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Evaluation And Adjustment Of The Dnp Benefit Equation: An Approach Based On Hedonic Prices

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Abstract

This study critically examines the benefit equation proposed by the National Planning Department (DNP) in the context of evaluating investment in social projects, identifying its weaknesses, mainly in relation to the absence of environmental variables and the regional context. The documentary review method was used, complemented by an analysis of econometric models in which hedonic prices were used to assess environmental and social attributes in public investment projects. Variables that can be assessed for their effects on quality of life and the environment were selected, and the analysis was carried out using various statistical techniques. The findings show that the current equation underestimates intangible benefits and presents a methodological rigidity that restricts its applicability at the regional level. Consequently, an alternative equation is presented with the intention of improving the valuation of these benefits by emphasizing environmental and social factors, thus favoring decision-making within public investment.

Keywords: Hedonic prices, benefit valuation, social investment, environmental variables, project evaluation.

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Introduction

The assessment and quantification of benefits in social investment projects is a fundamental process for ensuring the correct allocation of resources and evaluating the socioeconomic and environmental impact of interventions. These processes are essential in the planning and implementation of public policies, as they allow investments to be justified and their effectiveness in improving the well-being of communities to be measured (Baranauskienė and Aleknevičienė, 2019; Solntsev, 2023).

In this context, governments and entities responsible for project planning and evaluation have developed various methodologies to assess the benefits generated by public investment initiatives. Among these methodologies, econometric models play a fundamental role, providing quantitative tools to analyze and predict the economic and social impact of projects (Rogowski and Zagożdżon, 2022).

One of the most widely used methods for valuing benefits is the hedonic pricing model, which breaks down the value of a good or service into its individual attributes, assigning a monetary value to each one. This technique is particularly useful in sectors such as real estate, the environment, and infrastructure, where the intrinsic and extrinsic characteristics of goods significantly influence their market value (Potrawa and Tetereva, 2022).

However, the applicability of these models to the context of social investment projects can be a significant challenge, as the geographical, economic, and social diversity of regions can lead to significant variations in evaluation results, thus hindering the implementation of standardized models. Furthermore, the incorporation of environmental and social variables, which do not always have a direct market value, can make it even more difficult to accurately measure benefits (Ryu et al., 2019; Bülbül et al., 2020).

The National Planning Department (DNP), aware of the importance of these processes, developed the Manual for the Assessment and Quantification of Benefits as a methodological tool to guide the identification, assessment, and quantification of benefits in public investment projects (DNP, 2006). This manual provides a structured framework that facilitates the economic and social evaluation of projects, promoting more informed and efficient decisions.

However, the methodology proposed by the DNP has been subject to criticism and analysis due to certain limitations in its practical application. It has been identified that the proposed benefit equation may lack flexibility to adapt to specific local contexts and does not always adequately integrate environmental and social variables that are fundamental in the evaluation of social investment projects (Basurto and Caballero, 2020).

The objective of this research is to analyze the shortcomings of the DNP benefit equation and propose a corrected methodology that integrates environmental and social variables, using the hedonic pricing method as the main tool. This proposal seeks to improve the accuracy of benefit assessment and optimize decision-making in social investment.

The study is structured into different sections. First, a theoretical review of the evaluation of benefits and the use of the hedonic pricing technique is presented. Next, it analyzes the original equation proposed by the DNP, identifying its various shortcomings. Third, it describes the technique used for the review and critical analysis. It then presents the corrected equation, discusses its implications, and concludes with recommendations for future research and practical applications.

Theoretical Reference

The value of benefits in the different evaluation matrices for public and private investment projects is an important component in economic and social decision-making. In this context, the hedonic pricing methodology emerges, which allows intangible attributes to be valued based on different goods and services. Therefore, the theoretical reference of this study has focused on presenting the conceptual and methodological aspects that characterize the valuation of benefits with an emphasis on hedonic pricing theory, analyzing its scope of application and limitations. In addition, based on a review of the literature on the different approaches used to quantify economic, social, and environmental benefits, a conceptual reference is provided for debate and improvement of the models.

Theoretical Review of Benefit Valuation and the Use of Hedonic Pricing

The hedonic pricing method (HPM) is an economic tool that breaks down the price of a given good into the price of its characteristics; in other words, the HPM allows us to understand how much each attribute contributes to the final price of a good; thus, this methodology is based on the idea that goods are not homogeneous and that the market price of a good is the sum of the values of its attributes (Lisi, 2021). The MPH does not consider the good as a unit that cannot be altered, but rather considers that the good can be broken down into its constituent characteristics, valuing each characteristic according to the importance that consumers attribute to it.

