# How to assess the value of nature? Valuation of street trees in Lodz city center

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Nature is difficult to price and yet we know it has value. This value is revealed when people make certain decisions, e.g. choosing to live closer to green areas or protesting against the removal of trees in their city. Another way to determine this value is by asking city residents how much a particular nature element or service is worth to them. This type of study requires a hypothetical scenario in which the state of what is being valued may change. The marginal price that city residents are willing to pay for the good or service reflects the value that they assign to maintaining or increasing its availability. We conducted a study of this sort in the Polish city of Lodz, where residents were presented with a hypothetical plan to increase the number of trees in the city center.

Keywords: economic value of nature, choice experiment, street trees, urban ecosystem services

## Introduction

In May 1971, Stockholm was the site of massive protests against plans to cut down thirteen elm trees in one of the city center's small parks. The elms were due to be removed not only to make space for a new metro station, but also as part of a wider urban "modernization" scheme. Around 250 thousand people took part in the protests! Notably this mobilization took place long before the prevalence of contemporary communication systems which greatly facilitate protester organization. Clashes with the police and workers hired by the municipality erupted as they tried to cut down the first elm tree. Eventually the plans were revised and the proposed metro station was moved (Passow 1973). The event also sparked changes in the city's decision making process – the needs of residents became a much more relevant factor.

The event exemplified an extreme form of participation (conflict), as discussed in the previous article. The protest also served to show how similar problems can be avoided if only it is recognized that residents appreciate the value of city trees or ecosystem services in general. Of course the value assigned to trees differs from one person to another, just as each individual is willing to pay a different amount of money for say a book or a bike. The value that residents assign to trees can be determined through an economic study, and in this article the example of the Lodz city center street tree valuation is used to describe how such analyses can be conducted. First, however, the purpose of valuing non-market goods (such as trees or ecosystem services) is discussed and the most appropriate study methods are reviewed.

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## Why and how are non-market goods valued?

Value is a basic economic category. According to contemporary economics, value is reflected in market prices and as such is justified by the utility of a good or service, i.e. the consumer benefits from its consumption. According to neoclassical economics, anything that does not serve to meet human needs directly or indirectly, including the environment, has no value. However, this anthropocentric view does not imply that economic theory is materialistic. Economists agree that prices – and by extension values – contain elements that are related to the use of goods and services but also others that reflect satisfaction from the mere existence of a given good or service. The first type constitutes what is called use value, while the second – non-use value (Żylicz 2004).

For many years economists considered only use value defined in the very narrow sense. Although the existence of other value components had long been appreciated, they were rarely taken into account when managing resources since they were not subject to market transactions. The assessment of ecosystem services' use value concentrated largely on recreational value. However crucial in many cases, recreational value represents only a fraction of use value and usually just a small share of a natural resource's total economic value. Non-use value was highlighted in 1967 by John Krutilla (Krutilla 1967), with its main aspect, the so-called existence value, associated with satisfaction derived from a good's existence. Another aspect is the bequest value to future generations. A category in between use and non-use value is the option value which reflects the potential benefits that can be achieved in the future from a given good. An environmental good's total economic value is the sum of all these value categories (both use and non-use). Figure 1 shows the different categories of city tree value and examples of services provided by trees.

Although most ecosystem services are not subject to market exchange (they are non-market goods), they meet people's needs and thus have value. Their supply is determined mainly by public institutions. Let us assume that municipal authorities are to determine the optimum amount of green areas. The issue can be approached from a number of different perspectives. Here the focus is only on the economic aspects.

Certain individuals decide on the purchase of private goods by comparing market prices with the goods' utility. In the case of public goods, however, purchase decisions must be made by public administrative bodies. Economic theory assumes that the choices made by

**PUBLIC AND PRIVATE GOODS**

In economics, goods are divided into two basic categories: private and public. Nearly all goods and services purchased on the market bear the traits of private goods, i.e. consumption by one individual limits another individual's ability to consume the same good; moreover, the owner of a private good can readily exclude other people from its consumption. Conversely, no one can be excluded from the consumption of a public good and one person's consumption level should not influence other people's consumption levels.

decision makers should maximize social welfare. In the example discussed below, this would be the amount of green areas in the city that maximize the difference between total social benefits and costs.

