Integrating Equity and Efficiency Considerations in the Evaluation of Public Decisions

Doctoral Thesis
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I. INTRODUCTION

1. A general perspective

The concern for jointly considering efficiency and equity criteria in the social evaluation of public projects, and particularly in cost-benefit analysis (CBA), has been a persistent research topic since the seminal papers of Little and Mirlees (1969), Mcguire and Gran (1969), and Weisbrod (1968) among others. However, those contributions have not been free from criticism and the debate is still open.

This doctoral thesis is centered in the study of the consideration of efficiency and equity criteria in the decision making process. The first contribution deals with the integration of distributional effects in CBA. One of the main criticisms to CBA is the lack of consideration of this kind of effects in the evaluation of public projects. There are at least two different ways to incorporate them. One is to consider the different marginal utilities of individuals to income or consumption. The other is to measure the effects in utility of the changes in the income distribution caused by a project investment.

So far, the literature has focused on the former. In this area, the main solution has consisted in applying some set of distributional weights (Brent, 1984), but this is not widely accepted among academics and social decision makers and, thus, it has not become standard practice. Another solution proposed is the application of a ratio of household income to an adequate poverty line (Blackorby and Donaldson, 1987), but this has not been taken into account by practitioners.

This doctoral thesis deals with the second approach –thus incorporating the variation in utility due to the perception of the redistributional effects of the investment under evaluation. First, it proposes to explicitly measure the changes in the income distribution due to the project investment; and then, to find the effects of the investment on social welfare when considering both efficiency and equity in an integrated manner, through the Efficiency and Distributional Cost Benefit Analysis (hereafter EDCBA). This methodology is compatible with the application of distributional weights since the two approaches address two different equity issues.

The second contribution of the thesis focuses on the introduction of temporal preferences on equity. One of the concerns of welfare economics is the treatment of time (see Heal, 1998, for different approaches). In CBA, a discount rate is usually applied to the future costs and benefits. There is an ample literature on temporal preferences (see for example Samuelson, 1937; Koopmans, 1960; Loewenstein, 1987; Burton, 1993; Price, 1993; Heal, 1998; and Portney and Weyant, 1999, among others). Also, applications of discount rates on non monetary values, such as the number of lives saved or energy consumption, can be found in the literature –see for instance Price (1993).

However, even though there are numerous studies dealing with temporal preferences, with public projects evaluation and attitudes towards equity, there seems to be no specific literature on the temporal valuation of equity (be it inequality, equality, horizontal equity, etc). This thesis attempts to contribute to the development of a rationale for a discount rate on equity. Besides, we propose an empirical exercise to estimate the discount rate on equity, what constitutes a novelty itself.

The third contribution of this dissertation is an empirical illustration of EDCBA. The objective of this exercise is to show the feasibility of the implementation of the methodologies proposed in this research. Thus, the EDCBA methodology and the discount rate on equity are used and integrated into some social welfare functions.

The remaining of the chapter is structured as follows. Section 2 describes the state of the art and the main issues involved with the first contribution of this thesis, the Efficiency and Distributional Cost Benefit Analysis. Section 3 discusses the current literature on discounting and on attitudes towards equity, and their relation with the application of a discount rate for inequality. Section 4 introduces the main aspects of the integrated application as well as a sensitivity analysis.

2. The Efficiency and Distributional Cost Benefit Analysis

As mentioned, one of the main criticisms to CBA is the lack of consideration of the distributional aspects. There are at least two possibilities to take them into account. The first is to consider the impacts of an extra unit of income or consumption to different individuals. The second consists on estimating the effects on social welfare of the changes in the income distribution caused by the project investment.

Since the 1960's, the solution that has come apparent in the literature for the first alternative is the application of distributional weights for every distinct group of individuals affected by a project investment to correct for their different marginal utilities to income, consumption, or any other relevant variable.

In contrast, there are no clear guidelines in the literature for how to proceed with the second approach. A new methodology is proposed in the second chapter of this thesis. The mechanism incorporates some measures of inequality to construct a matrix (similar to the CBA) but expressed in terms of distributional changes, the DCBA. Additionally, a third matrix, reflecting social welfare changes, is introduced using the abbreviated social welfare functions.

Distributional Weights

Weights are applied either to different individuals or groups according to their income or some other variable, or to different variables according to their nature. The estimation of the values of the weights depends on several considerations, existing different approaches from different schools. The *a priori* school states that a constant elasticity parameter λ "should be specified in advance of the project appraisal by the social decision maker" (Brent, 1984, p. 221). Thus, $a_1 = (y_i / \bar{y})^{\lambda}$, where a_1 is a weight, y_i is individual *i*'s income and $\bar{y}$ is the mean income. The *imputational* school proposes to define λ from experience by deriving implicit weights used in the past by decision makers in similar circumstances (Brent, 1984). As a variation, the *Weisbrod* school (Weisbrod, 1968) requires the decision maker to explicitly declare the type of groups he or she is concerned with. What Brent (1984, p. 224) calls "the *social concerned* school" would include in the weighting equation other characteristics, in addition to income, which are considered socially important, like the age of retiring individuals, for example. In this vein, they propose the use of the expression $a_i = \left[\alpha_y\,(y_i/\bar{y}) + \alpha_A\,(A_i/\bar{A})\right]^{-\lambda}$ where A_i is the age of individual *i*, $\bar{A}$ is the retirement age, and α_y and α_A are factors that reflect the social importance of being poor and of being old.

Once the distributional weights have been determined, they are applied to costs and benefits. The consequence of this procedure is that for a given CBA in which costs exceed benefits, the results could turn into $a_1 \cdot$ *Costs* < $a_2 \cdot$*Benefits,* being a_1 and a_2 distributional weights. In this instance, a project that would have been rejected might be worth considering under CBA advice once weights are applied.

It has sometimes been suggested to limit the use of weights to disadvantaged groups or impoverished areas, cities or countries (Boardman et al., 1996), or to problems concerning the climate change (Johansson-Stenman, 2000). Most criticisms to the use of distributional weights focus on the “efficiency loss” this implies, to the distortion effects of the application of the Hicks-Kaldor criterion (Harberger, 1978; 1980), to its limited applicability (Little and Mirrlees, 1991), and the inconsistency in the assignation of weights to the benefits of the rich and the poor (Blackorby and Donaldson, 1987). For a complete survey on distributional weights see Brent (1984; 1998) and Londero (1996), among others.

Altogether has resulted in a small number of applications and, consequently, in this type of inequality criteria being in practice left out of CBA, although the debate on how to account for equity has been present since then (see UNIDO, 1972; Dasgupta and Pearce, 1972; Brent, 1984; Blackorby and Donaldson, 1987; Layard and Glaister, 1994, among many others).

Other approaches trying to introduce distributional aspects into the project evaluation are those proposed by Blackorby and Donaldson (1987) and by Slemrod and Yitzhaki (2001). The former suggested the introduction of a distributionally sensitive CBA by applying certain household welfare ratios into the cost benefit criterion. These were the ratios of household income to an appropriate poverty line. With a different approach, Slemrod and Yitzhaki focus on the marginal costs of funding a public project and its marginal benefits. By decomposing both concepts into a marginal efficiency (cost of funding or benefit of public projects) and a distributional characteristic (of funding and of the benefit of the project), it is possible to find the distributional effects of the project.

Choosing an inequality index

There is a considerable number of inequality indices, with different properties. A full revision of inequality indices is not the objective of this research in this section, but rather to highlight the main characteristics of the most widely used ones. A full revision can be found, for instance, in Sen (1973), Kakwani (1980), Coulter (1989), Lambert (1993), or Cowell (1995).

An appropriate index for a DCBA ought to meet the following desirable properties:

- *Anonymity (symmetry):*

$$_I(y_1, y_2, y_3, ..., y_n) \sim_I (y_2, y_1, y_3, ..., y_n) \sim_I (y_1, y_3, y_2, ..., y_n) ...,$$

where the I subscript refers to the inequality level and y_i refers to the income of individual *i*.

This property states that all permutations of personal labels (individuals' characteristics) are regarded as distributionally equivalent. It requires that the ordering principle uses only the information of the income variable and not of some other characteristics which might be discernible in a sample or an enumeration of the population (Cowell, 1998).

- *Population principle:*

$$_I(y_1, y_2, ..., y_n) \sim_I (y_1, y_1, y_2, y_2, ..., y_n, y_n) \sim ... \\ \sim_I (\underbrace{y_1, y_1, ..., y_1}_{m}, \underbrace{y_2, y_2, ..., y_2}_{m}, ..., \underbrace{y_n, y_n, ..., y_n}_{m}).$$

This principle implies that an income distribution is to be regarded as distributionally equivalent to a distribution formed by replications of it.

- *Principle of transfers (Pigou-Dalton condition):*

$$X_A(y_1, y_2, ..., y_i, ..., y_j, ..., y_n) \prec_I X_B(y_1, y_2, ..., y_i + \delta, ..., y_j - \delta, ..., y_n),$$

where $\boldsymbol{X}$ denotes an income distribution of the form $\boldsymbol{X}(y_1,y_2,\ldots,y_i,\ldots,y_n)$, $\delta>0$ and $y_1<y_2<\ldots<y_i<\ldots<y_j<\ldots<y_n$. This asserts that any transfer from an

individual of higher income to an individual of lower income reduces the inequality (Dalton, 1920; Sen, 1973).

There are two main groups of inequality indices, relative and absolute. Relative indices of inequality are scale invariants and absolute indices are translation invariants:

- Scale invariance: $I(y_1, y_2, ..., y_n) = I(\lambda y_1, \lambda y_2, ..., \lambda y_n)$ for any λ.
- Translation invariance: $I(y_1, y_2, ..., y_n) = I(\lambda + y_1, \lambda + y_2, ..., \lambda + y_n)$ for any λ.

While the first is invariant to equiproportional changes to income, the second is invariant to uniform changes to income.

Some of the relative inequality indicators that simultaneously meet the conditions above are the Gini index, the family of generalized entropy, and the Atkinson's inequality index, while some of the most important absolute ones are the variance and the Kolm-Pollack index of inequality. This research is restrained to the relative measures of inequality, leaving the absolute ones as an open line of research.

The Gini index (G) can be interpreted as the sum of the differences in income between every pair of individuals (i, j) (Gini, 1912). Formally, it can be expressed as:

$$G = \frac{\frac{1}{n(n-1)}\sum_{i=1}^{n}\sum_{j=1}^{n}\left|y_i - y_j\right|}{2\bar{y}}\ .$$

being $y_1, y_2, ..., y_n$ the individuals' incomes and $\bar{y}$ the society's mean income. The Gini index lies between zero and one, with $G = 0$ when total equality is achieved.

The generalized entropy family derives from the thermodynamic theory (Theil, 1967). Entropy is a measure of disorder. It satisfies the strong principle of transfers, the independence of scale and population, and it is decomposable (Pfähler, 1987). Its expression is

$$E_\theta = \frac{1}{\theta^2 - \theta}\left[\frac{1}{n}\sum_{i=1}^{n}\left[\frac{y_i}{\bar{y}}\right]^\theta - 1\right] \text{ for any } \theta \neq 0,1$$

$$E_0 = \frac{1}{n}\sum_{i=1}^{n} log\,\frac{\bar{y}}{y_i} \quad \text{for } \theta = 0$$

$$E_1 = \frac{1}{n}\sum_{i=1}^{n}\frac{y_i}{\bar{y}}\, log\,\frac{y_i}{\bar{y}} \quad \text{for } \theta = 1,$$

where θ is a parameter of distance between proportions of income of the individuals. Different values of θ give different weight to the distance between different proportions of income along the distribution. Its value depends on the society aversion to inequality. A $\theta > 1$ gives a higher weight to the distances in the upper part of the distribution, while $\theta < 1$ increases the weight importance of the distances among lower incomes. The Theil index and the coefficient of variation are particular cases of the generalized entropy family (E_θ) with $\theta = 1$ and $\theta = 2$ respectively.

Atkinson's inequality index (A_ε) is based on a social welfare function that is non-decreasing on income, symmetrical, additive, concave, and with a constant parameter (ε) of relative aversion to inequality (Atkinson, 1970). It is based on an economic normative foundation (Lambert, 1993). The Atkinson index can be expressed as

$$A_\varepsilon = 1 - \left[\frac{1}{n} \sum_{i=1}^{n} \left(\frac{y_i}{\bar{y}} \right)^{1-\varepsilon} \right]^{1/(1-\varepsilon)}.$$

The index A_ε becomes zero when all the individuals of society have the same income ($y_i = \bar{y}$). The index takes values between 0 and 1, and it can be interpreted as both a measure of inequality and an indicator of the potential welfare gain if income were distributed in an equalitarian way (Barr, 1998). An ε parameter equal to zero reflects that society is indifferent to inequality, and the index A_ε would be zero even if individuals had different income levels. On the other hand, a relative aversion to inequality ε tending to ∞ implies that society is very sensitive indeed to inequality, especially to the poorest individual.

Choosing an adequate decomposition methodology

Normally, project investments involve several variables (i.e. costs and benefits) that constitute the total welfare change when measured by efficiency criteria. The total variation in the income distribution, and thus, the total change in inequality can be decomposed into the contribution of each of the income components (i.e. costs and benefits) to total inequality.