Formalized by Rosen (1974), the MPH is understood as an alternative that analyzes how individual product characteristics influence the final prices of goods or services, mainly using more complex goods markets, such as the real estate market, where many characteristics determine the price of a home. Tangible characteristics or factors such as surface area, number of rooms, types of construction materials, architectural features of the home, among others, are what determine the final price of a home (He et al., 2021; Santoso and Anas, 2021). Similarly, intangible characteristics or factors such as location, proximity to basic services (schools, hospitals, shopping centers), the existence of green spaces, and neighborhood characteristics (such as street safety) also determine the price structure itself (He et al., 2021).

The WTP allows us to evaluate how these characteristics individually affect price and how they interact with each other to generate added value. For example, a home located in a central area may have a higher price, but if it also has nearby parks and low pollution levels, its value increases even more (Wu et al., 2018; Liu et al., 2023). In this way, the WTP provides a detailed analysis that reveals consumers' willingness to pay for each specific attribute (Wolf and Klaiber, 2021).

In addition to its usefulness in the real estate sector, MPH has applications in other markets, such as automotive, technology, and environmental, where products have multiple differentiated characteristics. In the environmental field, for example, it is used to assess the impact of factors such as air quality or proximity to green areas on property prices, allowing the economic value of ecosystem services that do not have a direct market to be estimated (Rosero and Campoverde, 2020).

The hedonic pricing method has established itself as an analytical tool that allows economists, urban planners, policymakers, and investors to gain an in-depth understanding of how the attributes of goods and services influence their market valuation. This knowledge is key to public policy formulation, sustainable urban development, and informed decision-making in various economic sectors (Liang and Yuan, 2021).

The valuation of benefits using the hedonic pricing method (HPM) is a key tool for valuing goods and services that do not have a specific market, such as environmental benefits. This method allows the price of a complex good to be segmented according to a set of specific characteristics, thereby assigning a possible monetary value to attributes that ultimately have an effect on consumers' willingness to pay (Engström and Gren, 2017), enabling analysts to extract the effect that environmental and social factors have on market prices and to establish a better relationship between private and public goods.

Bishop et al. (2020) conducted one of the studies applying MPH to demonstrate the effect of air pollution on housing, as their results show that consumers are willing to pay more for properties located in environments with better environmental quality, thus highlighting the existence of a proportional relationship between the ecological environment and this type of asset. This study is the origin of research on the valuation of environmental services. This type of research also describes how unobservable goods can affect perceptions of observable goods.

Currently, MPH is widely used in environmental and urban economics studies to quantify the economic value of non-tradable characteristics. Recent research, such as that by Liu et al. (2020), explores the relationship between accessibility, local pollution, and housing prices in Nantes, France. Their results show that residents place additional value on properties located in areas with low pollution and good access to public transportation, highlighting the importance of environmental conditions in the formation of real estate prices.

Similarly, studies such as that by Du and Li (2021) expand the use of MPH by analyzing the indirect effects of ecological land on the real estate market in Wuhan, China. Their research reveals that proximity to ecological areas not only increases the price of nearby properties but also generates spillover effects that raise values in adjacent areas, demonstrating the implicit value that consumers assign to environmental benefits.

MPH also allows for the assessment of the negative impact of specific sources of pollution on property values. Zuo (2021) examine the effect of waste plants on housing prices in Beijing, concluding that proximity to these facilities significantly reduces property values due to residents' negative perceptions of the associated environmental risks.

In Colombia, the application of MPH is adapted to the analysis of local environmental benefits. Camargo (2023) uses this methodology to estimate the hedonic prices of used homes in Bogotá, considering socioeconomic and environmental variables. His findings confirm that homes near parks and green areas have higher prices, reflecting the positive value that consumers place on these spaces.

MPH is also used in the valuation of public goods and ecosystem services. Bishop et al. (2020) highlight the usefulness of this tool for estimating the value of resources such as air quality and access to recreational spaces. These types of assessments are essential for public policies that seek to promote environmental conservation and improve the quality of urban life.

The hedonic pricing method allows the economic value of environmental and social attributes that do not have a direct market to be quantified, providing a solid analytical framework for urban planning, environmental management, and public policy formulation. This methodology remains in use today as a key tool for understanding how consumers value non-commercial characteristics and how these affect price formation in different markets.

In Colombia, the National Planning Department (DNP) adopted the hedonic pricing method (MPH) in 2006 as a fundamental tool for valuing and quantifying benefits in public investment projects (National Planning Department, 2006). This methodology aims to improve the efficiency of public resource allocation by providing a more accurate and objective assessment of the benefits generated by different projects. The HPM allows the total value of a good or service to be broken down according to its specific attributes, thus facilitating analysis of how these attributes influence the willingness to pay of consumers or project beneficiaries.