The assessment of a public good's provision costs is usually not a large issue: the task may not be easy but it is manageable. However, estimating social benefits is a real challenge. In a situation where municipal authorities are considering a plan to increase the amount of street trees, the question is what social benefits will the plan bring about? If there were a market for street trees, the issue would be trivial – social

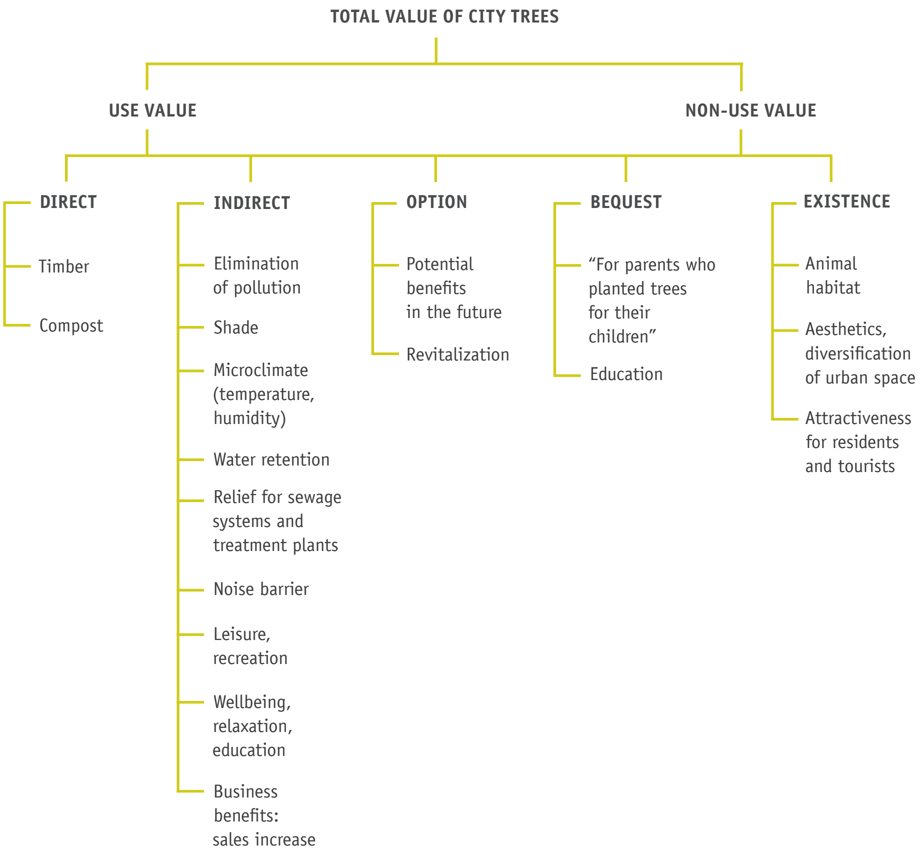


**Figure 1.** Different categories of city tree value and examples of services provided by trees

benefits could be drawn from market prices. However, due to the nature of public goods, there is no direct market for them. Therefore, the only way to assess the benefits derived from public goods is to create a hypothetical market where people can perform hypothetical transactions of public good purchase. A market of this sort was presented to the public in the Lodz study described here. Before discussing the details, however, a few different methods that are widely used to valuate ecosystem services will be analyzed, with a focus on urban green areas.

## Urban ecosystem service valuation methods

Non-market good valuation methods fall into the two categories of direct and indirect methods (Czajkowski 2010). The latter make use of revealed preferences concerning market goods related to the given non-market goods under consideration. Even if the good that is valued is not subject to market transactions, its value can be determined by observing the price of a related good which is available in the market. Direct methods, on the other hand, are based on stated preferences with regard to a certain non-market good. In this case, consumers are asked in an appropriate way how much a given good is worth to them. Below the most commonly used methods of urban nature valuation are reviewed with examples of their application in urban tree valuation studies (figure 2).

