be the case, for example, if hazard maps have to be obtained from a governmental agency or satellite imagery has to be leveraged to compute variables, such as access to green spaces or a slum index. The time and effort needed will depend on the type of data and analysis needed and may require advanced geospatial skills.

- **Effort: Significant.** In countries where household surveys are too old, and asking and transaction price data are not available, a household survey could be conducted. The advantage of collecting data is that questionnaires can be customized according to the information needed. Data collection does not require advanced technical skills and could be managed by the program manager and an economist experienced with household survey data design and collection (with the actual data collection outsourced to a survey firm). However, the process takes 6 months to a year and is expensive. Still, if a big urban development investment is planned for a city without available data, this effort may be worth the investment since the data can be used for many purposes throughout the project and can also serve as baseline data for the investment.

### Table 1. Effort and time matrix for property value and urban infrastructure data

<table>
<thead>
<tr>
<th>Effort level</th>
<th>Time</th>
<th>Property value</th>
<th>Urban infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Self-reported</td>
<td>Observed</td>
</tr>
<tr>
<td>Easy</td>
<td>1 week</td>
<td>-</td>
<td>Survey available, incl. relevant infrastructure info</td>
</tr>
<tr>
<td>Medium</td>
<td>2 weeks</td>
<td>Survey available, incl. property value info</td>
<td>-</td>
</tr>
<tr>
<td>Significant</td>
<td>1-6 months</td>
<td>-</td>
<td>Asking/transaction price data available (online data or public data)</td>
</tr>
<tr>
<td>Significant</td>
<td>6-12 months</td>
<td>Survey data collection</td>
<td>-</td>
</tr>
</tbody>
</table>
Challenges and limitations of the hedonic pricing method

The hedonic pricing approach assumes that the housing market is efficient, i.e., buyers/renters are fully informed and free to move within the market, market prices are set, and transactions costs are equal to zero. This means that identical dwellings should be sold/rented at the same price throughout the defined market. It assumes that people have the ability to select a combination of amenities they prefer, given their income, in a housing market that is free from distortions associated with, among other things, subsidies, taxes, informal and insecure tenure arrangements, and, in some cases, misinformation.

Hedonic price models are applied using data representing a limited period. The results therefore reflect the revealed preferences of dwellers in that moment. If the results are used as an input to a cost-benefit assessment of an investment with a lifespan of several decades, it is important to keep in mind that the analysis is based on “current” observed preferences, and that these may change over time. For example, the implicit price of better access to public transport may decrease over time if more people start working from home.

Informality and weak institutions characterizing many housing markets in developing countries present an additional challenge, since this can result in discrepancies in prices of similar dwellings within the same market. While few housing markets are completely perfect, there are some characteristics in highly informal and underdeveloped housing markets that are important to point out. Both renters and landlords, and buyers and sellers face higher risks in countries with unreliable legal systems and this has consequences for the market functionality. For example, in some contexts, prices tend to be set inside of informal networks, such as family, religious groups or other social groups, instead of in an open market due to the trust that the networks provide. Landlords also tend to request large down payments for renters in less developed contexts, which affects dwellers’ mobility and, by extension, the functioning of the market. In this context, it is important to control for tenure arrangements and tenure security if possible. Also, government housing subsidies cause price distortions, and if possible, subsidized dwellings should not be included in the analysis, unless data availability allows for a correction of this.

This brief guide does not cover all the theoretical and econometric considerations for an application of a hedonic price function. For more detail on the hedonic pricing approach, see the seminal paper of Rosen (1974); best practices covered in Bishop et al., (2020); and a guide to the theory and econometrics of the hedonic method in Taylor (2003).
References