However, despite its potential, various studies highlight the limitations of the MPH when applied without contextual adaptations. In Colombia, one of the main challenges identified lies in the lack of consideration of the specific environmental and socioeconomic variables of each region when using this methodology (Jiménez et al, 2019). The standard model tends to homogenize contexts, which can lead to inaccurate or incomplete estimates of the benefits generated by a project. This limitation is particularly evident in a country with such marked geographical, social, and environmental diversity as Colombia, where local conditions vary significantly between regions.

For example, when applying the MPH to social housing projects in different Colombian cities, it can be observed that factors such as air quality, proximity to green spaces, or access to essential public services can have different impacts on property prices depending on the regional context. In densely populated urban areas, proximity to green spaces may represent greater added value than in rural areas, where these spaces are more abundant. This regional variability highlights the need to adapt the MPH to more accurately capture the effects of local environmental and social characteristics on prices and benefit valuation (Julius et al., 2022).

Furthermore, another critical aspect that arises in the application of HVA in Colombia is the difficulty of adequately integrating the intangible costs and benefits associated with public investment projects. Although HVA allows the value of an asset to be broken down according to its observable attributes, it is more complex to incorporate subjective or difficult-to-quantify elements, such as the perception of security in an area, social cohesion, or the cultural value of certain spaces. These limitations highlight the importance of combining the HIA with other methodological approaches that allow these qualitative aspects to be captured in the valuation processes (Enache and Srivastava, 2017).

Given these limitations, adapting the MPH to local contexts becomes an essential challenge for optimizing decision-making in public resource management. This adaptation implies that, in addition to adjusting the variables considered in hedonic pricing models, participatory tools should be integrated to incorporate the perceptions and preferences of local communities in assessing the benefits of projects (Nguyen, 2020). In this sense, the development of hybrid models that combine quantitative and qualitative approaches can contribute to a more comprehensive and accurate assessment, thus promoting more equitable and efficient public management.

The theoretical foundations of MPH are based on the utility theory developed by Lancaster in 1966, who argues that consumers derive satisfaction not directly from the good itself, but from its attributes or characteristics (Lancaster, 1966). This perspective represents a significant shift in how the value of goods is understood, recognizing that consumers do not buy products for their intrinsic nature, but for the specific benefits they offer. For example, when purchasing a home, buyers consider its size or design and factors such as location, proximity to services, neighborhood safety, and environmental quality.

This attribute-based utility theory has enabled economists to better understand how consumers value different characteristics of goods and how these preferences are reflected in market prices. Based on this approach, MPH becomes a significant analytical tool for breaking down the price of a complex good into its individual components, thus facilitating the analysis of consumer preferences and the factors that determine prices in various markets (Soler and Gemar, 2018).

Rosen (1974) expands on these ideas by formalizing the concept of implicit markets, where the prices of individual attributes are revealed through consumer choices in the market. According to Rosen, MPH allows for the estimation of hedonic price functions that represent the relationship between the price of a good and its specific characteristics, thus providing a robust analytical framework for studying how consumers value individual attributes and how these influence price formation in the market.

In the Colombian context, applying the MPH under these theoretical principles offers a significant opportunity to improve efficiency and equity in the planning and management of public investment projects. However, as noted, its application requires adaptations that take into account regional particularities and the social and environmental complexities of the country. Only then will it be possible to maximize the potential of this tool to generate public value and promote sustainable development in the different regions of Colombia.

The use of the hedonic pricing method (HPM) has undergone significant evolution since its early applications, incorporating more sophisticated models that consider spatial variables, mixed effects, and dynamic market components. This evolution responds to the need to capture the complexity of real markets and overcome some limitations of traditional models. In cities such as Bogotá, Camargo (2023) applies spatial models to analyze the prices of used homes, demonstrating how environmental, socioeconomic, and spatial factors significantly influence the city's real estate market. His study highlights that variables such as proximity to green spaces, accessibility to public transportation, and the socioeconomic conditions of the surrounding area directly affect property prices. By integrating these spatial variables, the MPH allows for more accurate estimates, better reflecting the heterogeneity and complexity of local markets.

These advanced approaches improve the accuracy of estimates and enable the analysis of spatial patterns, such as the concentration of high prices in certain areas or the existence of spillover effects, where the characteristics of one neighborhood influence the prices of nearby properties. This type of spatial analysis is particularly useful in complex and expanding real estate markets, such as those in large Latin American cities, where socioeconomic and environmental variability between neighborhoods can be significant.

However, despite these improvements, the MPH is not without its critics. Ellul et al. (2019) highlight several limitations inherent in this methodology, particularly with regard to its ability to capture real market dynamics. One of the most relevant criticisms points to the inability of MPH to adequately incorporate intangible or difficult-to-quantify factors, such as the perception of safety in a neighborhood, the prestige of an area, or the cultural preferences of consumers. These elements, although subjective, can have a significant impact on market prices and, if not explicitly considered, can introduce biases in the results.