### Replacement cost method

The method most commonly applied when decisions concerning city trees are made is the replacement cost method which takes into account the costs of recreating tree services. It includes the costs of planting and maintaining an appropriate number of new trees that are to replace a removed or damaged tree. The factors that need to be taken into consideration when assessing replacement cost include tree species, size, condition and location. In the USA, where urban tree valuation has the longest history, the replacement cost method is an officially approved aid to planning decisions (CTLA 1992). The resulting calculations of tree value in different cities are publicly available. For example, tree value in New York was estimated at 5.2 billion USD (996 USD per tree) (Nowak et al. 2002).

In 1974 Lodz became the first Polish city to have a tree price list introduced. This price list was to be based precisely on replacement cost, i.e. the calculated number of new trees which would have to be planted in order to achieve the same ecological benefits that removed or damaged trees provided. However, the final price list included values that were just 1/6$^{th}$ of what

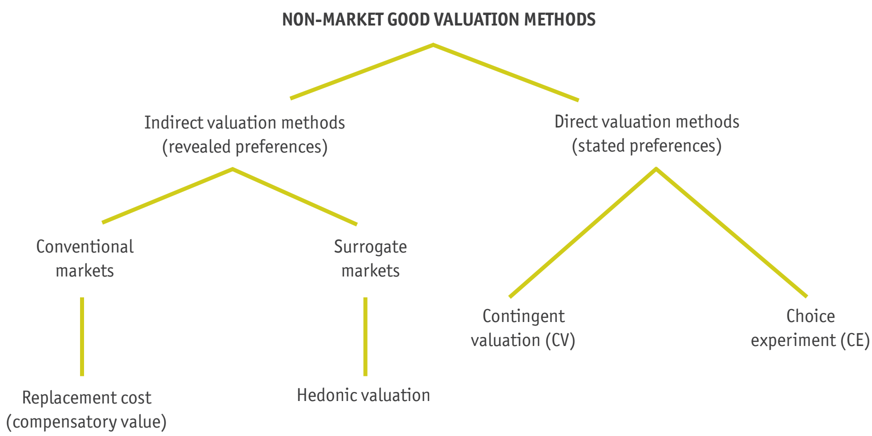


**Figure 2.** Examples of the most commonly used urban nature valuation methods

was proposed in the project. As Romuald Olaczek put it, "the (originally) estimated tree values most probably exceeded some psychological barrier of municipal officers, who would not acknowledge that a simple street tree could have the value of a few passenger cars" (quoted from Szczepanowska 2007, pp. 116–117). The current charging system for removing trees in Poland[1] is not based on any valuation method and the substantive grounds for establishing unit charges are not known. Aiming to adjust the Polish system to international standards, the Institute of Spatial Management and Housing developed a replacement cost method adapted to Polish circumstances (Szczepanowska 2009).

### Hedonic valuation

Scientific studies on the value of city trees most commonly apply the so-called hedonic valuation method. It draws on the fact that the presence of trees (or other nature elements, such as parks, aquifers or protected areas) influences the value of real estate on which or in the vicinity of which the analyzed trees grow. Relevant econometric models have enabled researchers to separate the influences of different factors, such as location and, in the case of apartments and houses, also their size, layout and window view, on real estate price. The influence of nature on the quality of life in a certain place is reflected in the price that buyers are willing to pay for a piece of real estate as well as the time needed to find purchasers. The majority of studies confirm that trees and other nature elements increase the value of real estate, especially in urban areas (Donovan and Butry 2010; Waltert and Schläpfer 2010). Aware of the fact that green areas can increase the attractiveness of real estate, developers highlight the presence of such areas even when in fact the property contains little or no trees. A quick look at sales advertisements in a random newspaper's real estate section will confirm that this is truly the case.

The presence of trees separating a house from the street or growing no more than 30.5 m away (excluding those that grew immediately next to a home) increased real estate price on average by 8870 USD (3% of the real estate value).

Hedonic valuation has also been used to value street trees. Donovan and Butry (2010) estimated the value of street trees in Portland by analyzing house prices. The presence of trees separating a house from the street or growing no more than 30.5 m away (excluding those that grew immediately next to a home) increased real estate price on average by 8870 USD (3% of the real estate value). By extrapolating this value to all of Portland, the authors indicated that the city's street trees had an estimated value of 1.35 billion USD. They also showed that homes near street trees were easier to sell (such offers found purchasers on average 1.7 days faster compared with the average market time of 71 days).