A cost-benefit analysis could identify how the project investment affects the income distribution in different groups of individuals in a society. It is possible to analyze the inequality effects in the CBA by decomposing inequality indices by population subgroups. This is that there is consistency between the inequality indicator for the whole society and the indicators for its different groups of individuals (Bourguignon, 1979; Cowell, 1995).

This section is devoted to the discussion of the decomposition methodologies applicable to inequality measures.

<u>Decomposition by income factors</u>

An inequality index $I(\boldsymbol{X})$, being $\boldsymbol{X}$ an income distribution of the form $\boldsymbol{X}(y_1,y_2,\ldots,y_i,\ldots,y_n)$, can be decomposed into the contributions of each of the k income factors of y_i to total inequality, where y_i is defined as personal income . Then:

$$y_i = \sum_{j=1}^{k} y_{i,j} \ . \qquad [1.1]$$

Let the income distribution of factor j be $\boldsymbol{X_j}(y_{1,j}, y_{2,j}, \ldots, y_{n,j})$

$$\boldsymbol{X} = \sum_{j=1}^{k} X_j \ . \qquad [1.2]$$

There are at least two decomposition methodologies. The "natural" decomposition, by Shorrocks (1982), and the Shapley value decomposition, proposed by Chantreuil and Trannoy (1999). Both procedures have different implications, but rely on a set of assumptions to decompose any inequality index, although there are still some limitations for decomposing certain inequality measures. These assumptions are that the index to be decomposed has to be symmetric and continuous, and require also that the decomposition has to be independent of the level of disaggregation and to be consistent, i.e. $I(\mathbf{X}) = \sum_{j=1}^{k} S_j$, where S_j is the absolute contribution of factor j to overall inequality (Jenkins, 1995). Additionally, given the large number of income sources, it must be defined for zero incomes (Shorrocks, 1982; Jenkins, 1995). Income factor j provides an unequalising effect if $S_j > 0$, and an equalising effect if $S_j < 0$. A large value of S_j suggests that factor j is an important source of total inequality.

The exact decomposition procedure depends on the measure of inequality used. Only a few measures, such as the Entropy family and the Gini index, can be decomposed "naturally". In practice the easiest measure to decompose in this way is E_2 (coefficient of variation). In that case (Litchfield 1999):

$$S_j = \rho_j \chi_j \sqrt{E_2(X) \cdot E_2(X_j)},$$

where $\boldsymbol{X}_j$ is factor j's income distribution; ρ_j is the correlation between component j and total income; $\chi_j = \frac{\mu_j}{\mu}$ is j's factor share of total income; μ_j is the mean of factor j; μ is the mean income; and $E_2(\boldsymbol{X}) = \sum_{j=1}^{k} S_j$.

For the Gini index: $S_j(G) = \frac{\mu_j}{\mu} \overline{G}_j$, where $\overline{G}_j$ is the pseudo-Gini of income of factor j (in the sense that individuals are weighted by total income ranking and not by every factor rankings). And $G = \sum_{j=0}^{k} S_j(G)$.

This kind of decomposition can be regarded as a weighted sum of factor j incomes, where the weights are determined by the functional representation of the inequality index used.

A different approach to the decomposition by income sources of the inequality measures is proposed by Chantreuil and Trannoy (1999) based on the Shapley value (Shapley, 1953). They showed that using the Shapley value to decompose any inequality index, the contribution of each income source, S_j, to total inequality $I(\boldsymbol{X})$, is the marginal contribution of this income source.

There are two possible ways to interpret this marginalist view. First, accounting for the differences between total inequality and the inequality arising from eliminating the income source which effect is being assessed (known as the zero income decomposition). Second, accounting for the differences between total inequality and inequality assuming that the income source being analyzed is equally distributed (i.e. assigning the mean of income source j to every agent), known as the equalized income decomposition. Both procedures are now briefly explained (for further references see Shapley, 1953; Shorrocks, 1999; Chantreuil and Trannoy, 1999; and Sastre, 2001).

Some additional notation needs to be introduced. Let Q be a subset of income sources. The size of admissible subsets is of 2^k. Let q be the number of elements in Q. Define $\boldsymbol{X}$ as in [1.2] and $\mathbf{X}_{-h}$ as

$$\mathbf{X}_{-h} = \sum_{j=0, j\neq h}^{k} X_j \ , \forall j \subset h \ .$$

For the zero income decomposition let $y(Q)$ be the income distribution of Q, such that:

$$y(Q)=\left(\sum_{j\in S} y_{1,j},\sum_{j\in S} y_{2,j},\dots,\sum_{j\in S} y_{n,j}\right).$$

The contribution of factor *j* to total inequality would be:

$$Q_j = \sum_{S\subset k, j\in S} \frac{(s-1)!\,(k-s)!}{k!}\left[I(y(S))-I(y(S-\{j\}))\right], \qquad [1.3]$$

and

$$I(X)=\sum_{j=1}^{k} Q_j \ . \qquad [1.4]$$

For the equalized income decomposition, the difference resides in the income distribution of subset Q, which now is defined as:

$$y^e(Q)=\left(\sum_{j\in S} y_{1,j}+\sum_{j\notin S}\mu(y_j),\sum_{j\in S} y_{2,j}+\sum_{j\notin S}\mu(y_j),\dots,\sum_{j\in S} y_{n,j}+\sum_{j\notin S}\mu(y_j)\right),$$

where $y^e(Q)$ is the income distribution of subset Q equalizing the distribution of the income sources which are not included in Q, and $\mu(y_j)$ is the mean income from source *j*.

Substituting $y^e(Q)$ into [1.3] to get the contribution of factor *j* to inequality and into [1.4], the overall index of inequality is obtained.

Although there is no clear superiority of any of these approaches, some empirical results show preferences for the equalized income decomposition approach (Sastre, 2001).

Shapley inequality decomposition offers some advantages to the analysis of the contribution of income sources to the total inequality in relation to the natural decomposition. It leads to a perfect symmetric decomposition (the sum of the contributions adds up to the amount of inequality), it is sensible to the choice of the inequality index, and it can be applied to any inequality index. It has also some disadvantages. Its main drawback is its lack of independence of the level of disaggregation. This means that the marginal contribution of the income sources is dependent on the number of income sources. Also, as the number of income sources grow, its calculation becomes rather complex; for example, for a 6 income-source income distribution, the size of the subset of feasible income distributions is 64. In summary, both the “natural” and the “Shapley” income factor decompositions have advantages and drawbacks. Shorrock’s natural decomposition is widely accepted and used in empirical applications, whereas Shapley value decomposition can be applied consistently to any measure of inequality.

However, the interpretation of the income sources contribution to inequality is somewhat different. Under the natural decomposition, these elements represent the absolute contribution of income factor j to the total inequality, while for the Shapley value decomposition these elements are the marginal contribution to inequality.

Decomposition by population subgroups

Some of the most used inequality indices can be decomposed rather easily by population subgroups, but others cannot. The generalized entropy family of indices and the Atkinson per capita index of inequality can be additively decomposed, while the Gini index fails to be decomposable.

For the Atkinson index, decomposition can be formulated as follows: If m subgroups are considered from a given population, the proportion of the population of subgroup p over the total could be denoted as f_p. Therefore, $\sum_{p=1}^{m} f_p = 1$. If the mean income of subgroup p is $\bar{y}_p$, and the proportion of the income of this subgroup over the total income is denoted by g_p, then $\sum_{p=1}^{m} g_p = 1$. Also, denote the Atkinson index for subgroup p as $A_{\varepsilon p}$. Following Blackorby et al (1981), the overall per capita index of inequality can then be expressed as

$$A_{total} = A_{\varepsilon,within} + A_{\varepsilon,between} ,$$

where

$$A_{\varepsilon,between} = \sum_{p=1}^{m} f_p \left(\frac{\bar{y}_p}{\bar{y}} \right) (1 - A_{\varepsilon,p}) - (1 - A_\varepsilon),$$
$$A_{\varepsilon,within} = \sum_{p=1}^{m} g_p A_{\varepsilon,p}.$$

For a full discussion of decomposability, see for instance Bourguignon (1979), or Blackorby *et al.* (1981).

For the generalized entropy index, total inequality can be decomposed as follows. The generalized entropy index for subgroup j, is denoted by $E_{\theta,j}$.

The total inequality index can be estimated as $E_{\theta,total}$=$E_{\theta,between}$ + $E_{\theta,within}$., where

$$E_{\theta,between} = \frac{1}{\theta^2 - \theta} \left[\sum_{j=1}^{m} f_j \left[\frac{\bar{y}_j}{\bar{y}} \right]^\theta - 1 \right]$$
$$E_{\theta,within} = \sum_{j=1}^{m} w_j E_{\theta,j}$$

being $w_j = g_j^\theta f_j^{1-\theta}$ (for a more detailed discussion, see for instance Cowell, 1995).

3. Application of a social discount rate on equity

One of the main concerns in the evaluation of social policies is the valuation of future costs and benefits. Social policies usually affect differently the income of individuals. As a consequence, the income distribution of the affected society is modified. These variations can take place at any time during the life of the project investment, and the treatment of these future values may have a significant impact in the social decision making.

So far, academic attention has been directed to the forms and rationale of utility discounting with monetary values, proposing different functional forms and models when the very long run is considered, or taking intergenerational equity into account. On the other hand, from the equity standpoint, there is a growing concern on the attitudes of individuals toward equity. In this field there are some recent reports of experimental research in which individuals are to decide on the provision of public goods (Chan *et al*, 1996; Chan *et al*, 1997; Amiel et *al*, 1999; Kroll and Davidovitz, 1999; Rutström and Williams, 2000).

However, to our knowledge there is no published research on the attitudes towards equity in a temporal scenario. In other words there are no reports of research on the perception of future equity or income distribution changes.

The third chapter of the thesis deals with the application of a discount rate for equity. It is argued that the changes in the income distribution due to a project investment should be discounted and integrated to the efficiency evaluation of public projects. A procedure for the derivation of the discount rate is also proposed, as well as an empirical exercise using stated preference methods.

The debate on the social rate of discount

Although there is an extensive use of discounting, the debate on the use of a discount rate in the social decision making process is still open. The details of this debate are out of the scope of this research, but can be found in Price (1993), Schelling (1995), Azar and Sterner (1996), Philibert (1999), and Portney and Weyant (1999), among others.

There are at least four reasons to discount. The first refers to the pure time preference of individuals. Also known as impatience, it is related to the preference that individuals generally express to consume a certain good in the present instead of consuming it in the future. The second argument deals with risk and uncertainty. It is argued that a certain event is riskier or more uncertain to occur as long as it will happen farther in the future. As an example, an individual might prefer present to future consumption because of the risk of dying before the time of consumption. The third argument in favor of discounting is based on the idea of marginal utility of consumption, and on the assumption that the society will be richer in the future. Thus, each additional unit of welfare generated by an investment project will be less valued for individuals as time goes on. Finally, the fourth argument for the application of a discount rate is the opportunity cost. To invest instead of consuming in the present means that one will be able to consume a larger quantity of goods in the future due to the capital productivity.

On the other hand, there are many arguments against those exposed above. In the first place, it is argued that it is not ethical to discount based on pure temporal preferences, and besides that, it is inconsistent according to the individual's life cycle welfare model. The ethical argument is repeated with respect to the uncertainty motive, next to inconsistencies of the exponential functional form of the discount rate. Likewise, the permanent growth of the economy cannot be guaranteed, which is the basic assumption to support discounting due to the decreasing marginal utility argument. Finally, with respect to the fourth reason, it would not be adequate to discount if the benefits of the investment were to be consumed instead of reinvested, as it is assumed under this argument. (Schelling, 1995; Lind, 1997; Philibert, 1999)

The functional form of the discount rate has been under debate, too. Several functional forms have been proposed. Negative discount rates, zero rates, constant rates, variable rates according to the number of years, different rates according to the kind of project and its duration, and mixed schemes among them (Lind, 1990; Weitzman, 1994; Lind, 1995; Rabl, 1996; Henderson and Langford, 1998).

Generally, these discount rates have been applied to monetary future costs or benefits. However, there is a literature on the derivation of discount rates for energy (Barrow et al 1986), job opportunities (Johnson and Price, 1987), radiation exposure levels (Demin *et al*, 1983) and human lives or years of life saved (Cropper and Portney, 1990), among others (Price, 1993). This broadens the scope for equity changes to be discounted within the framework of the evaluation of project investments.

Stated Preference methods

The discipline of economics has developed a set of techniques to estimate values for unmarketed goods. These methods are usually divided into revealed and stated preference methods. Under stated preference methods, individuals express their preferences in hypothetical situations, while the revealed preference methods are based in actual choices made by the individuals in observable situations. There is an ample literature dealing with the different methods to value unmarketed goods. See, for example, Freeman (1993) and Braden and Kolstad (1991).