Furthermore, MPH is based on theoretical assumptions that are not always true in practice. For example, the methodology assumes perfectly competitive markets where consumers have complete information and make rational decisions based on all the relevant attributes of goods. However, in the real world, consumers often lack complete or up-to-date information, and their decisions may be influenced by cognitive biases, fads, or social pressures (Ellul et al., 2019). These factors limit the ability of the MPH to accurately represent the dynamics of supply and demand in real estate markets and other sectors.

In the field of environmental economic valuation, MPH has established itself as an essential tool for quantifying environmental benefits that do not have a direct market price. Basurto and Caballero (2020) highlight the importance of this methodology for assigning monetary values to ecosystem services and environmental benefits, facilitating their inclusion in economic decision-making and public policy processes. Through the MPH, aspects such as air quality, the presence of green areas, proximity to bodies of water, and the tranquility of the environment can be assessed, which is crucial for integrating environmental considerations into urban planning and land management.

For example, in urban studies, MPH is used to estimate how much consumers are willing to pay to live near parks or green spaces, or how environmental quality influences residential property prices. This type of analysis provides valuable information to public policymakers and urban planners for designing strategies that promote sustainable development and improve residents' quality of life (Basurto and Caballero, 2020).

The relationship between environmental certifications and market prices has also become an area of growing interest in the application of the MPH. Overbeek et al. (2023) analyze the office market in the Netherlands and find that properties with environmental certifications, such as energy efficiency labels or sustainable building seals, command higher prices and greater demand compared to those without certification. These findings highlight how environmental considerations increasingly influence consumer and investor decisions, reflecting greater awareness of sustainability and environmental impact.

The study by Overbeek et al. (2023) also reveals that environmental certifications not only increase the market value of properties, but also reduce leasing times and increase occupant satisfaction. These results suggest that consumers are willing to pay a premium for sustainable properties, which encourages real estate developers to invest in green and environmentally friendly construction.

Overall, the hedonic pricing method offers valuable insight into how various attributes affect the value of goods and services, allowing for a more accurate and comprehensive assessment in different contexts. Although it has limitations, its continuous adaptation and improvement make it a relevant tool for assessing economic, social, and environmental benefits, especially in situations where these are not directly tradable in the market. The incorporation of spatial models, advanced analysis techniques, and the integration of environmental and social variables strengthen the HPM's ability to capture the complexity of real markets, thus contributing to better decision-making in areas such as urban planning, environmental management, and sustainable development.

Materials and Methods

The methodology adopted in this research follows an analytical and descriptive approach, focusing on the theoretical and documentary analysis of the benefit equation proposed by the National Planning Department (DNP). The purpose is to critically examine the structure and components of the current equation, identify its main shortcomings, and develop a revised equation that integrates environmental and social variables, which are fundamental in the evaluation of social investment projects. It should be noted that this research is limited to theoretical analysis and the formulation of an improved proposal, without reaching the practical or empirical application of the suggested equation.

The methodological process is based on a review of academic literature on economic valuation and hedonic pricing methods, as well as an analysis of official and technical documents related to the DNP guidelines on the valuation and quantification of benefits. This review includes studies that address the inclusion of environmental and social variables in the economic evaluation of projects, allowing for the contextualization and substantiation of the proposed modification of the original equation. Sources are selected based on criteria of relevance, timeliness, and applicability to the Colombian context, ensuring a solid basis for analysis.

In the analytical phase, the components and assumptions of the current benefit equation are examined, identifying limitations related to lack of flexibility, absence of contextual variables, and underestimation of intangible benefits. The statistical and econometric methods used in the current equation are analyzed, highlighting their rigidity in not considering regional or environmental factors that can significantly influence project valuation.

Based on these findings, a revised equation incorporating environmental and social variables is proposed, with the aim of improving the accuracy and contextualization of benefit valuation. The proposal is based on sound theoretical principles and best practices identified in the reviewed literature, including the use of hedonic pricing models to value intangible and environmental attributes.

It is important to note that this research does not consider the empirical application or statistical validation of the proposed equation in real contexts. The methodology is limited to the conceptual and theoretical development of an alternative proposal, intended to serve as a basis for future research that may lead to the practical application and empirical validation of the suggested model. In this way, it offers a robust conceptual framework that allows for reflection on current deficiencies in benefit assessment and proposes a path toward more inclusive and accurate models in the management of social investment projects.