### Contingent valuation

Another method used relatively frequently with regard to urban ecosystem services is contingent valuation (CV). Typically for a direct valuation method, respondents are asked about their willingness to pay for ecosystem services. A scenario for the supply of a given service, as well as its projected cost, is presented. Respondents state if they would be willing to bear a particular cost in order to benefit from a particular ecosystem service. The scenarios most commonly used in this method refer to the costs of maintaining urban green areas. This also relates to the barriers that were discussed in the second article, such as the insufficiency of financial means for the maintenance of urban nature and/or a failure on the part of decision makers to recognize the value that city residents assign to nature.

Treitman and Gartner (2006) determined the willingness to pay for better maintenance of trees in 44 cities in the state of Missouri, including St. Louis and Kansas. More than half of their respondents, especially in larger cities, declared a willingness to pay 14–16 USD annually per household where the scenario included creating a fund for better tree care in the city. In another study conducted in 1996 concerning tree-covered areas in the Finnish cities of Joensuu and Salo, 2/3rds of residents were willing to pay for recreation opportunities in urban green areas (7–9 EUR a month) and half were willing to pay for halting

[1] Nature Protection Act of 16 April 2004 and Ordinance of the Minister of Environment of 13 October 2004 on charging rates for certain tree species.

the transformation of natural areas into built-up ones (at 21–35 EUR a year per household, over 3 years) (Tyrväinen 2001). Such calculations of the benefits of recreation in these areas by far surpassed their maintenance costs incurred by public institutions at the time. The costs were to be met in the form of fees for the use of recreational areas and a tax to impede their transformation into built-up areas.

### Choice experiment

The most complex solution that can be applied to assess the value of trees in a city is the choice experiment (CE). Similarly to contingent valuation, it requires prior preparation of hypothetical service provision scenarios. In this case, respondents are asked to select their preferred alternative out of a given set of alternatives. Some researchers (e.g. Carlsson and Martinson 2001) claim that the complex structure of CE produces answers that are more thought through than those from the CV method, thereby reducing the problem of respondents answering without sufficient consideration. Moreover, CE forces respondents to think of the detailed comparisons (exchange rates) between different characteristics of given projects. There are researchers who argue that this approach encourages respondents to think in terms of maximizing utility (i.e. choosing the program that is most satisfying) and minimizes the number of random answers. This was the method applied in the Lodz study described below. For more information on the method, see the appendix at the end of this article intended for readers with a particular interest in economics.

### Cost-benefit analysis

The types of studies described above refer to the benefits obtained from the presence of trees in a city, but urban tree maintenance also has its costs. Therefore, another method that is also frequently used by economists analyzing the economic value of urban trees and ecosystem services is cost-benefit analysis. One of the most renowned applications of this method in recent years was the New York study by Peper et al. (2007).

**Urban nature valuation – how is it done?**

Economic valuation facilitates the decision-making process in cities: it helps find common ground on matters that are often difficult to decide (because of diverse vantage points) by expressing them in purely monetary terms. Thanks to economic valuation methods, the decisions made by municipal authorities can relate to a wider range of issues concerning quality of life in a city.

The methods discussed here are commonly used in developed countries, which means that there are models readily available for use. Besides the first method, all require econometric tools and thus the involvement of an econometrician. In Poland, researchers at the University of Warsaw's Warsaw Ecological Economics Center have a particularly broad experience in the field of economic valuation studies while the Institute of Spatial Management and Housing uses a replacement cost method adapted to Polish conditions.

Valuation studies also require a large data collection if statistical conclusions are to be drawn. The data may come from the real estate market (through hedonic valuation) or be collected specifically for the purpose of a given valuation (through CV and CE). The time required to complete a study results from the amount of time needed for data collection.

There are many publications and other materials concerning valuation which could serve as a basis for further work, e.g. online at <www.ecosystemvaluation.org>.