There are several methods based on stated preferences, such as contingent valuation, contingent ranking, contingent rating, contingent choice, and its variant pairwise choice. A few publications contrast the different stated preference methods (Mackenzie 1993, Mogas *et al*. 2002). Each stated preference method might yield slightly different values for the same good. Several reasons have been given to explain this. For example, in all but the contingent valuation, substitute goods are made explicit, this forcing the individual to further explore her preferences and her trade offs (Boxall *et al.*, 1996). Another reason is that, from a psychological perspective, the process of choosing in the contingent choice, contingent ranking and contingent rating formats can be different to the associated process when making choices about willingness to pay in the contingent valuation (Irwin *et al*, 1993; Mckenzie, 1993). Next, one of these stated preference methods, the contingent choice, is briefly outlined. This will be the method used to estimate the equity discount rate in chapter 3.

Contingent Choice

The contingent choice or choice experiment has its origins in the conjoint analysis, which is used to represent individual judgments or multiattribute stimulus (Batsell and Louviere, 1991). Choice experiments have been used in marketing, transport and psychology (Batsell and Louviere, 1991; Louviere 1988a; 1988b; 1991; Henser and Johnson, 1981).

In a contingent choice application, respondents are presented with a series of choice sets, each containing usually three or more alternative goods. An alternative is a combination of several attributes, with each attribute taking on a value, usually called level. For instance, an alternative could be described as *h* hectares of additional forest with *p* percentage of tree species *S*, which would cost *c* monetary units. One of the alternatives in each choice set describes the current or future business-as-usual situation, and remains constant across the choice sets. From each choice set, respondents are asked to choose their preferred alternative. The attributes used are common across all alternatives.

Their levels vary from one alternative to another according to an experimental design (for a review, see Bennett and Blamey, 2001).

The theoretical foundation of contingent choice is grounded on the random utility maximization model (RUM) (Thurstone, 1927; McFadden, 1973). According to the RUM framework, the indirect utility function for each respondent can be expressed as:

$$U_{ij} = V_{ij} + \varepsilon_{ij} , \qquad [1.5]$$

Where U_{ij} is person i's utility of choosing alternative j, V_{ij} is the deterministic component of the utility function and ε_{ij} is a stochastic variable that represents unobservable influences on individual choices.

In contingent choice, the probability that any particular respondent prefers option j in the choice set to any alternative option k, can be expressed as the probability that the utility associated with option j exceeds the probability associated to each alternative option. Formally,

$$P_{ij} = \text{Prob} \{ V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik} ; \forall k \in C \}, \qquad [1.6]$$

where C is the set of all possible options (usually called alternatives). Assuming a Type I Extreme Value distribution for the error term, the probability of choosing alternative j is:

$$P_{ij} = \frac{e^{\omega V_{ij}}}{\sum_{k=1}^{m} e^{\omega V_{ik}}} \cdot \qquad [1.7]$$

This specification is known as the conditional logit model (McFadden, 1973), where ω is a scale parameter inversely proportional to the standard deviation of the error distribution, typically assumed to be one.

4. An integrated application

The final chapter of this thesis before the general conclusions is dedicated to an empirical application of the EDCBA, using a discount rate for equity. In this sense, it represents an integrated application of the concepts and methodologies discussed in the previous chapters.

The project investment under evaluation consists of a toll road proposed for the area of Barcelona, Spain. It is a 10 km long road, with a large tunnel to facilitate faster access between the city center and the suburbs to the west, behind Collserola Mountain. This project is first valuated under the traditional CBA, and then the EDCBA methodology is applied to complement the study. In the construction of the second and third matrices, a discount rate for equity values is introduced.

II. EFFICIENCY AND DISTRIBUTIONAL COST-BENEFIT ANALYSIS AS A TOOL TO ASSESS CHANGES IN INEQUALITY FROM PUBLIC PROJECT INVESTMENTS

Abstract

One of the main criticisms to Cost-Benefit Analysis (CBA) has been that it takes no explicit account of income differences among affected individuals. In trying to overcome this shortcoming, efforts have been devoted to capture differences on the marginal utility of income, whereas the utility derived from changes in the distribution of income itself has been more neglected. This paper proposes a new approach –the Efficiency and Distributional Cost-Benefit Analysis (EDCBA)– that explicitly incorporates the perception of changes in income distribution into Cost-Benefit Analysis.

1. Introduction

As currently practiced, cost-benefit analysis (CBA) is a tool that does not usually incorporate the differences in the income distribution of the affected population. The unequal distribution of income has at least two possible effects on CBA. One is the different impact on utility of an additional unit of income if it goes to an individual with lower or higher wealth. The other is the change in people's utility derived from the knowledge of the income distribution effects triggered by the project under scrutiny.

The former has been the focus of the equity considerations from CBA researchers since the 1960s (see Little and Mirless, 1969; Mcguire and Garn, 1969; and Weisbrod, 1968, among others). The solution that came up as dominant was the use of distributional weights. Weights were applied either to different individuals or groups according to their income or some other variable, or to different variables according to their nature. Distributional weights were to correct the differences in marginal utilities of income or consumption for agents with different income levels. As a consequence, the usual efficiency indicators like the Internal Rate of Return (IRR) or the Net Present Value (NPV) were "corrected" (Boardman *et al*, 1996).

The other equity issue –the utility changes due to the income distribution effects of the investment analyzed– is also worth considering. Usually, a project investment affects the income of members of a given society (income effects can be both monetary and non monetary). These income changes can produce variations in the income distribution, and these can be regarded as gains or losses in equality, which in turn can be contemplated by the members of society as a gain or loss of welfare from the knowledge of living in a more or less equalitarian community. To motivate the relevance of incorporating this type of distributional effects into the evaluation of investments, consider two otherwise equivalent investments, A and B, where A improves the distribution of income if undertaken and B worsens it. Society might actually prefer A over B. Likewise, when a traditional CBA finds B being slightly better than A, the increase in utility society perceives from knowing that A is a positive distributional project might make it more preferred than B. Not considering distributional effects would lead to an overall lower level of social welfare.

Nonetheless, this aspect of equity effects has been more neglected so far in CBA. Blackorby and Donaldson (1987) proposed to use welfare ratios (the ratio of household income to an appropriate poverty line) in cost-benefit rules, in order to make CBA distributionally sensitive. However, as recognized by the authors, these welfare ratios are not, in general, exact indices of well-being.

Slemrod and Yitzhaki (2001) focused on the marginal costs of financing the provision of a public good (or the spending in a public project) and the marginal benefits of projects. They decompose both concepts into the marginal efficiency cost of public funds and the distributional characteristics of the tax base, for the former, and into the marginal efficient benefit of funds and the distributional characteristics of the public good (or the public project under evaluation). They state that if the distributional characteristics for both concepts are equivalent, then the distributional impacts of the project can be ignored.

This paper turns its attention in a different direction while focusing on how to explicitly incorporate to the CBA type of evaluation the welfare effects that might arise from the income distribution impact of an investment. It proposes an intuitively simple triple matrix approach. The first matrix corresponds to the traditional CBA, the second one reflects the income distribution effects of the investment, and the third matrix combines the other two to synthesize the welfare effects of efficiency (first matrix) and equity (second matrix).

The paper is structured as follows: the procedure to construct a CBA matrix of distributional impacts (equity matrix) is explained in section two. The overall welfare effects of an investment project (third matrix) are treated in section three, and finally, section four contains the general conclusions.

2. An explicit distributional approach

Basic Assumptions

First, consider a society which income $\boldsymbol{X}$ is distributed among its n individuals, such that y_i denotes the income of individual i and $\boldsymbol{X} = \sum_{i=1}^{n} y_i$.

Secondly, consider a CBA for a project that affects the above society, with $k = 1,2,\ldots k$ variables and $t = 0,1,\ldots,T$ relevant periods (say years), being *0* the present period. These variables can either be costs (which reduce income) or benefits (an increase of income), and alter the earnings of individuals.

When the income distribution is not influenced by the investment to be evaluated, $\boldsymbol{X}$ is denoted $\boldsymbol{X}_{SQ,t}$ reflecting the *status quo* or *do-nothing* situation in period t, such that $y_{i,SQ,t}$ denotes the individual income of person (or household) i in period t if the project is not undertaken. The income distribution would be:

$$\boldsymbol{X}_{SQ,t} = \left(y_{1,SQ,t}, y_{2,SQ,t}, \ldots, y_{n,SQ,t}\right).$$

Third, let $P_{i,j,t}$ denote the change individual *i* will experiment in period t (compared to her income in *t-1*) due to the effect of variable j in this period. Therefore, the new income of individual i at the end of period t due to the investment would be

$$y_{i,t} = y_{i,t-1} + \sum_{j=1}^{k} P_{i,j,t} \,, \qquad [2.1]$$

and

$$\boldsymbol{X}_t = \sum_{i=1}^{n} y_{i,t} \,. \qquad [2.2]$$

Now consider individual i's income is also changed for reasons other than the investment project. To account for this variation, let Z_t be a new variable that denotes the income variation of variables not affected by the investment from period t-1 to period t. Therefore,

$$Z_{i,t} = y_{i,t} - \left(y_{i,t-1} + \sum_{j=1}^{k} P_{i,j,t} \right). \qquad [2.3]$$

And the income of individual i can be expressed as

$$y_{i,t} = y_{i,t-1} + Z_t + \sum_{j=1}^{k} P_{i,j,t} \,. \qquad [2.4]$$

Note that in [2.4], $y_{i,t}$ can be divided into $k+2$ income sources (k affected by the investment, final income of the last period, and variations in variables not related to the project) instead of $k+1$ as in [2.1].

Introducing Z_t is useful to determine the global change in the income distribution that the society exercises under the project investment. Even thought it could be assumed that the project investment is the only source of income variation, it is plausible that there might be different income affections apart from the public project under evaluation that should be taken into account.

Distributional measurement

The left hand side of equation [2.2] is what typically constitutes the elements of a cost-benefit matrix. The distributional matrix proposed here is concerned with the changes on the individual incomes reflected in the right hand side of [2.4]. The usual way to calculate the income distribution changes due to the project investment, and thus, the gain or loss of equality, is by indices of inequality. These measures were briefly discussed in chapter 1.

Once the appropriate inequality index has been chosen, it is calculated for the income distribution of each period. In this way, the gain or loss of equality due to the project investment at each period t can be expressed as the difference of the inequality index of period t-1 and the inequality of period t. This difference is known as the redistributive effect in the inequality literature (see Lambert, 1993, among others). This measure constitutes an estimation of the "aggregated" gain or loss in equality in the proposed distributional CBA matrix.

In short notation, let $I_{SQ,t}$ be the index measuring the status quo inequality level of the income distribution at period t; $I_{j,t}$ the inequality level of the income distribution at period t originated by the income changes from variable (or income source) j; and I_t the level of the overall inequality distribution index at the end of period t if the investment is undertaken. Furthermore, the measure of the accumulated redistributive effect (the gain or loss of equality) of the project at the end of period t will be denoted as

$$REP_t = I_{SQ} - I_t \quad \text{for } t=0$$

$$REP_t = I_{t-1} - I_t \quad \text{for } t=1,..,T \qquad [2.5]$$

If the sign of the correspondent *REP* is positive, it reflects an overall gain of equality (an “equity benefit”), and a loss (“equity cost”) if it is negative.

Decomposition of the Inequality Measure

However, the source or variable due to which the income distribution among individuals changes does not need to be unique, but can be decomposed into several. Thus, an investment project can have simultaneous separable effects conveniently identified for analytical reasons. There might be improvements in the income distribution due to a variable that increases the overall income (benefit, in terms of traditional CBA) or reduces it (cost). Likewise, a cost or a benefit in income level terms can induce a worsening of the income distribution. As shown in chapter 1, inequality indices can be decomposed by income factors (sources, or variables). This property makes it easier to estimate the distributional impact of given affected variables and the overall redistributive effects of the investment.

As mentioned earlier, $y_{i,t}$ can be decomposed into $k+2$ sources. The contribution (*S*) of each of these $k+2$ income factors to the gain or loss in equality can be obtained by the inequality decomposition by income factors, such that

$$I_t = \sum_{j=1}^{k+2} S_j \ , \qquad [2.6]$$

where S_j is the contribution of income factor j to total inequality, the k+1^th^ income source is $\boldsymbol{X}_{t-1}$ and the k+2^nd^ income source are the external income variations. Substituting [2.6] into [2.5] and operating, [2.7] is obtained.

$$REP_t = I_{t-1} - I_t = \left(\Delta S_{1,t}\right) + \left(\Delta S_{2,t}\right) + \ldots + \left(\Delta S_{k+1,t}\right), \qquad [2.7]$$

where $\Delta S_{j,t}=S_{j,t-1}-S_{j,t}$ are the contributions of each of the variables to the total gain or loss of equality.

Aggregation Over Time

A decomposition similar to the one for j can be applied to t. The overall gain or loss of inequality as measured by the indices can be seen as an aggregation over time of the effects in each relevant period in relation to the previous one. Thus, the total redistributive effect (gain or loss of equality) of a project, accumulated over the periods of study, is $REP_T = \sum_{t=0}^{T} REP_t$.