Results

The theoretical and documentary analysis carried out in this research allows us to identify the main shortcomings in the benefit equation proposed by the National Planning Department (DNP) and to substantiate the proposal for a corrected equation. The results are derived from a detailed examination of the structure and components of the original equation, as well as a review of specialized literature on economic valuation and hedonic pricing models. This analysis reveals the limitations of the current methodology and justifies the need to integrate environmental and social variables to improve the accuracy and relevance of benefit valuation in social investment projects. The most relevant findings are presented below, highlighting the shortcomings of the current equation and detailing the proposal for a revised version that broadens the scope and applicability of the model.

Analysis of the Original Equation

One of the key aspects analyzed relates to the calculation of sample size, a fundamental element in ensuring the statistical validity and representativeness of the data used in the assessment of benefits.

The original equation for calculating sample size is based on standard parameters that consider the total population size, confidence level, and margin of error, following the formula:

$$n = \frac{(N * Z^2 * p * q)}{[(\sigma^2 * (N-1) + (Z^2 * p * q)]} \qquad (1)$$

Where n is the sample size, N is the population size, Z corresponds to the critical value according to the confidence level (usually 1.96 for 95% confidence), p represents the expected proportion, q is the complement of p (1-p), and σ is the standard deviation or assumed margin of error.

Although this formula is adequate for general estimates, the analysis shows that it does not adequately consider the variability that certain social investment projects may present, especially those with a strong environmental or social component. The dispersion of data and the heterogeneity of the communities and regions where the projects are implemented may require adjustments to the parameters used for the sample calculation.

The use of a standard margin of error and a fixed expected proportion may be insufficient in contexts where citizen perceptions or environmental impacts vary considerably. Furthermore, the formula does not consider the inclusion of qualitative variables that could influence the assessment of benefits, limiting the analysis's ability to capture important nuances in the perception of social and environmental impacts.

As a result of this analysis, a revision of the approach to sample size calculation is proposed, suggesting the incorporation of techniques that consider contextual variability and allow parameters to be adjusted according to the specific characteristics of each project. This would contribute to obtaining more representative samples and improving the accuracy of the data used in benefit assessment, thus strengthening the validity of the corrected equation proposed in this study.

The benefit equation proposed by the National Planning Department (DNP) seeks to estimate the net benefit generated by social investment projects. This equation is expressed as:

$$B = \sum (P_i * Q_i) - C \qquad (2)$$

Where B represents the total benefit of the project, P_i s the unit price of good or service i, Q_i corresponds to the quantity produced or affected of good or service i, and C refers to the total cost of the project.

The structure of the equation is based on a traditional economic valuation approach, in which benefits are calculated as the difference between the income generated by the project and the costs incurred. This approach has the advantage of being simple and easy to apply, allowing for quick estimates based on quantifiable data, such as market prices and production or consumption volumes.

However, this simplicity also brings with it significant limitations. The equation takes a purely economic approach that focuses exclusively on tangible and monetary variables, leaving aside environmental, social, and cultural factors that also influence the benefits generated by projects. This omission leads to an underestimation of the real benefits, especially in projects that seek to improve quality of life or preserve the environment.

Furthermore, the equation does not consider variables related to the natural environment, public health, social cohesion, or access to basic services. These aspects are fundamental in social investment projects, and their exclusion limits the model's ability to accurately reflect the total impact of interventions. The absence of environmental and social variables also prevents an adequate assessment of intangible benefits, such as improvements in quality of life and community well-being.

Another relevant aspect is the lack of regional contextualization. The equation applies a standardized approach that does not take into account the socioeconomic and environmental particularities of the areas where the projects are implemented. Local conditions significantly influence the perceived benefits and costs, so ignoring them can distort the results obtained.

The equation also does not provide information on how benefits are distributed among different social groups or communities. This makes it impossible to assess the equity and social justice of projects, which are key aspects of initiatives that seek to improve the living conditions of vulnerable populations.

The methodological rigidity of the equation limits its ability to adapt to complex and diverse contexts. By focusing exclusively on prices and quantities, it does not allow for the incorporation of qualitative variables or alternative indicators that could offer a more complete and detailed view of the impact of projects.

The original DNP equation, although useful for basic estimates of economic benefits, is insufficient for comprehensively evaluating social investment projects. Its limitations in considering environmental, social, and contextual variables reduce the accuracy of the results and may affect decision-making. These findings highlight the need for a revised equation that broadens the scope of the assessment, integrating economic, social, and environmental factors to obtain a more accurate and representative assessment of the real impact of projects.

Proposed Methodological Adjustment: Equation for Sample Calculation and Adjusted Benefit Equation.