Photo: Tomasz Jeleński


**Figure 3.** A campaign conveying the results of a street tree valuation study in Chicago

It assessed the costs and benefits associated with street trees that were the responsibility of municipal authorities, comprising nearly 600 thousand trees and excluding 4.5 million trees in parks and on private property. The net benefit of the trees that were analyzed was estimated at 122 million USD a year (i.e. 209 USD per tree). Every dollar spent on New York tree maintenance brought the city 5.60 USD of benefits. The benefits that were highlighted included reduction of energy use, sequestration of $CO_2$ and other pollutants, water retention in the landscape and a positive influence on real estate values.[2]

## The valuation of street trees in Lodz city center

The study aimed to bring decision makers' and city residents' attention to the value of urban trees and the need to include this value in planning decisions. By having an effect on the presence of trees, planning decisions translate into quality of life for a city. Unfortunately, this fact is rarely recognized in public debates in Polish cities.

For the needs of the study, we prepared a simplified inventory of trees in the very center of the city. Based on the number of trees that grew there, the streets were divided into the three following categories:[3]

1. high number of trees (10 or more);
2. medium number of trees (4–9);
3. very few or no trees (0–3).

Figure 4 shows the inventory results; different street categories are marked with different colors. This was

[2] The New York study was conducted with the i-Tree Streets tool developed by the USDA Forest Service. You can find more details on this and similar tools at <www.itreetools.org>.

[3] Including the number of trees on a 100 m street segment, up to 5 m from the edge of a roadway.

By Adam Świć

legend:

number of street trees

low

medium

high

**Figure 4.** A map of Lodz city center (street colors indicate the number of trees)

used as a starting point to plan a hypothetical program of increasing the number of trees in the area of analysis. This program was presented to surveyed Lodz residents in order to learn the value that they assign to trees in their city center.

## Hypothetical program

The proposed hypothetical program assumed an increase in the length of streets with medium and high numbers of trees (by way of planting new trees along the streets with no trees and those with a medium number of trees). The study made an approximate specification of the streets where additional trees could be planted, disregarding any technical or institutional barriers, such as those discussed in the second article. Based on the possibility of planting new trees, three types of streets were distinguished:

1. streets where sidewalk (and sidewalk greenery) width allowed the planting of trees by the side of the street;
2. streets where sidewalk (and sidewalk greenery) width was insufficient for planting trees (yet it was possible to introduce trees on some of these streets in specially created traffic islands between the road and sidewalk, as shown in figure 5);
3. streets with very few or no trees, where significant traffic concentration and insufficient width made it impractical to create traffic islands and plant trees in the roadway or by the side of the street.

In figure 6, the green dots on the appropriate sides of streets indicate locations where street trees could be introduced. In many places, trees removed because of illness or old age have not been replaced by new ones and empty spaces remain. Yellow-green flower symbols on the map indicate streets with the potential to

Photo: Tomasz Bużałek

**Figure 5.** Helsinki, tree islands between parking spaces


legend:

number of street trees

low

medium

high

street segments with no possibility of increasing the amount of tall greenery

potential tree-planting site

potential tree island in a roadway

**Figure 6.** A map of Lodz city center with possible tree planting areas

introduce tree islands like those found in some cities in Western Europe and the USA. This solution was proposed only where trees could not be planted at the side of the street. The islands would be sectioned off from parts of the sidewalk and roadway only in streets where one lane is occupied by parking spaces. Every 15 meters, a square 1.5 x 1.5 m accommodating a tree would be allocated from a parking space. For the needs of this hypothetical scenario, it was assumed that the parking spaces "taken over" by planted trees would be recreated in the immediate vicinity.

Another assumption made when preparing the program was that new trees could be planted only along streets with no trees or a medium number of trees in order to ensure "fair" access to these public goods. It was also assumed that trees would not be planted along the roadway if they could be planted by the side of a given street. Finally, it was assumed that the only possible changes consisted of increasing the number of trees and the basic scenario (the status quo) meant the existing number of trees (although in reality this number is decreasing). Figure 7 shows the possible variants as follows:

- increasing the number of trees in the streets that do not have them, so as to achieve a medium number of trees, by creating tree islands;
- increasing the number of trees in streets that do not have them, achieving a medium number of trees;
- increasing the number of trees in streets with a medium number of trees so as to achieve a high number of trees.