This expression is based on the total accumulated redistributive effect, which would be

$$REP_T = I_{SQ,0} - I_T . \qquad [2.8]$$

Operating [2.8], it can be seen that

$$\begin{aligned} REP_T = I_{SQ,0} - I_T &= REP_0 + REP_1 + \ldots + REP_T \\ &= \left(I_{SQ,0} - I_0\right) + \left(I_0 - I_1\right) + \ldots + \left(I_{T-1} - I_T\right). \end{aligned}$$

The elements on the right hand side show the yearly gain or loss of equality (ΔI_t).

The overall aggregated index (REP_T) would be the evaluation measure of the inequality effects of the investment. In this sense, it is the counterpart of the net present value (NPV) in the traditional CBA.

Changes in the Status Quo

In order to determine the real distributional effect of the project investment, it is necessary to account for the possible income distribution changes to occur along the period of study of the project if the investment were not undertaken. In other words, it is necessary to consider the changes in the status quo situation.

Denote $\boldsymbol{X}_{SQ,t}$ as the income distribution at period t if the project investment is not undertaken, such that $y_{i,SQ,t}$ denotes the individual income of individual (or household) i in period t if the project is not undertaken. The income distribution would be:

$$\boldsymbol{X}_{SQ,t} = \left(y_{1,SQ,t}, y_{2,SQ,t}, \ldots, y_{n,SQ,t}\right).$$

Analogously to the case considered above, for the status quo variation case, the redistributive effect at period t would be $RESQ_t = ISQ_{t-1}-ISQ_t$, and the accumulated effect $RESQ_T = ISQ_0-ISQ_T$.

The total redistributive effect of the project for period t, deducting the changes in the income distribution due to the status quo variation not related to the project, would be

$$TRE_t = REP_t-RESQ_t. \qquad [2.9]$$

And the accumulated redistributive effect

$$TRE_T = \sum_{t=0}^{T} TRE_t \,. \qquad [2.10]$$

Note that TRE_T can also be written as REP_T-RESQ_T or equivalently as

$$TRE_T = \sum_{t=0}^{T} \left(REP_t - RESQ_t\right).$$

Note, too, that TRE_t is bounded between –2 and 2, but TRE_T lies between –1 and 1, being the TER_T index consistent with the inequality literature. If TRE_T = 1, it would mean that the project equalized incomes departing from a totally unequal income distribution, while a TRE_T = -1 value would be interpreted exactly as the opposite.

Population subgroup analysis

The property of decomposition into population subgroups of the inequality indices (see chapter 1) provides a way to analyse the evolution of the changes in the income distribution for the relevant groups of the society. To account for these variations, in addition to the construction of the DCBA matrix described, several “partial” DCBA matrices can be built, one for each group, and finally, another matrix containing the changes in the within and between inequalities. The way to proceed for the *m* different partial DCBA matrices is exactly as for the “global” DCBA, so the procedure is not redeveloped again.

The DCBA methodology is compatible with the application of distributional weights, since it takes the results of the traditional (or eventually weighted) CBA as an input. Applied to a weighted CBA, the DCBA could be interpreted as the gains or losses of equality once the analyst has previously “corrected” costs and benefits, thus capturing how the different variables involved in the evaluation process differently affect groups of individuals.

3. Relationship between inequality and efficiency measures

Once the equity matrix is completed, a new matrix can be introduced to the approach, the efficiency and distributional cost benefit analysis (EDCBA) matrix, to combine the results of efficiency (CBA) and inequality (DCBA). This aggregation can be based on the abbreviated (or reduced) social welfare functions (ASWF). These functions (Lambert, 1990) combine an efficiency measure with an inequality value. In general,

$$v(x) = V(\mu, I),$$

where $v(x)$ is the aggregated welfare measure, μ is the efficiency value and I the relevant inequality indicator. The efficiency measure takes often the form of mean income (or income per capita), and can be interpreted as a “social good”, whereas the inequality would be a “social bad” (Lambert, 1990). The function reflects the trade-off society faces when willing to give up efficiency for a gain in equity (Sheshinski, 1972; Okun, 1975).

Several properties are usually demanded to an ASWF (see Dutta and Esteban, 1992; and Ruiz-Castillo, 1995). The component $v(x)$ has to be symmetrical, increasing, and allow for transfers; and $V(\mu,I)$ has to be increasing with respect to the first argument and decreasing with respect to the second. This implies that I has to be symmetrical and meet the principle of transfer, which is the case for the Gini, Atkinson, and generalized entropy indices (Blackorby and Donaldson, 1978; Lambert. 1993). Furthermore, an inequality index is said to be consistent with a social evaluation function if for any two distributions $\boldsymbol{M}$ and $\boldsymbol{Y}$ with the same mean, $I(m) \geq I(y) \Leftrightarrow V(m) \leq V(y)$ (Ruiz-Castillo, 1995; Salas, 1996).

The most common functional form of the ASWF is $V(\mu,I) = \mu(1\text{-}I)$. Researchers have developed this functional form for the most common indices of inequality. For detail on this and other functional forms, see Sheshinski (1972), Blackorby and Donaldson (1978), Shorrocks (1988), Salas (1996), Tomas and Villar (1993), Lambert (1993), and Ruiz-Castillo (1995; 1998) among others. The result is expressed in monetary units, and it can be interpreted as the weighted gain in welfare when inequality is also taken into account.

Considering time, let WP_t be the welfare level at period t, such that $WP_t = \boldsymbol{X}_t(1\text{-}I_t)$, where $\boldsymbol{X}_t$ is final income at period t according to [2.4]. To estimate the welfare effects of an investment project, it is necessary to find the differences between the status quo situation (the situation without the investment) and the welfare level reached by the project investment. Let $\Delta WP_t = WP_t\text{-}WP_{t-1}$ be the welfare change from period (t-1) to period t, or

$$\Delta WP_t = \boldsymbol{X}_t(1 - I_t) - \boldsymbol{X}_{t-1}(1 - I_{t-1}). \qquad [2.11]$$

The welfare effect of a project investment at period t can be written as

$$\Delta WP_t = \left(\sum_{j=1}^{k} P_{j,t} + Z_t \right) + \boldsymbol{X}_{t-1}\left(REP_t\right) - I_t \left(\sum_{j=1}^{k} P_{j,t} + Z_t \right), \qquad [2.12]$$

and the accumulated welfare change due to an investment project up to period T can be stated as

$$\Delta WP_T = \sum_{t=0}^{T}\sum_{j=1}^{k} P_{j,t} + \sum_{t=0}^{T} Z_t + \boldsymbol{X}_{SQ,0}\left(REP_T\right) - I_T \left(\sum_{t=0}^{T}\sum_{j=1}^{k} P_{j,t} + \sum_{t=0}^{T} Z_t \right). \qquad [2.13]$$

Operating in [2.11],

$$\Delta WP_t = (\boldsymbol{X}_t\text{-}\boldsymbol{X}_{t-1})+\boldsymbol{X}_{t-1}(I_{t-1}\text{-}I_t)\text{-}I_t(\boldsymbol{X}_t\text{-}\boldsymbol{X}_{t-1}).$$

By [2.5], it is known that I_{t-1}-$I_t = REP_t$. For simplicity, suppose that $k=1$. Using [4],

$$\boldsymbol{X}_t = \boldsymbol{X}_{t-1}+P_t+Z_t.$$

Then,

$$\boldsymbol{X}_t\text{-}\boldsymbol{X}_{t-1} = P_t+Z_t,$$

And therefore,

$$\Delta WP_t = (P_t+Z_t)+\boldsymbol{X}_{t-1}(REP_t)-I_t(P_t+Z_t).$$

In the case of the accumulated welfare effect,

$$\Delta WP_T = (WP_T-WP_{T-1})+(WP_{T-1}-WP_{T-2})+\ldots+(WP_1-WP_{SQ}) = WP_T-WP_{SQ}.$$

Using [2.3], [2.5], and [2.11] in the expression above, ΔWP_T can be rewritten as

$$\Delta WP_T = \sum_{t=0}^{T}\sum_{j=1}^{k} P_{j,t} + \sum_{t=0}^{T} Z_t + \boldsymbol{X}_{SQ,0}\left(REP_T\right) - I_T\left(\sum_{t=0}^{T}\sum_{j=1}^{k} P_{j,t} + \sum_{t=0}^{T} Z_t\right).$$

The first term on the right hand side of [2.12] can be interpreted as the efficiency effect, in money metrics, of the project investment and the variations non related to the project. The second term would be the gain or loss of welfare due to the more or less egalitarian income distribution at period t with respect to period t-1. The third term can be seen as an error term for the combined effect of the efficiency and the equality.

Similarly, the right hand side terms of [2.13] can be interpreted as the sum of the accumulated efficiency contribution to social welfare, the accumulated effect on social welfare due to the improvement of the income distribution and the total effect of the error term, respectively.

It is possible to divide [2.12] into $k+2$ income sources as in [2.4]. It is only necessary to substitute [2.4] into [2.12] to obtain

$$\Delta WP_t = P_{1,t}(1-I_t)+P_{2,t}(1-I_t)+...+P_{k,t}(1-I_t)+Z_t(1-I_t)+\boldsymbol{X}_{t-1}(REP_t). \qquad [2.14]$$

These would be the elements of the third matrix. They are expressed in monetary units and represent the welfare effects relative to the changes in the income caused by the investment and the status quo variation weighted by the inequality level and the welfare effect of the gain or loss of equality in period t as a proportion of the income of period $t-1$.

Taking the status quo variation into consideration, let $WSQ_t = \boldsymbol{X}_{SQ,t}(1-I_{SQ,t})$ be the welfare level reached at period t in the status quo situation, and define the welfare variation from period $t-1$ to period t as

$$\Delta WSQ_t = \boldsymbol{X}_{SQ,t}(1-I_{SQ,t})-\boldsymbol{X}_{SQ,t-1}(1-I_{SQ,t-1}) \qquad [2.15]$$

In an analogous manner to the procedure followed to obtain [2.11], [2.15] can be rewritten as

$$\Delta WSQ_t = \boldsymbol{X}_{SQ,t}+\boldsymbol{X}_{SQ,t-1}(RESQ_t)-I_{SQ,t}\boldsymbol{X}_{SQ,t}.$$

Finally, the total welfare effect of the project investment considering the possible income changes in the status quo situation is defined as

$$\Delta TW_t = \Delta WP_t - \Delta WSQ_t \quad , \qquad [2.16]$$

and the accumulated welfare effect, as $\Delta TW_T = \sum_{t=0}^{T} \Delta TW_t$.

This would give the accumulated welfare changes of the project under evaluation. Note that if the status quo is assumed to remain unaltered, [2.16] is reduced to ΔWP_t and ΔTW_T to [2.13]. If the do-nothing situation brings positive welfare effects, then $\Delta TW_T < WP_T$; and in the contrary case, $\Delta TW_T > WP_T$.

4. Conclusions and further research.

Equality considerations are rarely introduced in the CBA of an investment, in spite of its interest. This paper proposed a new framework to account for the gains or losses in equality.

DCBA explicitly considers the changes in the income distribution by introducing measures of inequality to the changes in the income of the individuals of the affected population. DCBA is proposed to be of a similar format to the CBA (in a matrix with benefit or cost variables and time periods), which might make the new procedure a bit easier to apply for those practitioners already familiar with CBA, since the elaboration and interpretation of the equality component would present many similarities to the traditional CBA.

This twin matrix system can be seen as an extension of the efficiency evaluation to equality, so the decision maker has more explicit elements to base the decision on.

Also, DCBA makes explicit the social judgments made behind the results of the gains or losses of equality by openly stating the assumptions that lie behind the different indices of inequality and the decomposition procedures applied. This is believed to be an advantage as far as it facilitates the understanding of the results, their limitations, and their implications.

DCBA is compatible too with the analysis of the equality effects when the analyst has previously *"corrected"* the costs and benefits by the introduction of distributional weights. Also, it is flexible enough to identify winners and losers. There is an option too, to find the changes in the income distribution of different subgroups of the population when this is of relevance for the decision maker.

By introducing a third matrix, the EDCBA, it is possible to find the effect on social welfare of a project investment when both measures (efficiency and equality) are to be accounted. This is done based on the abbreviated social welfare functions. The procedure allows the decision maker to weight both criteria into a single indicator of the social desirability of a public project.

From the several measures of inequality available in the literature, the relative inequality Atkinson index, generalized entropy family, and Gini coefficient, have been considered here as appropriate for DCBA due to the properties they have, although the analysis could be extended to absolute inequality, horizontal equity or poverty measures. Those constitute possible extensions for an open line of research.

Natural and Shapley decomposition by income factors of the inequality indices are thought to be suitable to be used in DCBA. However, none of these approaches is fully satisfactory. It is a potential line of research to improve these methodologies to overcome their shortcomings. One possibility could come from the use of Nested Shapley decomposition.

III. ON THE APPLICATION OF A SOCIAL DISCOUNT RATE FOR (IN)EQUALITY

Abstract

The economic evaluation of public policies is usually assessed in efficiency terms, with future costs and benefits are discounted at an appropriate rate. However, equity issues could also be considered, and when the analysis involves different time periods, a rate of discount ought to be applied as well, since individuals may have time preferences for the application of policies regarding their income distributional effects. This paper introduces the application of discounting to equity and a procedure to find the appropriate discount rate. An empirical exercise is developed to illustrate the feasibility of the discount rate estimation.