The methodological adjustment proposed in this research is based on the principles of the Hedonic Pricing Methodology (HPM), a tool widely used in environmental and urban economics to break down the value of a good or service according to its specific attributes. HPM allows us to evaluate how different tangible and intangible characteristics influence the market price of a good, providing a robust analytical framework for valuing benefits that are not always directly reflected in monetary terms. In the context of social investment projects, this methodology is particularly useful for integrating environmental, social, and economic variables into the evaluation of benefits, overcoming the limitations of traditional models that focus exclusively on direct economic aspects.

The hedonic approach applied in this research allows us to capture the influence of contextual factors, such as environmental quality, access to public services, and improvements in quality of life, in the overall assessment of the benefits generated by the projects. From this perspective, a comprehensive review is proposed for both the calculation of sample size and the formulation of the benefit equation, with the aim of achieving a more accurate, contextualized, and representative assessment of actual impacts. This methodological adjustment improves the robustness of statistical analyses and at the same time broadens the scope of benefit assessment, enabling better decision-making in the planning and execution of social investment projects.

Critical analysis of the original equation used to calculate sample size reveals significant limitations in its ability to adapt to the complexity and diversity of social investment projects. The traditional formula, based on standard parameters such as confidence level and margin of error, assumes homogeneity in the populations studied and omits contextual factors that directly influence the representativeness of the sample. This methodological simplification can lead to underestimating or overestimating the necessary sample size, affecting the validity and accuracy of the results obtained.

In response to these limitations, a new equation is proposed that expands on the traditional approach by incorporating factors that allow the sample size to be adjusted according to the variability of the data and the particularities of the context in which the project is carried out. The corrected equation is proposed as follows:

$$n = \frac{\frac{(N * Z^2 * p * q)}{e^2} * (DE * CF)}{[(\sigma^2 * (N-1) + (Z^2 * p * q)]} \qquad (3)$$

This formula retains the fundamental components of classical sample calculation, but introduces two new key variables: standard deviation (SD) and the correction coefficient for contextual factors (CF). These additions refine the calculation and improve sample accuracy, ensuring that the data collected is representative and adequately reflects the characteristics of the environment.

Standard deviation (SD) is incorporated as an essential factor to capture the variability of the key variables considered in the analysis. In social investment projects, community responses and perceptions can vary widely due to socioeconomic, cultural, and environmental factors. Ignoring this variability can lead to biased or inaccurate results. By including standard deviation in the sample calculation, the equation automatically adjusts the sample size based on the heterogeneity observed in the data. The greater the dispersion of responses, the larger the sample size needed to accurately capture different perspectives and ensure the statistical validity of the results.

On the other hand, the correction coefficient for contextual factors (CF) responds to the need to adapt the sample calculation to the specific characteristics of the environment where the project is carried out. This coefficient considers elements such as geographical heterogeneity, socioeconomic diversity, cultural particularities, and environmental factors specific to each region. In projects implemented in diverse or complex contexts, where local conditions vary significantly, the CF adjusts the sample size to ensure that all relevant subpopulations are adequately represented. For example, in rural areas with low population density or in communities with distinctive cultural characteristics, the coefficient increases the sample size to ensure that these differences are reflected in the data collected.

The combination of standard deviation and correction coefficient allows the new equation to provide a more accurate and contextualized calculation of sample size. This approach improves data representativeness and helps optimize resources allocated to information collection by avoiding insufficient or unnecessarily large samples. Furthermore, by explicitly considering data variability and contextual characteristics, the equation strengthens the external validity of the results, facilitating their generalization to similar contexts.

Thus, the proposed equation for calculating sample size offers a more robust methodological tool that is better suited to the complexity of social investment projects. By incorporating standard deviation and the correction coefficient for contextual factors, the formula allows for more representative samples and more accurate results, thus contributing to improving the quality of analysis and evidence-based decision-making. This comprehensive approach recognizes the importance of considering social, economic, and environmental dynamics in benefit assessment processes, promoting more inclusive and contextualized evaluations.

Regarding the benefit equation proposed by the National Planning Department (DNP), a thorough analysis reveals a limited structure that focuses exclusively on tangible economic variables, leaving aside environmental and social factors that are essential in the assessment of social investment projects. This limitation leads to a significant underestimation of the real benefits, which can affect the accuracy of the analyses and the effectiveness of decision-making. To overcome these shortcomings, a new benefit equation is proposed that adopts a comprehensive approach, incorporating economic, environmental, and social variables, as well as contextual factors that directly influence the assessment of the benefits generated by projects.

The proposed equation is formulated as follows:

$$B = \sum \left[(P_I * Q_i) + (E_j * W_j) + V_k \right] - C \qquad (4)$$

Where:

● B = Total benefit of the project.

● P_i = Unit price of good or service i.

● Q_i = Quantity produced or affected of good or service i.

● E_j = Economic value of environmental variable j.

● W_j = Weight or relative importance of environmental variable j in the context of the project.