## Table A1: Property pricing measurement

<table>
<thead>
<tr>
<th>Property value measure/variable</th>
<th>Countries/Applications</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transaction prices</td>
<td>Chile, Hungary, Poland, China</td>
<td>Central Bank (Chile), Statistics Office (Hungary, Poland), Real Estate Administration (China)</td>
</tr>
<tr>
<td>Property asking prices</td>
<td>La Plata, Argentina; Shanghai, China</td>
<td>Publication of prices from local real estate agencies</td>
</tr>
<tr>
<td>Modeled property value</td>
<td>Jakarta, Indonesia</td>
<td>Online data, from the National Land Agency for property tax purposes. Modeled property value with data from brokers, online websites, administrative and notary offices, including market transaction prices.</td>
</tr>
<tr>
<td>Rent reported</td>
<td>Brazil; Kinshasa, DRC; Accra, Ghana; Urban areas, Guatemala; Kisumu, Kenya; Islamabad, Pakistan; Kigali, Rwanda; Peri-urban Lusaka, Zambia</td>
<td>Household surveys</td>
</tr>
<tr>
<td>Predicted property value</td>
<td>Dapaong city, Togo</td>
<td>Survey</td>
</tr>
<tr>
<td>Predicted rent value</td>
<td>Mumbai, India</td>
<td>Survey</td>
</tr>
<tr>
<td>Commercial property asking prices</td>
<td>Jakarta, Indonesia</td>
<td>Online real estate marketplaces</td>
</tr>
</tbody>
</table>

## Table A2: Urban infrastructure measurement

<table>
<thead>
<tr>
<th>Sector</th>
<th>Urban infrastructure</th>
<th>Urban infrastructure measure/variable</th>
<th>Example of application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water; Sanitation; Waste management; Electricity</td>
<td>Access to public and private solid waste collection, access to sewerage system; access to latrine and toilet; access to piped water</td>
<td>Dummy for access to the infrastructure</td>
<td>Brazil; Kinshasa, DRC; Urban areas, Guatemala; Kigali, Rwanda; Dapaong, Togo; Lusaka, Zambia; all the countries with LSMS data</td>
</tr>
<tr>
<td>Disaster risk reduction: flooding</td>
<td>Hydraulic infrastructure; Drainage system; Flood risk mitigation and erosion control infrastructure</td>
<td>Flood risks map; historic flood map; Self-reported exposure to floods</td>
<td>La Plata, Buenos Aires, Argentina; Kinshasa, Congo; Accra, Ghana; Antananarivo, Madagascar; Dar es Salaam, Tanzania</td>
</tr>
<tr>
<td>Housing; Slum upgrading</td>
<td>Slum upgrading and relocation programs; improve roads and basic public goods.</td>
<td>Access to jobs (distance to job, and average distance from dwelling to the 100 nearest jobs), housing quality (roof, floor, wall materials, etc.); Index of informality of settlements taking values 0 to 4 (0 = formal, 4 = very informal)</td>
<td>Mumbai, India; Jakarta, Indonesia; Islamabad, Pakistan</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td>Methodology</td>
<td>Location</td>
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<tr>
<td>Transport: Public transport</td>
<td>Dar es Salaam Bus Rapid Transit (BRT) Co-benefits: reduction of travel times, reduction of air pollution</td>
<td>Travel time, km per bus and per day, x fuel liters per km.</td>
<td>Dar es Salaam, Tanzania</td>
</tr>
<tr>
<td>Streetscaping</td>
<td>Street greenery</td>
<td>Share of certain area covered in green space</td>
<td>Shanghai</td>
</tr>
<tr>
<td>Tourism</td>
<td>Tourism development and improved infrastructure Co-benefits: Increase in property and rent values, and income revenues. Job creation.</td>
<td>Data on number of overnight stays (days), number of hotel rooms, number of beds in hotels, number of guesthouses; visitors to the main touristic attractions; tourist spending</td>
<td>Kakheti, Georgia; South of Albania</td>
</tr>
</tbody>
</table>
The hedonic pricing method is a data-driven decision-making tool that can be used by policymakers and researchers to quantify the benefits of urban infrastructure investments. This note is an introduction to the hedonic pricing method and provides guidance on its application to assess the benefits of urban infrastructure investments, with a focus on developing countries. The objective is to support World Bank task teams in building a value proposition of urban investments that can help inform decisions and to enhance the quality of project economic analysis of urban infrastructure investments. By enabling the monetization of the benefits of a wide range of urban investments, the hedonic pricing method is a tool particularly well-placed to support this effort. At the same time, it is also important to be aware of the method’s limitations to prevent its inappropriate application, which are also discussed in this note.