The study generated a dozen variants for the program with varying emphases on different ways to increase tree numbers. The variants were presented in tables such as the one shown in figure 8. The "Status

Photo: Jakub Kronenberg and Tomasz Bużałek

**Figure 7.** Hypothetical tree scenarios that could be achieved

| CHOICE CARD – SCENARIO 11 | | Status quo (maintaining) | Program 1 (increase) | Program 2 (increase) | Program 3 (increase) |
|---|---|---|---|---|---|
| Length of streets with a high number of trees |  | 10 km | 18 km | 14 km | 14 km |
| Length of streets with a medium number of trees |  | 12 km | 6 km | 14 km | 12 km |
| Length of streets with islets |  | 0 km | 14 km | 3.5 km | 3.5 km |
| Length of streets with no trees |  | 28 km | 12 km | 19 km | 20.5 km |
| Cost/month/person |  | 0 PLN | 20 PLN | 5 PLN | 50 PLN |
| Choice | | | | | |

**Figure 8.** Example of a choice card

quo" column shows the existing street length in each category. Subsequent columns show the length (in kilometers) of streets in each category after the enforcement of a given program. The last row contains the hypothetical expenses associated with each variant of the scenario. The expenses would be covered each month by respondents in the form of an additional hypothetical tax.

Once acquainted with this information, respondents were asked to rank the programs from best to worst. They were presented with the programs as proposals that were actually being considered and asked to make their choices bearing in mind that they would have to, in reality, bear the relevant costs. At the same time respondents were reminded that a higher tax would decrease their funds available for other purposes. For every variant, the respondents first chose the one they thought was best, then the one they thought was worst, and finally the one that was better than the two remaining variants. Respondents who decided they were not able to bear any additional cost or were not interested in increasing the number of trees chose "Status quo" as their preferred program. In the final stage of the study, respondents answered socio-demographic questions.

## Results

The study was carried out in two rounds. In the first round, 150 people were interviewed. The results were then used to prepare another dozen sets which were better adjusted to average preferences. 250 people took part in the second round. Only Lodz residents aged eighteen and above were interviewed. A total of 400 interviews were carried out which yielded 382 complete questionnaires that were used to analyze stated preferences and assess willingness to pay. The interviews were carried out in the city center by trained pollsters (in streets and squares, in shops and shopping malls). The size of the sample and public availability of places where the interviews took place legitimized the assumption that the structure of Lodz residents was well represented.

The data obtained from the questionnaires was subjected to econometric analysis.[4] The results suggested that the surveyed Lodz residents gave the most importance to increasing tree numbers in streets with few or no trees. According to the surveyed Lodz residents, the key issue was increasing the number of trees from low level (few or no trees) to medium level, while increasing the number of trees from medium to high level was of secondary importance. In line with expectations, respondents found the costs of certain programs highly significant – *ceteris paribus* (everything else unchanged) the higher the cost of the program, the lower the respondents' satisfaction. The results also showed that on average, the Lodz respondents were not attached to the existing number of trees, i.e. changes in these numbers in terms of economics did not have a negative influence on their utility. This utility would grow only when the number of trees increased in the streets where they were scarce.

17.7 million PLN. Such would be the assessed change in social welfare resulting from the implementation of the program in question. Meanwhile, the municipal budget for 2012 predicted only around 2 million PLN for street greenery-related expenses. This gives an idea of how maladjusted the actions undertaken by the municipality are to social needs in relation to trees.

The subject of this study was economic valuation, i.e. determining the willingness to pay by Lodz residents for increasing the number of street trees. Willingness to pay is a measure of welfare and provides information on the maximum price that respondents would be willing to pay in order for the good in question to attain a given feature (attribute). In this study, the attribute was the number of trees (high, medium, low/none) and their cost. The assessments that are presented here are the average values for the interviewed group of respondents, which means that the group was made up of people whose willingness to pay could be zero and others who had a very high willingness to pay. Because in the logit model that was used for data analysis the mean and median values are equal, the given amounts may be considered as the level of willingness to pay that divided the sample in two, where 50% of respondents had a higher willingness to pay and 50% had a lower willingness to pay compared to the amount calculated. This is to say that if the given tax amount were to be voted on in a referendum, 50% of respondents would be for the introduction of a tax at this level and 50% would be against it.