● V_k = Valuation of intangible benefits k (such as improvements in quality of life, health, social well-being, among others).

● C = Total cost of the project.

One of the most innovative elements of the proposed equation is the explicit incorporation of environmental variables (E_j) weighted by their relative importance (W_j) in the context of the project. This component recognizes that social investment projects not only generate direct economic impacts, but also significant environmental effects, both positive and negative. By quantifying the economic value of factors such as air quality, preservation of green areas, conservation of water resources, and biodiversity, the equation allows for the capture of benefits that have traditionally been ignored in evaluation models.

Weighting these variables using relative weight (W_j) adds an additional level of precision to the analysis, as it recognizes that not all environmental factors have the same impact or relevance in each project. For example, in an urban development project, the preservation of green areas could have a greater weight due to its direct influence on the quality of life of residents, while in a road infrastructure project, proper water resource management could be the most relevant environmental factor.

The inclusion of intangible benefits (V_k) represents another significant advance in the proposed benefits equation. This component allows for the incorporation of aspects that are difficult to quantify but essential in the evaluation of social projects, such as improvements in quality of life, public health, social cohesion, community safety, and access to basic services. These intangible benefits, although not always reflected in direct monetary figures, have a profound impact on the communities benefiting from the projects.

These elements can be assessed using techniques such as citizen perception surveys, quality of life analyses, subjective well-being studies, and contingent valuation methods, which allow an approximate economic value to be assigned to these intangible benefits. This integration expands the model's ability to capture the total impact of projects and provides a more comprehensive and realistic view of the benefits generated.

The structure of the proposed equation also stands out for its flexibility and adaptability to different contexts and types of projects. By allowing for the incorporation and weighting of specific variables according to the characteristics of the environment and the objectives of the project, the equation can be adjusted to accurately reflect the particularities of each case. This is especially relevant in projects developed in regions with diverse socioeconomic and environmental contexts, where local dynamics significantly influence the benefits generated.

In addition, the equation facilitates comparison between different projects by maintaining a common base structure, while allowing components to be customized according to the specific needs of each evaluation. This flexibility makes the proposal a versatile tool that can be applied to a wide range of social investment initiatives.

Applying this equation to project evaluation allows for more informed and accurate decision-making. By integrating economic, social, and environmental factors, those responsible for project planning and execution can obtain a more comprehensive view of the expected impact, facilitating investment prioritization and efficient resource allocation. Furthermore, considering intangible and environmental benefits helps promote more sustainable and equitable projects, aligned with the principles of sustainable development and social responsibility.

Another noteworthy aspect of the proposed equation is its ability to assess the long-term impact of projects. By including environmental and social variables, the model makes it possible to anticipate future effects that may not be evident in the early stages of the project, such as progressive improvements in the quality of life of communities or the cumulative environmental benefits derived from sustainable practices. This long-term perspective is essential for strategic planning and comprehensive evaluation of investments.

While the proposed equation offers numerous advantages, it also presents certain methodological challenges that must be considered. The valuation of environmental variables and intangible benefits can be complex and require the application of specific analytical methods, such as contingent valuation studies, multi-criteria analysis, and perception surveys. In addition, the assignment of relative weights to environmental variables (W_j) requires a participatory and transparent process, involving experts and local stakeholders to ensure that the assigned values adequately reflect the priorities and needs of the community.

Data collection also poses a challenge, especially in contexts where information is limited or difficult to access. Effective implementation of this equation will require coordinated efforts to collect reliable and up-to-date data, as well as training for the teams responsible for evaluation.

This new benefit equation represents a significant advance in the methodology for evaluating social investment projects. By integrating economic, environmental, and social variables, and by considering both tangible and intangible benefits, the model offers a more comprehensive and realistic analysis of project impact. This comprehensive approach contributes to improved decision-making, promotes more efficient resource allocation, and encourages sustainable and equitable initiatives.

The equation also strengthens the ability of project managers to anticipate and manage long-term impacts, enabling more strategic planning that is aligned with the principles of sustainable development. Although the application of this methodology presents technical and logistical challenges, its potential benefits in terms of accuracy, representativeness, and relevance justify its adoption in social investment project evaluation processes. This tool provides a solid foundation for promoting public policies and projects that generate real and lasting benefits for communities and the environment.

Discussion

The analysis carried out in this research highlights the need to rethink the traditional approaches used in assessing the benefits of social investment projects. The equation proposed by the National Planning Department (DNP), which focuses exclusively on tangible economic variables, is limited in that it does not consider the complexity of the environmental and social impacts associated with these projects. This methodological limitation affects the ability of assessments to accurately reflect the true scope of the benefits generated, compromising the quality of decisions based on these analyses.