1. Introduction

When evaluating public policies from the discipline of economics, it is usual to express its effects in terms of welfare changes. In this way, a certain policy will be rejected if it diminishes social welfare, and it will be considered among the potentially desirable ones if it improves social welfare. The overall welfare effect is the result of considering the flow along time of increases (benefits) and decreases (costs) in welfare, with the appropriate discount rate.

From the seminal works of Fisher (1930), Samuelson (1937), Strotz (1956) and Koopmans (1960), to the most recent research of Price (1993), Schelling(1995), Rabl (1996), and Portney and Weyant (1999), among many others, there is an ample literature on the application of social discount rates in different time periods to utility levels expressed in monetary terms. Discount rates have been applied to a wide range of issues, such as human lives saved (Cropper and Portney, 1990), energy consumption (Barrow et al, 1986), job opportunities (Johnson and Price, 1987), and radiation exposure levels (Demin et al, 1983), among others.

Generally, social policies also affect the income distribution of the society, and thus, have effects on equity. These equity effects can take place at any given period of time, and be measured by inequality indices. So far, little attention has been paid to the introduction of the distributional effects into the social evaluation process and, to our knowledge, the consideration of welfare effects due to future changes in the income distribution and how these may be incorporated into the social valuation process when using inequality indices, have been absent topics in the literature.

This chapter claims the requirement to discount future changes occurring in the income distribution due to a public project investment. A procedure based on stated preference methods is introduced in order to be able test whether there is indeed a social time preference for a given redistribution to take place in one period or another, to estimate the sign of the preference, and quantify the intensity of the preference in terms of a discount rate for a given inequality index. This procedure is illustrated with an experimental exercise involving forest subsides, which shows the feasibility of its implementation. The case study obtains an empirical estimation of the discount rate for the Atkinson index.

The remaining of the chapter is divided as follows. Section 2 discusses the convenience of the use of a discount rate for equity values. Section 3 introduces the procedure aimed at finding a social discount rate for equity. Section 4 presents the empirical illustration of this procedure, which shows the feasibility of its implementation. Section 5 highlights the main conclusions.

2. Why should a discount rate to equity values be applied?

In order to explain why equity should be discounted, assume a decision maker considers implementing a perishable local public good that has the virtue of benefiting the lower income segment of the population during its one period duration. While the (distributional) benefit is the same regardless of the period, assume the cost of implementing it in the next period is lower in real terms than providing it now, due to expected technological change or some other reason. If the decision maker wants to take into account both the cost and the benefit, and cares for the distributional effects, it is not clear which is the best period to implement the policy. It depends at least on the magnitude of the cost differential, the traditional discount rate, and the time preference over equality. If the latter did not matter, it could be better to wait for an extra period. However, in real life, time seems to matter when affects distributional issues. If so, discounting is a matter of interest, because it could overcome the extra cost saving of waiting one period.

In a similar way, assume now that the decision maker considers implementing a subsidy that is going to worsen efficiency but improve equity. The subsidy is to be implemented if the overall gain in welfare due to the change in equity overcomes the loss in efficiency. Say its net impact on efficiency along time is expected to be $-y_0,-y_1,\ldots,-y_T$, while the improvement in equality is represented by a series of indicators $E_0, E_1, \ldots, E_T$. How the decision maker can balance out both streams of numbers has been discussed in chapters two. Assume also that when discounting the y_t-stream, the preference of the decision maker favors not to implement the subsidy. However, if both y_t and E_t are discounted, the decision could be the opposite.

3. Finding an equity discount rate

Suppose a social decision maker considers whether to provide of a certain (local) public good to society within a number of years. It is assumed that individuals may have time preferences on the equity variations the public good will cause. A way to empirically estimate a temporal discount rate is by inquiring people through a stated preference method. In this section, a well-known stated preference method is proposed: the *pairwise choice*, also known as *choice experiment* or *conjoint analysis* (Batsell and Louviere, 1991; Adamowicz et al, 1998; Hanley et al., 1998a; Hanley et al., 1998b; Adamowicz et al., 1994; Louviere, 1991). The pairwise choice experiment is a valuation method where the respondent has to choose the preferred alternative within three options (including the status quo situation) composed of different attributes of the public good, where the level of at least one attribute varies among alternatives (Hanley et al., 1998a; Hanley et al., 1998b; Morrison et al., 1999). For instance, the attributes could be the year of provision, the amount of public good, and its distribution among the affected population.

Formally, the probability that an individual chooses alternative j among M alternatives can be defined as

$$P(j|z,\theta) = \frac{e^{V_j(z_j,\theta)}}{\sum_{j=1}^{M} e^{V_j(z_j,\theta)}},$$

where $V_j(z_j,\theta)$ is the utility function of alternative j, z_j is a vector that includes the attributes of alternative j and the individual's socio-economic characteristics, and θ is the coefficient for each $j = 1,...,M$ alternatives (Mcfadden, 1973).

The functional form of $V_j(z_j,\theta)$ most commonly applied is:

$$V_j(z_j,\theta) = z_j \cdot \theta ,$$

The coefficients above are usually estimated using a multinomial logit model (MNL). The coefficients indicate the rate at which respondents are willing to trade-off one attribute for another. This rate of substitution can be estimated simply by calculating the negative of the ratio between the coefficients of the traded-off attributes (Bennet and Blamey, 2001).

According to the latter, when one of the attributes is the delay in years of the provision of the public good, what individuals are willing to receive or sacrifice for a variation in a certain attribute per year is determined by the ratio of the coefficient of this attribute to the coefficient of the delay variable, times minus one. If this rate of trade-off is positive, then individuals will be demanding an increase of the attribute as the provision of the public good is delayed one year. On the contrary, if the rate of trade off is negative, then individuals are willing to sacrifice some units of this attribute for the delay in the provision of the public good.

The next step for the estimation of the discount rate is to calculate the appropriate equality index levels. At this point it is necessary to know the income distribution of the relevant society (and its associated equality index) at a given period of time. From that, one estimates the equality index for the next period that leaves people indifferent between both distributions if the social discount rate is applied. This index can be found empirically, as will be shown in the next section. Once this number is estimated, the implicit social discount rate can be derived.

To do this, denote the income distributions of the society for two consecutive periods of time as $\mathbf{X}_t = \left(y_{1,t}, y_{2,t}, ..., y_{n,t}\right)$ and $\mathbf{X}_{t+1} = \left(y_{1,t+1}, y_{2,t+1}, ..., y_{n,t+1}\right)$, where y indicates income levels, subscripts $1,2,\ldots,n$ refer to the different members of the society, and subscript t denotes time periods.

In shorter notation, let $E(X_t)$ and $E(X_{t+1})$ be the equality indices for the two income distributions. The discount rate to be estimated is the one that yields an equivalence between the two appropriate equality levels, $E(\boldsymbol{X}_t)$ and $E(\boldsymbol{X}_{t+1})$, such that

$$\frac{E(X_t)}{(1+r_E)^t} = \frac{E(X_{t+1})}{(1+r_E)^{t+1}}$$

when assuming exponential discounts.

The rate of discount can then be estimated from

$$r_E = \left(\frac{E(X_{t+1})}{E(X_t)}\right) - 1. \qquad [3.1]$$

This discount rate can be either positive or negative, according to the preferences of society. It can be seen that the discount rate depends on the equality measure used (these measures were briefly discussed in chapter 1).

In the empirical exercise introduced in the next section, the target will be to estimate $E(X_{t+1})$, at period *t+1*, from a given $E(X_t)$ at period *t*, and deduce from there the social discount rate for equity, r_E, implicit in people's choices as expressed in the survey.

4. An empirical illustration

An experimental exercise was undertaken as an illustration of the methodology introduced in the previous section. A survey was applied to inhabitants of Catalonia, Spain, in 2002.

The hypothetical scenario developed proposed a modification of the current subsidy scheme that incentives farmers to transform unproductive agricultural lands to forest use. Thus, the questionnaire (appendix 2) explained that, under current regulations, farmers receive the same amount of subsidies for every hectare they transform regardless of their income. Respondents were informed that a proposal existed for having the current regulation changed in a certain future year. This included a variation of the current normative so that subsidies would be obtained according to income.

The variation would be in the portion of subsidies given to the 50% poorest farmers. Thus, the current (status quo) situation consisted in giving 50% of the total subsidies to the 50% poorest farmers participating in the forestation program, while the remaining 50% would go to the rest of the participating farmers. The percentage of the subsidies given to the poorest 50% was to be changed in the future under the new regulation. There were no participating farmers in the sample of the survey, and thus respondents were not affected in their earnings by these proposals. The preferences to be captured were on income redistribution among third parties.

Respondents faced choice sets consisting of three scenarios. One of them, included in all sets, was the base line scenario, which corresponded to the status quo or do-nothing situation. Therefore subsidies would continue to be granted equally among all the program participating farmers regardless of income levels. The other two scenarios differed in how the other two attributes of the subsidies were modified.

The attributes of the choice present in the cards (appendix 3) handed to the survey participants were as follows:

1. *Number of years*. It was referred to the year in which the new regulation would be enforced. Before the enforcement, the status quo situation would remain.
2. *Percentage of targeted farmers*. This attribute reflected the percentage of the farmers with lower income that would receive a certain portion of the subsidies. This was fixed to the 50% poorest farmers participating in the program.
3. *Percentage of discriminating subsidies*. This is the percentage of the total subsidies that would be rewarded to the poorest transforming farmers.

The combination of the second and the third attributes establish the equality level.

While the percentage of targeted farmers was fixed, the other two attributes varied. They could take four values or *levels* in the survey. The levels were selected according to variability convenience after a pilot survey and focus group sessions had been conducted, and they are shown in Table 3.1.

Table 3.1. Attributes and levels for the empirical exercise

Attribute	Levels
Number of years	3 5 10 15
% of total subsidies	40 60 80 100

A typical choice of three alternatives faced by respondents is presented in figure 3.1 (see appendix 3).

Figure 3.1. Typical choice of the empirical exercise

Please, take a look at this card. In this card, option A means the current regulation would not be modified and subsidies would remain being distributed as the currently. Option B states that for the next two years subsidies would be distributed as they currently are. By the third year, the 40% of the total subsidies would be directed to the 50% poorest farmers. Finally, option C suggests that during the following four years subsidies would de distributed as currently, and from the fifth year on, the 80% of the total subsidies would be directed to the 50% poorest of the farmers.

Question: Which of these three options would you prefer to be implemented?

Within **1** year, **50**% of the subsidies to the **50**% poorest	Within **3** years, **40**% of the subsidies to the **50**% poorest	Within **5** years, **80**% of the subsidies to the **50**% poorest
Option A	**Option B**	**Option C**

Option A reflected the status quo situation, while alternatives B and C were proposed legislation changes.

A total of 4^2 combinations of attributes and levels per choice were possible, yielding a total of 256 alternatives ($4^2 x 4^2$ combinations of attributes, levels and choices). Applying a fractional factorial design, and after eliminating repeated and implausible alternatives, a total of 60 possible choice sets were obtained. These were grouped into series of six choice sets per respondent, for a total of 10 different answer sheets. Each answer sheet was submitted at least 15 times in the survey.

As mentioned, respondents were not to receive any monetary benefit themselves from the subsidies, nor were them to directly notice any changes in the location of the forested land. Their benefit would derive from knowing that the policy implements a more equitable income distribution (according to their own conception of equitable income distribution). In this way, it was in respondents' interest to choose among the alternatives according to their own perception of equity and time.

In total, 250 personal interviews were undertaken between September and October 2002. As mentioned, each of the respondents answered a sheet containing a set of six groups of choices. Respondents had to choose one of three alternatives for each of the six groups of choices (see appendix 3). A total of 1,328 answers were obtained. A MNL model was employed to interpret results according to the discrete choice model, presented in section 3. Table 3.2 shows the results of the MNL regression model for the two variable attributes.

Table 3.2. Coefficients of the pairwise model

Variable	Coefficients	
Constant Years	-0.1856 (-1.194)	
Constant % subsidies	0.3155* (3.134)	
Years	-0.02117 (-1.63)	
% Subsidy	0.02271* (11.428)	
Maximum Log-likelihood		-1,324.581
Observations		1,328

t-statistic values in parenthesis

* Significant at a 5% level.

It can be seen that the probability for an alternative to be chosen increases with the percentage of subsidies given to the poorest farmers, showing an overall positive social preference for redistribution toward poorer farmers. Also, as the number of years at which the new regulation will come into action increases, the probability to choose an alternative diminishes, which suggests there is no social indifference for time, but a willingness for redistribution to take place sooner than later.

The trade off rates resulting from the ratio between the years and the subsidies coefficients served to build the income distribution after the change in the legislation, this resulting of 0.9321 percentage change for a year delay. This suggests that for every year the new regulation is delayed, the percentage of the subsidies given to the poorest farmers should increase in 0.9321 percentage points in order for respondents to be indifferent between both options.