The study showed that respondents were willing to pay, in the form of increased tax, the following amounts per person per year:

- 1.58 PLN per kilometer of a street where the number of trees would be increased from low to medium level by planting trees along the street;
- 2.25 PLN per kilometer of a street where tree islands would be created.

The values obtained may serve to calculate the willingness to pay for a program which would increase the number of trees from low to medium levels and by creating tree islands in streets of a certain length. For example, the willingness to pay for a program to increase the number of trees from low to medium level on 5 km of streets and create tree islands on 9 km of streets (the average lengths used in the study) was 28.15 PLN/year in the form of increased taxes per resident.

Assuming the representativeness of the sample, the study results could be extrapolated to the entire population of Lodz residents above eighteen years of age (627,000 at the end of 2010). The value of a program to increase the number of city trees from low to medium level along 5 km of streets and create tree islands on 9 km of streets would amount to 17.7 million PLN. Such would be the assessed change in social welfare resulting from the implementation of the program in question, and the 17.7 million PLN only referred to the center of Lodz. Meanwhile, the municipal budget for 2012 predicted only around 2 million PLN for street greenery-related expenses, which included tree management, removal and planting, for the whole city. Another 11.5 million PLN was allotted to the maintenance of green areas (including parks) and related investment costs but not street-side greenery. This gives an idea of how maladjusted the actions undertaken by the municipality are to social needs in relation to trees.

[4] More information on the applied method of data analysis (multinomial logit model) and detailed results are included in the appendix. Here, only the general characteristics are presented.

## Conclusion

City trees provide a range of services which bear the characteristics of public goods, benefitting all city residents. Economic theory implies that whenever social benefits bear the characteristics of public goods, there is a need for administrative intervention in order to determine the amount of public goods needed to meet the social optimum. The task requires an assessment of the costs and benefits, followed by the choice of a solution which maximizes social benefits.

The study presented here included an assessment of the willingness to pay for increasing street tree numbers in the city center of Lodz. The resulting values could be regarded as an approximation of the social benefits potentially achieved by residents if the tree increase program was realized. The study could also provide decision makers with useful suggestions concerning the preferences of residents who, as shown by the results of this study, would benefit significantly from increasing the number of street trees in the city center.

The study indicated that there is a negative correlation between the social benefits from an increase in tree numbers and tree numbers themselves. In other words, people are more willing to pay for increasing tree numbers in places where trees are scarce. This does not necessarily mean that planting trees in such places is socially optimal – the perceived benefits will need to be compared with the costs. If the costs of increasing tree numbers along streets with few trees and streets with a medium number of trees turn out to be similar, then, from the perspective of economic effectiveness, the number of trees should be increased first and foremost in places where they are absent.

People are more willing to pay for increasing tree numbers in places where trees are scarce. This does not necessarily mean that planting trees in such places is socially optimal – the perceived benefits will need to be compared with the costs. If the costs of increasing tree numbers along streets with few trees and streets with a medium number of trees turn out to be similar, then, the number of trees should be increased first and foremost in places where they are absent.

## Appendix

This article was meant for a readership with no background knowledge of economics. Provided below is more detailed information that may be a useful supplement to the text.

### Choice experiment

This method allows to analyze the preferences of consumers by having them participate in hypothetical choice situations, whereby the analysis is a market simulation. By using choice experiment (CE), investigators identify consumer preferences which can then be described, analyzed and used to predict choice. This method was initially applied in marketing studies and in the discussion of different transport options. Its first application in non-market good valuation was carried out by Adamowicz et al. in 1994.

The foundations of CE are built on a combination of characteristics theory of value (Lancaster 1966) and the random utility theory (Manski 1977). According to Lancaster's (1966) theory, people achieve utility through particular features of consumed goods and not from the mere consumption of these goods. Another assumption is that each good can be described by certain characteristics (attributes). CE allows the valuation of particular attributes. In a CE study, respondents are presented with a selection of project proposals and asked to select what they think is the best one. Each option is described using a set of attributes, which always include the cost of a project. In some versions of CE, respondents are asked to rank all the alternatives provided (from best to worst).