The methodological proposal developed in this study introduces significant adjustments to both the benefit equation and the sample size calculation. By integrating weighted environmental and social variables, as well as intangible benefits such as quality of life and community well-being, the revised equation broadens the spectrum of factors considered, providing a more comprehensive assessment. This approach responds to existing criticisms of conventional methodologies and aligns with current trends in project evaluation, which demand greater attention to social and environmental impacts.

The adjustment in the sample size calculation, which incorporates the standard deviation of key variables and a correction coefficient for contextual factors, represents another significant methodological advance. This change improves the representativeness of the data collected, allowing statistical analyses to be more robust and appropriate to the specific characteristics of each project and its context. The inclusion of these elements strengthens the internal and external validity of the results, ensuring that the conclusions derived from the analyses are more reliable and applicable to decision-making.

When comparing these results with previous studies, there is a growing trend toward incorporating environmental and social variables into economic valuation. Research such as that by Brécard et al. (2018) highlights the importance of considering environmental factors in the valuation of urban projects, while Rosero and Campoverde (2020) advocate for more inclusive methodologies that reflect social impacts. The proposal presented in this study is aligned with these approaches, contributing to the evolution of project evaluation methodologies.

However, implementing these proposals also poses challenges. Assessing intangible and environmental benefits requires precise and rigorous methods, as well as detailed and up-to-date data, which can increase the costs and complexity of evaluation processes. Furthermore, assigning monetary values to intangible factors can lead to debates about the subjectivity of the methods used and the reliability of the results obtained.

Despite these limitations, the methodological approach proposed in this study represents a significant advance in the evaluation of benefits in social investment projects. By offering a more comprehensive and contextualized approach, this methodology improves the ability of analyses to reflect the complexity of the impacts generated and contributes to more informed and responsible decision-making.

Ultimately, this discussion highlights the importance of continuing to develop and refine assessment methodologies, incorporating multidimensional perspectives that allow for a more accurate capture of the various impacts of projects. The integration of economic, social, and environmental approaches into benefit assessment not only improves the quality of analysis but also promotes more sustainable and equitable investment practices, aligned with the principles of sustainable development and social responsibility.

Conclusions

This study addresses the need to adjust the benefit equation proposed by the National Planning Department (DNP) for social investment projects, highlighting the methodological limitations that affect its ability to comprehensively evaluate the benefits generated by these projects. Through theoretical and documentary analysis, critical flaws in the original equation are identified, particularly its limited focus on tangible economic variables and the omission of environmental and social factors that play an essential role in the real assessment of the impact of projects.

In response to these limitations, an adjusted benefit equation is proposed that integrates weighted environmental variables and intangible benefits, applying the principles of the Hedonic Pricing Methodology (HPM). This proposal broadens the scope of benefit assessment by considering factors such as environmental quality, public health, social cohesion, and other intangible elements that enrich the analysis. The new equation offers a more complete and accurate view of the benefits generated and facilitates more informed and responsible decision-making in the planning and execution of social projects.

With regard to sample size calculation, a revised formula has been introduced that incorporates the standard deviation of key variables and a correction coefficient for contextual factors. This methodology allows the sample size to be adapted to the specific characteristics of each project and context, improving the representativeness of the data and the statistical validity of the results obtained. This adjustment is essential to ensure that the analyses accurately reflect the social and environmental dynamics of the beneficiary communities.

Among the main conclusions, it is noteworthy that the adjusted equation provides a more robust and flexible tool for evaluating social investment projects. By integrating economic, social, and environmental dimensions, the proposed model overcomes the limitations of the traditional approach and responds to the need for a more comprehensive and contextualized assessment. Likewise, the new methodology contributes to the promotion of more sustainable and equitable projects, aligned with the principles of sustainable development and social responsibility.

However, the study also acknowledges certain limitations. The application of the adjusted equation and the new sampling formula requires accurate and up-to-date data, as well as methodological and technical resources for the assessment of intangible and environmental variables. Collecting this data can be challenging, especially in contexts where information is limited or difficult to obtain. Furthermore, assigning monetary values to intangible benefits can generate debate about the subjectivity of the methods used.

As a key recommendation, we suggest the empirical application of the proposed equation in specific case studies, which would allow for the validation and adjustment of the methodology based on the results obtained. Future studies could focus on developing standardized tools for the assessment of intangible benefits and improving methods for weighting environmental variables, thereby strengthening the applicability of the model in different contexts.

Finally, future research should explore complementary methodologies that allow for a more in-depth social and environmental assessment of projects, as well as the development of indicators that facilitate the measurement of intangible benefits and their integration into decision-making processes. The evolution of these approaches will contribute to the design of more inclusive and sustainable public policies focused on maximizing the well-being of communities and the preservation of the environment.

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