The next step is to translate this figure into a discount rate applicable to a specific distributional index. This requires the estimation of the index between two consecutive periods taking into account the 0.9231 percentage variation. For the estimation of the equality levels, data from the Spanish Expenditure Survey (INE, 1993) for Catalonia were used. The distribution of income from those households with agriculture as their main activity was taken as a proxy for subsidy distribution. The estimation of the actual equality level was obtained by equally distributing an amount of subsidies among these households. The total of the subsidies for this specific policy was estimated to be of €7,000,000, according to own calculations.

The equality index employed in this exercise was *1-Atkinson inequality index,* with an inequality aversion parameter of 0.5. A value of 1 would reflect total equality and zero would mean total inequality. Some other indices could be employed, such as 1-Gini or the equality Theil index proposed by Blackorby and Donaldson (1978). The estimated equality levels were 0.745213 for the Atkinson index at period *t* and 0.745231 for Atkinson at period *t+1*.

The first index refers to the equality level reached by society if subsidies were to be distributed as they currently are, while the *t+1* situation represents the income distribution after the subsidies have been distributed, according to the 0.9231% variation in the total subsidies given to the poorest farmers.

With the results from this exercise when the Atkinson index is used, and substituting the indices into [3.1], a positive yearly discount rate of 0.00253% was deduced.

Using 1-Gini indices, a social rate of discount of 0.00397% is estimated. This is derived in the same way as the previous one, from a 1-Gini index of 0.561378 for period *t* and of 0.561361 for period *t+1*. This is also the discount rate to be applied in the next chapter. Since the value is specific for each equality index, a list of social equity discount rate could be obtained from a single empirical exercise for the different indices and parameters within a given index.

5. Conclusions

The welfare of individuals may vary over time for the knowledge of living in a more o less equally distributed society with respect to income. Individuals may also have preferences over time for policies that alter the income distribution. Social decision makers concerned with equity issues might want to take into consideration the time preferences in equality when evaluating social policies.

There might be several ways to find the temporal preferences over equity. In this paper, a methodology based on stated preference methods was proposed to derive an equity rate of discount.

The undertaken empirical exercise showed that Catalonia's residents had positive time preferences on equality. On average, people would prefer that for every year the policy is delayed, the subsidy change or the egalitarian action were increased. A discount rate of 0.00253% was obtained when the Atkinson index was the measure used to express the differences in income distribution.

This paper is intended to be a first step in the area of equity discounting. Further research on this subject could look at the theory of discounting for equity values. A second line of research could be to improve or develop different and more accurate methods to derive this discount rate. A third string of research would be to explore the link between these results and the social evaluation of public projects.

IV. AN INTEGRATED APPLICATION

Abstract

In this chapter, an integrated application of the EDCBA and the discount rate for equity is presented for a toll road investment project, to illustrate the feasibility of implementation of the procedures proposed in the previous chapters. A three-matrix system is built, each matrix summarizing the project impact in terms of efficiency, inequality, and welfare respectively. The case study illustrates how the distribution of costs and benefits is a key issue when computing the EDCBA, and how results are especially sensitive to changes in the financial sources of the project.

1. Introduction

The procedures described in chapters two and three are here illustrated with an application to a project investment of a toll road in the area of Barcelona, Spain. It is a 10 km-long road, with a large tunnel to facilitate faster access between the city center and the suburbs to the west, behind Collserola Mountain.

The estimated construction cost is about 192 million of euros, to be spread along three years. The expected economic life of the road is 30 years. The main beneficiaries are the future users of the tunnel as well as the users of the alternative highways, who will benefit from some degree of decongestion at peak hours.

2. Data sources

For the computation of the first matrix, including standard cost and benefits, data from a mobility study for the new road area (facilitated by the promoters of the project) were used, as well as road accident statistics collected by regional and central government agencies.

For practical reasons, the relevant population to be considered in the distributional analysis of this application was restricted to the set of residents in the province of Barcelona. The expenditure survey of Spanish households (INE,

1993) contains information on income and different types of expenditures of over 20,000 families. It also contains socio-demographic data and characteristics of the house, including address. In that way, people from the province of Barcelona could be isolated; this resulted in a sample of 594 observations for a population of 1.6 million households. The expenditures registered include data on gasoline, toll payments, and other transport related variables. The expenditure survey was the main source used in the distributional estimations.

Since the available data on income was at household level, a transformation to equivalent individualized income (Yeq_i) was undertaken. The parametric equivalence factor used was

$$e_h = [A_h + \alpha M_h]^{\beta}, \alpha \in [0,1], \beta \in [0,1],$$

where A_h represents the number of adults, and M_h denotes the number people under age of 16 in household h. Values α = 0.5 and β = 0.5 were used. For a more detailed discussion on the transformation and a discussion on the scales of equivalences, see Buhmann *et al.* (1988), Coulter *et al.* (1992), Banks and Johnson (1994), Jenkins and Cowell (1994), Ebert (1995), and Cowell and Mercader (1999).

3. Cost Benefit Analysis

The construction cost was the largest of the two costs considered, the other one being maintenance and operation. The cost of the toll payments by road users was also included, although it also appears as a benefit for the road managers. These variables are to play an important role in the second matrix. The remaining benefits were time savings, accident savings, and reductions of running costs, which were calculated according to standard practice. The details on those computations are not reproduced here because they do not represent a novelty in the illustration, and can be found in Riera and Nájera (2000). Table 4.1 shows the first matrix with the values obtained.

Table 4.1. Horta's Tunnel discounted CBA (thousands of Euros)

Period	Investment	Maintenance	Toll Payments	Toll Returns	Users' Time Savings	Non users' Time Savings	Accidents Savings	Running Costs Savings	Total Costs	Total Benefits	Difference
0	65,578	0	0	0	0	0	0	0	65,578	0	-65,578
1	62,456	0	0	0	0	0	0	0	62,456	0	-62,456
2	59,482	0	0	0	0	0	0	0	59,482	0	-59,482
3	0	1,558	12,381	12,381	10,748	1,624	1,074	3,472	13,938	29,300	15,361
4	0	1,483	12,263	12,263	10,646	1,515	1,064	3,439	13,746	28,927	15,181
5	0	1,413	12,146	12,146	10,544	1,412	1,054	3,406	13,559	28,562	15,004
6	0	1,345	12,030	12,030	10,444	1,314	1,044	3,374	13,376	28,206	14,830
7	0	1,281	11,916	11,916	10,344	1,222	1,034	3,342	13,197	27,858	14,661
8	0	1,627	11,802	11,802	10,246	1,135	1,024	3,310	13,429	27,517	14,088
9	0	1,550	11,690	11,690	10,148	1,053	1,014	3,278	13,240	27,184	13,944
10	0	1,476	11,356	11,356	9,858	975	985	3,185	12,832	26,359	13,528
11	0	1,406	11,031	11,031	9,577	902	957	3,094	12,437	25,561	13,124
12	0	1,339	10,716	10,716	9,303	833	930	3,005	12,055	24,787	12,732
13	0	1,275	10,410	10,410	9,037	768	903	2,919	11,685	24,038	12,353
14	0	1,214	10,113	10,113	8,779	706	877	2,836	11,327	23,312	11,985
15	0	1,156	9,824	9,824	8,528	649	852	2,755	10,980	22,608	11,628
16	0	1,101	9,543	9,543	8,285	594	828	2,676	10,644	21,926	11,282
17	0	1,049	9,270	9,270	8,048	543	804	2,600	10,319	21,265	10,946
18	0	999	9,006	9,006	7,818	495	781	2,526	10,004	20,625	10,621
19	0	951	8,748	8,748	7,595	450	759	2,453	9,700	20,005	10,305
20	0	906	8,498	8,498	7,378	407	737	2,383	9,404	19,403	9,999
21	0	863	8,255	8,255	7,167	367	716	2,315	9,118	18,821	9,702

22	0	822	8,020	8,020	6,962	329	696	2,249	8,841	18,256	9,415
23	0	783	7,790	7,790	6,763	294	676	2,185	8,573	17,709	9,135
24	0	745	7,568	7,568	6,570	261	657	2,122	8,313	17,178	8,865
25	0	710	7,352	7,352	6,382	230	638	2,062	8,062	16,664	8,602
26	0	676	7,142	7,142	6,200	201	620	2,003	7,818	16,165	8,348
27	0	644	6,938	6,938	6,023	174	602	1,946	7,581	15,682	8,101
28	0	613	6,739	6,739	5,851	149	585	1,890	7,353	15,214	7,861
29	0	584	6,547	6,547	5,683	126	568	1,836	7,131	14,760	7,629
30	0	556	6,360	6,360	5,521	103	552	1,784	6,916	14,320	7,404
31	0	530	6,178	6,178	5,363	83	536	1,733	6,708	13,893	7,185
32	0	505	6,002	6,002	5,210	64	521	1,683	6,506	13,479	6,973
33	0	481	5,830	5,830	5,061	46	506	1,635	6,311	13,078	6,768
Total											150,043

The internal rate of return (IRR) is of 9.78%. Applying a discount rate of 5%, the net present value is close to 150 million euros of year 2001 values, the benefit to cost ratio is 1.29, and the break-even point is expected to take place after 16 years.

4. Distributional Assumptions

Variables were distributed among households according to the following assumptions.

Investment and maintenance. Both variables reduce the income of the population. The project is to be financed by money which otherwise would remain in a savings bank, where it was supposed that people have deposits in proportion to their income. Thus, the distribution of the income loss followed the functional form of the actual distribution of income. Therefore, if an individual had 0.05% of the total income, her contribution to the finance of the project would be 0.05% of the total expenditure in the period.

Toll payments. The reduction of income due to toll payments of the new tunnel users was assigned accordingly to the proportion of the expenditure under this concept in the expenditure survey.

Toll returns. It was taken as an increase in income for the investor, who, as mentioned earlier, is a savings bank. However, there is a legal impossibility for savings banks in Spain to distribute benefits to shareholders (there are no shareholders, unlike in commercial banks), and either they reinvest the benefits or dedicate profits to social oriented projects. Consequently, the assumption made for this variable was twofold. First, the returns were supposed to go back to the investors, up to covering (once discounted) the income loss associated to the investment and maintenance costs they had. Second, the excess benefits were uniformly assigned to all individuals, as if public goods were to be provided. In an upcoming section we perform a sensitivity analysis in which this assumption is substituted by a scenario where the investment is made by a commercial bank.

Operation cost savings. The savings in the running costs of the vehicles are enjoyed by the users of the tunnel, as the average length of their journeys shorten. According to the information included in the expenditure survey on individuals' expenditures in road tolls, toll expenditures increase more than proportionally with income (income elasticity of demand above one), and so do benefits related to operation cost savings.

Accident savings. It is a non-monetary benefit derived from the safer standard of similar toll roads compared to the alternative highways. The monetary valuation of the savings was expected to increase the income of the new tunnel road users, as in the previous variable.

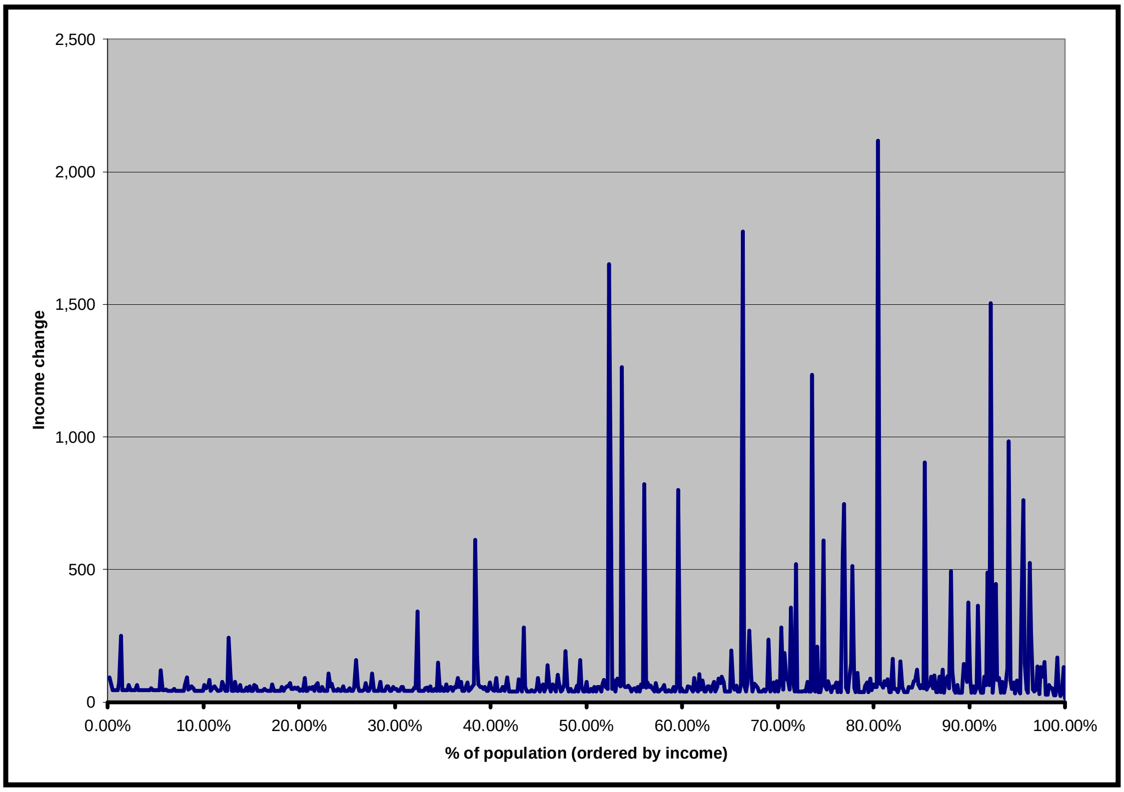
Time savings. It positively affects both tunnel users and those of the alternative less congested highways. For the first group, the distribution of the increase of (non-monetary) income was done in the same way than for operation costs and accident savings. For the users of alternative roads, though, the proxy variable considered was the expenditure in gasoline reported in the expenditure survey.