CE has some advantages over contingent valuation (CV). First, in CE it is much easier to calculate the marginal willingness to pay for a particular attribute of the valued good or project. In this case, the marginal willingness to pay is the monetary value that a person is willing to pay for an *extra* unit of a commodity or higher level of a given attribute.

Second, in CE each respondent makes their choice from a set of alternatives (options). This way the same number of respondents yield more data than in CV. What is more, investigators applying CE can obtain additional information about respondent preferences by increasing the number of alternatives in each choice set.

However, the most commonly cited drawback of CE is that it demands relatively high intellectual effort from respondents. Typically, they have to choose the preferred option out of a set of 3–6 options associated with several attributes.

The most commonly applied measure of welfare that may be obtained from CE is the marginal willingness to pay. Assuming that reality is reflected by a linear utility function, the marginal rate of substitution between any of the attributes and income may be expressed as the ratio of a parameter estimated for the attribute and a parameter estimated for the cost (i.e. the marginal utility of income). In the case of the multinomial logit model, the parameters are estimated using the maximum likelihood method. That is to say that the best solution of the model are such parameters of the utility function for which the model does the best job of predicting choices which were actually observed. The estimated utility function parameters are then used to calculate the marginal willingness to pay.

## The applied data analysis method and detailed results

For the purpose of data analysis, the multinomial logit model (MNL) was used in the study above. Models of this type are a basic tool for discrete choice analysis (i.e. choosing a preferred program option out of a finite set of program options). The MNL model is an effective tool when the main aim of a study is the assessment of the average willingness to pay for a program or given attribute. The model also has limitations, which become significant when the main aim of a study is the analysis of preference heterogeneity – in these cases, more complex models should be used. However, the fundamental purpose of the Lodz study was the estimation of the average willingness to pay, so the use of the MNL model was adequate. The results of the MNL model and willingness to pay are presented in the table.

**Table.** Results of the Lodz study

| ATTRIBUTE | UTILITY FUNCTION PARAMETERS (STANDARD DEVIATION) | WILLINGNESS TO PAY (PLN/KM) (STANDARD DEVIATION) |
|---|---|---|
| High number of trees | 0.01108<br>(0.00821) | 0.83592<br>(0.61905) |
| Medium number of trees | 0.02097***<br>(0.00799) | 1.58223***<br>(0.61032) |
| Tree islands | 0.02994***<br>(0.00470) | 2.25885***<br>(0.42695) |
| Cost | -0.01326***<br>(0.00115) | |
| SQ | 0.07438<br>(0.08634) | |
| LL constant | -6338.90 | |
| LL full model | -6247.71 | |
| N (number of observations) | 4584 | |

SQ — status quo  LL — logarithm of the likelihood function  ***estimates statistically significant at the level of 0.01

The direct interpretation of utility function parameters in the logit model can be quite difficult. Typically, what is taken into consideration are the estimates' sign (plus or minus) and their statistical significance.[5] The usual assumption is that parameters differ from zero significantly when the ratio of the parameter and its standard error is higher than 1.96 or lower than -1.96. This is to say that the statistical significance is 0.05, i.e. the probability of rejecting a true zero hypothesis that a given parameter equals zero is lower than 0.05.

Because utility function parameters are impossible to interpret directly, the third column of the table above shows the willingness to pay for certain attributes. Willingness to pay was calculated by dividing the parameter of a given attribute (the marginal utility of a given attribute) by the cost parameter (the marginal utility of income).

This article does not include measures of the perception of increasing the number of trees along streets with a medium number of trees (the "High number of trees" attribute). The parameter of this attribute was positive (i.e. increasing the number of trees along streets with a medium number of trees on average increases the satisfaction of Lodz residents), yet it did not statistically differ from zero, making it difficult to draw accurate conclusions. Another factor that did not statistically differ from zero was the willingness to pay for increasing the number of trees from medium to high, estimated at 0.83 PLN/km.

[5] In other words, whether utility function parameters are significantly different from zero. If a parameter is not statistically different from zero, it means that it did not influence respondents' choices.

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Distinction in the Contest "Nature in the City"

Dagmara Kwolek: *Wawel*
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