5. Winners and losers

When computing the income variation of each individual, the winners and losers can also be identified, and their income variations can be separately computed. By identifying winners and losers, actual compensations among individuals could be made

The income variation ($P_{i,j,t}$) of each individual i was estimated for each variable j and period t, following the distributional assumptions. Figure 4.1 shows this result, where individuals haven been ordered according to income and grouped in centiles.

Figure 4.1. Winners and losers. Income variation due to the project investment (Euros of 2001).



Overall, all individuals were winners with this project, according to the variables taken into account. A similar analysis of winners and losers could also be undertaken for different attributes other than income, such as age, profession, place of residence and many others, with little additional effort.

6. Distributional Cost Benefit Analysis

The matrix of the DCBA was constructed using the Gini index. Later in the chapter, other indices are used to build the DCBA, and it will be discussed the extent to which results are sensitive to the choice of the inequality index. The Gini inequality index before the project takes place had a value of 0.2916.

As for the project situation, the variables behave in different ways. Toll payments and the time savings of non-users of the tunnel (i.e., users of the alternative roads) bring the income distribution closer to equality. On the other hand, the time savings of the users of the tunnel, accident savings and running cost savings imply increases in the yearly overall inequality. Toll returns lead to two different patterns, regarding their influence on inequality. In the first place, they represent neutral effects in inequality up to the 22^{nd} year, while recovering the initial investment and maintenance expenses. Afterwards, they had a reducing effect on inequality (see table 7.2 in appendix 1) due to the assumption that toll returns are distributed among society members in the form of a public good and have zero income elasticity (in section 8 of this chapter, this assumption is modified to a unitary income elasticity). Finally, investment and maintenance have no effect on inequality, since savings banks are assumed to obtain the funds from the general population in a fixed proportion to their income. Table 4.2 shows the DCBA matrix (see appendix 1 for the pseudo Gini and redistributive effect of each variable, and table 7.2 of appendix 1 for the quantification of the redistributive effects).

Table 4.2. DCBA matrix for Horta Tunnel

period	Inequality level		X_{t-1}	Investment	Maintenance	Tolls payments	Tolls Returns	Users' Time Savings	Non users' time Savings	Accidents Savings	Running Costs Savings	Annual Redistributive Effect	Discounted Redistributive Effect
0	0.291582	S_j	0.291983	-0.000402	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000%
		S_j/I_t	100.1377%	-0.1377%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	**0.0000%**	**0.0000%**
1	0.291582	S_j	0.291965	-0.000383	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000%
		S_j/I_t	100.1314%	-0.1314%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	**0.0000%**	**0.0000%**
2	0.291582	S_j	0.291947	-0.000365	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000%
		S_j/I_t	100.13%	-0.13%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**0.0000%**	**0.0000%**
3	0.291587	S_j	0.291487	0.000000	-0.000010	-0.000102	0.000076	0.000089	0.000009	0.000009	0.000029	-0.000005	-0.0005%
		S_j/I_t	99.9658%	0.0000%	-0.0033%	-0.0350%	0.0261%	0.0304%	0.0032%	0.0030%	0.0098%	**-0.0019%**	**-0.0019%**
4	0.291593	S_j	0.291494	0.000000	-0.000009	-0.000101	0.000075	0.000088	0.000009	0.000009	0.000028	-0.000006	-0.0006%
		S_j/I_t	99.9661%	0.0000%	-0.0031%	-0.0348%	0.0258%	0.0302%	0.0030%	0.0030%	0.0098%	**-0.0019%**	**-0.0019%**
5	0.291598	S_j	0.291501	0.000000	-0.000009	-0.000101	0.000075	0.000087	0.000008	0.000009	0.000028	-0.000006	-0.0006%
		S_j/I_t	99.9665%	0.0000%	-0.0030%	-0.0345%	0.0256%	0.0300%	0.0028%	0.0030%	0.0097%	**-0.0019%**	**-0.0019%**
6	0.291604	S_j	0.291507	0.000000	-0.000008	-0.000100	0.000074	0.000087	0.000008	0.000009	0.000028	-0.000006	-0.0006%
		S_j/I_t	99.9669%	0.0000%	-0.0028%	-0.0343%	0.0253%	0.0298%	0.0026%	0.0030%	0.0096%	**-0.0019%**	**-0.0019%**
7	0.291610	S_j	0.291514	0.000000	-0.000008	-0.000100	0.000073	0.000086	0.000007	0.000009	0.000028	-0.000006	-0.0006%
		S_j/I_t	99.9672%	0.0000%	-0.0027%	-0.0341%	0.0251%	0.0296%	0.0024%	0.0030%	0.0096%	**-0.0020%**	**-0.0020%**
8	0.291616	S_j	0.291523	0.000000	-0.000010	-0.000099	0.000072	0.000086	0.000007	0.000009	0.000028	-0.000006	-0.0006%
		S_j/I_t	99.9684%	0.0000%	-0.0034%	-0.0339%	0.0248%	0.0294%	0.0022%	0.0029%	0.0095%	**-0.0020%**	**-0.0020%**
9	0.291621	S_j	0.291530	0.000000	-0.000009	-0.000098	0.000072	0.000085	0.000006	0.000009	0.000028	-0.000006	-0.0006%
		S_j/I_t	99.9687%	0.0000%	-0.0033%	-0.0336%	0.0246%	0.0292%	0.0021%	0.0029%	0.0094%	**-0.0020%**	**-0.0020%**
10	0.291627	S_j	0.291538	0.000000	-0.000009	-0.000096	0.000070	0.000083	0.000006	0.000008	0.000027	-0.000006	-0.0006%
		S_j/I_t	99.9696%	0.0000%	-0.0031%	-0.0328%	0.0239%	0.0285%	0.0019%	0.0028%	0.0092%	**-0.0020%**	**-0.0020%**
11	0.291633	S_j	0.291547	0.000000	-0.000009	-0.000093	0.000068	0.000081	0.000005	0.000008	0.000026	-0.000006	-0.0006%
		S_j/I_t	99.9705%	0.0000%	-0.0030%	-0.0319%	0.0232%	0.0277%	0.0018%	0.0028%	0.0090%	**-0.0019%**	**-0.0019%**
12	0.291638	S_j	0.291555	0.000000	-0.000008	-0.000091	0.000066	0.000079	0.000005	0.000008	0.000025	-0.000006	-0.0006%
		S_j/I_t	99.9714%	0.0000%	-0.0028%	-0.0311%	0.0225%	0.0270%	0.0016%	0.0027%	0.0087%	**-0.0019%**	**-0.0019%**
13	0.291644	S_j	0.291563	0.000000	-0.000008	-0.000089	0.000064	0.000077	0.000004	0.000008	0.000025	-0.000005	-0.0005%

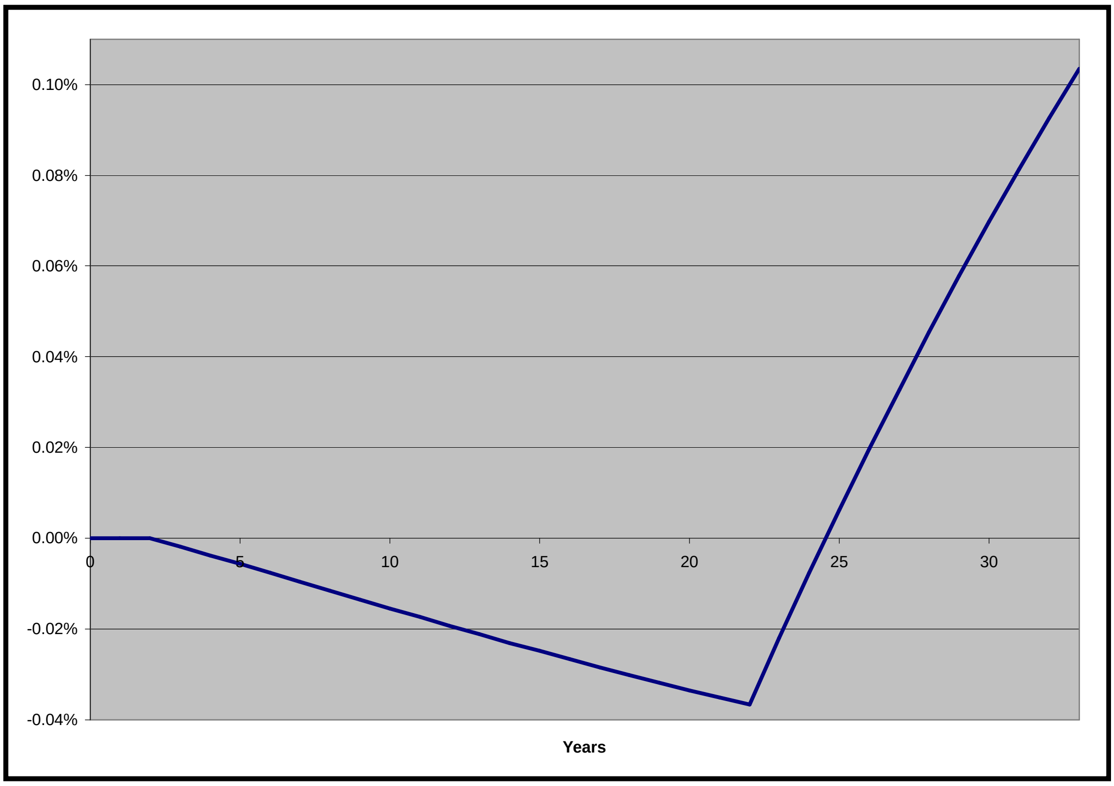
		S_j/I_t	99.9722%	0.0000%	-0.0027%	-0.0304%	0.0218%	0.0264%	0.0015%	0.0026%	0.0085%	**-0.0019%**	**-0.0019%**
14	0.291649	S_j	*0.291570*	*0.000000*	*-0.000007*	*-0.000086*	*0.000062*	*0.000075*	*0.000004*	*0.000007*	*0.000024*	*-0.000005*	*-0.0005%*
		S_j/I_t	99.9730%	0.0000%	-0.0025%	-0.0295%	0.0212%	0.0256%	0.0014%	0.0026%	0.0083%	**-0.0019%**	**-0.0019%**
15	0.291654	S_j	*0.291578*	*0.000000*	*-0.000007*	*-0.000084*	*0.000060*	*0.000073*	*0.000004*	*0.000007*	*0.000024*	*-0.000005*	*-0.0005%*
		S_j/I_t	99.9738%	0.0000%	-0.0024%	-0.0287%	0.0206%	0.0249%	0.0013%	0.0025%	0.0081%	**-0.0018%**	**-0.0018%**
16	0.291660	S_j	*0.291585*	*0.000000*	*-0.000007*	*-0.000082*	*0.000058*	*0.000071*	*0.000003*	*0.000007*	*0.000023*	*-0.000005*	*-0.0005%*
		S_j/I_t	99.9745%	0.0000%	-0.0023%	-0.0280%	0.0200%	0.0243%	0.0012%	0.0024%	0.0079%	**-0.0018%**	**-0.0018%**
17	0.291665	S_j	*0.291593*	*0.000000*	*-0.000006*	*-0.000080*	*0.000057*	*0.000069*	*0.000003*	*0.000007*	*0.000022*	*-0.000005*	*-0.0005%*
		S_j/I_t	99.9753%	0.0000%	-0.0022%	-0.0273%	0.0194%	0.0237%	0.0011%	0.0024%	0.0076%	**-0.0018%**	**-0.0018%**
18	0.291670	S_j	*0.291600*	*0.000000*	*-0.000006*	*-0.000077*	*0.000055*	*0.000067*	*0.000003*	*0.000007*	*0.000022*	*-0.000005*	*-0.0005%*
		S_j/I_t	99.9760%	0.0000%	-0.0021%	-0.0265%	0.0189%	0.0230%	0.0010%	0.0023%	0.0074%	**-0.0017%**	**-0.0017%**
19	0.291675	S_j	*0.291607*	*0.000000*	*-0.000006*	*-0.000075*	*0.000053*	*0.000065*	*0.000003*	*0.000007*	*0.000021*	*-0.000005*	*-0.0005%*
		S_j/I_t	99.9767%	0.0000%	-0.0020%	-0.0258%	0.0183%	0.0224%	0.0009%	0.0022%	0.0072%	**-0.0017%**	**-0.0017%**
20	0.291680	S_j	*0.291614*	*0.000000*	*-0.000006*	*-0.000073*	*0.000052*	*0.000064*	*0.000002*	*0.000006*	*0.000021*	*-0.000005*	*-0.0005%*
		S_j/I_t	99.9774%	0.0000%	-0.0019%	-0.0251%	0.0178%	0.0218%	0.0008%	0.0022%	0.0070%	**-0.0017%**	**-0.0017%**
21	0.291684	S_j	*0.291620*	*0.000000*	*-0.000005*	*-0.000071*	*0.000050*	*0.000062*	*0.000002*	*0.000006*	*0.000020*	*-0.000005*	*-0.0005%*
		S_j/I_t	99.9780%	0.0000%	-0.0018%	-0.0245%	0.0173%	0.0212%	0.0007%	0.0021%	0.0069%	**-0.0016%**	**-0.0016%**
22	0.291689	S_j	*0.291627*	*0.000000*	*-0.000005*	*-0.000069*	*0.000049*	*0.000060*	*0.000002*	*0.000006*	*0.000019*	*-0.000005*	*-0.0005%*
		S_j/I_t	99.9787%	0.0000%	-0.0017%	-0.0238%	0.0168%	0.0206%	0.0006%	0.0021%	0.0067%	**-0.0016%**	**-0.0016%**
23	0.291646	S_j	*0.291633*	*0.000000*	*-0.000005*	*-0.000068*	*0.000000*	*0.000059*	*0.000002*	*0.000006*	*0.000019*	*0.000043*	*0.0043%*
		S_j/I_t	99.9956%	0.0000%	-0.0016%	-0.0232%	0.0000%	0.0201%	0.0006%	0.0020%	0.0065%	**0.0148%**	**0.0147%**
24	0.291604	S_j	*0.291592*	*0.000000*	*-0.000005*	*-0.000066*	*0.000000*	*0.000057*	*0.000002*	*0.000006*	*0.000018*	*0.000042*	*0.0042%*
		S_j/I_t	99.9957%	0.0000%	-0.0016%	-0.0225%	0.0000%	0.0195%	0.0005%	0.0020%	0.0063%	**0.0143%**	**0.0143%**
25	0.291564	S_j	*0.291552*	*0.000000*	*-0.000004*	*-0.000064*	*0.000000*	*0.000055*	*0.000001*	*0.000006*	*0.000018*	*0.000041*	*0.0040%*
		S_j/I_t	99.9959%	0.0000%	-0.0015%	-0.0219%	0.0000%	0.0190%	0.0005%	0.0019%	0.0061%	**0.0139%**	**0.0139%**
26	0.291524	S_j	*0.291513*	*0.000000*	*-0.000004*	*-0.000062*	*0.000000*	*0.000054*	*0.000001*	*0.000005*	*0.000017*	*0.000039*	*0.0039%*
		S_j/I_t	99.9960%	0.0000%	-0.0014%	-0.0213%	0.0000%	0.0185%	0.0004%	0.0018%	0.0060%	**0.0135%**	**0.0135%**
27	0.291486	S_j	*0.291475*	*0.000000*	*-0.000004*	*-0.000060*	*0.000000*	*0.000052*	*0.000001*	*0.000005*	*0.000017*	*0.000038*	*0.0038%*
		S_j/I_t	99.9961%	0.0000%	-0.0013%	-0.0207%	0.0000%	0.0180%	0.0003%	0.0018%	0.0058%	**0.0131%**	**0.0131%**
28	0.291449	S_j	*0.291438*	*0.000000*	*-0.000004*	*-0.000059*	*0.000000*	*0.000051*	*0.000001*	*0.000005*	*0.000016*	*0.000037*	*0.0037%*
		S_j/I_t	99.9963%	0.0000%	-0.0013%	-0.0201%	0.0000%	0.0175%	0.0003%	0.0017%	0.0056%	**0.0127%**	**0.0127%**
29	0.291413	S_j	*0.291403*	*0.000000*	*-0.000004*	*-0.000057*	*0.000000*	*0.000050*	*0.000001*	*0.000005*	*0.000016*	*0.000036*	*0.0036%*

		S_j/I_t	99.9964%	0.0000%	-0.0012%	-0.0196%	0.0000%	0.0170%	0.0002%	0.0017%	0.0055%	**0.0123%**	**0.0123%**
30	0.291378	S_j	*0.291368*	*0.000000*	*-0.000003*	*-0.000056*	*0.000000*	*0.000048*	*0.000001*	*0.000005*	*0.000016*	*0.000035*	*0.0035%*
		S_j/I_t	99.9965%	0.0000%	-0.0012%	-0.0191%	0.0000%	0.0166%	0.0002%	0.0017%	0.0054%	**0.0120%**	**0.0119%**
31	0.291345	S_j	*0.291335*	*0.000000*	*-0.000003*	*-0.000054*	*0.000000*	*0.000047*	*0.000000*	*0.000005*	*0.000015*	*0.000034*	*0.0034%*
		S_j/I_t	99.9966%	0.0000%	-0.0011%	-0.0186%	0.0000%	0.0161%	0.0002%	0.0016%	0.0052%	**0.0116%**	**0.0116%**
32	0.291312	S_j	*0.291302*	*0.000000*	*-0.000003*	*-0.000053*	*0.000000*	*0.000046*	*0.000000*	*0.000005*	*0.000015*	*0.000033*	*0.0033%*
		S_j/I_t	99.9967%	0.0000%	-0.0011%	-0.0180%	0.0000%	0.0157%	0.0001%	0.0016%	0.0051%	**0.0113%**	**0.0112%**
33	0.291280	S_j	*0.291271*	*0.000000*	*-0.000003*	*-0.000051*	*0.000000*	*0.000044*	*0.000000*	*0.000004*	*0.000014*	*0.000032*	*0.0032%*
		S_j/I_t	99.9968%	0.0000%	-0.0010%	-0.0176%	0.0000%	0.0152%	0.0001%	0.0015%	0.0049%	**0.0109%**	**0.0109%**
Total												*0.000302*	*0.000301*
												0.1035%	**0.1034%**

After 30 years of operation of the new tunnel, the overall Gini index was estimated to be 0.2912, which translates into a positive distributive effect of 0.1035%. However, if a 0.00397% discount rate on equality is applied, thus capturing the time preferences as analyzed in chapter 3, the redistributive effect diminishes to 0.1034%. This figure is shown at the end of the last column of table 4.2.

Figure 4.2 shows the distributional effects along the 33 periods considered. The change of tendency is caused by the toll returns being provided as goods after period 23. The "distributional break-even point" of the project is estimated at around period 25.

Figure 4.2. Accumulated redistributive effect expressed in percentages of $I_{SQ,0}$, by the Gini index.



At the light of the results, the tunnel project would be desirable in both efficiency and equality terms.

7. Efficiency and Distributional Cost Benefit Analysis

When computing the CBA and the DCBA of a project, the results arising from the efficiency and distributional matrices may differ in their sign. The decision maker could bear both in mind when assessing alternative investments, or otherwise could prefer to synthesize them both into a single indicator. In chapter two a procedure to do so by means of the abbreviated social welfare functions (ASWF) was presented.

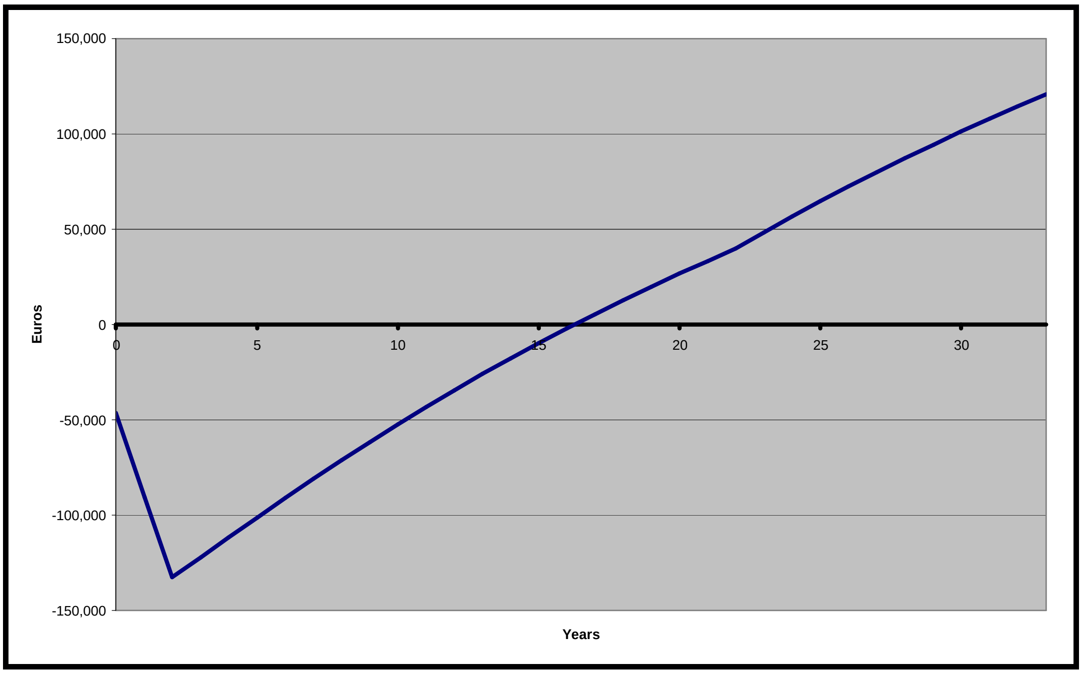
The procedure was applied to the efficiency and equity matrices of the tunnel road investment. Table 4.3 shows the results in terms of variations in the ASWF. The estimated internal rate of return of the project was of 9.95%.

Similarly, Figure 4.3 plots the accumulated change in the ASWF during the first 30 years of operation. From this perspective, society recovered the initial welfare level at year 17, while for the DCBA considered before the break even point was attained in the 25th period and in the CBA the break-even point was situated in year 16. This is because in the ASWF both efficiency (CBA) and equality (DCBA) are weighted.

Table 4.3. EDCBA for Horta's Tunnel (thousands of Euros of 2001).

Period	X_{t-1}	Investment	Maintenance	Toll Payments	Toll Returns	User's Time Savings	Non user's Time Savings	Accidents Savings	Running Costs Savings	Annual Welfare Change
0	0	-46,457	0	0	0	0	0	0	0	-46,457
1	0	-44,245	0	0	0	0	0	0	0	-44,245
2	0	-42,138	0	0	0	0	0	0	0	-42,138
3	-260	0	-1,103	-8,771	8,771	7,614	1,151	761	2,460	10,622
4	-263	0	-1,051	-8,687	8,687	7,541	1,073	754	2,436	10,491
5	-265	0	-1,001	-8,604	8,604	7,470	1,000	747	2,413	10,364
6	-268	0	-953	-8,522	8,522	7,398	931	739	2,390	10,237
7	-271	0	-908	-8,441	8,441	7,328	866	732	2,367	10,114
8	-274	0	-1,153	-8,361	8,361	7,258	804	725	2,345	9,706
9	-275	0	-1,098	-8,281	8,281	7,189	746	718	2,322	9,603
10	-272	0	-1,045	-8,044	8,044	6,983	691	698	2,256	9,311
11	-268	0	-996	-7,814	7,814	6,784	639	678	2,192	9,029
12	-264	0	-948	-7,591	7,591	6,590	590	659	2,129	8,755
13	-261	0	-903	-7,374	7,374	6,402	544	640	2,068	8,489
14	-258	0	-860	-7,163	7,163	6,219	500	622	2,009	8,231
15	-253	0	-819	-6,959	6,959	6,041	459	604	1,952	7,983
16	-248	0	-780	-6,760	6,760	5,868	421	587	1,896	7,743
17	-245	0	-743	-6,567	6,567	5,701	385	570	1,842	7,509
18	-241	0	-708	-6,379	6,379	5,538	351	553	1,789	7,282
19	-236	0	-674	-6,197	6,197	5,379	318	538	1,738	7,063
20	-231	0	-642	-6,020	6,020	5,226	288	522	1,688	6,852
21	-227	0	-611	-5,847	5,847	5,076	260	507	1,640	6,646
22	-222	0	-582	-5,680	5,680	4,931	233	493	1,593	6,446
23	2,054	0	-554	-5,518	5,518	4,791	208	479	1,548	8,525
24	1,993	0	-528	-5,361	5,361	4,654	185	465	1,503	8,273
25	1,934	0	-503	-5,208	5,208	4,521	163	452	1,461	8,028
26	1,877	0	-479	-5,060	5,060	4,392	143	439	1,419	7,791
27	1,822	0	-456	-4,915	4,915	4,267	124	426	1,378	7,562
28	1,769	0	-435	-4,775	4,775	4,145	106	414	1,339	7,339
29	1,717	0	-414	-4,639	4,639	4,027	89	403	1,301	7,123
30	1,666	0	-394	-4,507	4,507	3,912	73	391	1,264	6,912
31	1,617	0	-375	-4,378	4,378	3,801	59	380	1,228	6,709
32	1,570	0	-358	-4,253	4,253	3,692	45	369	1,193	6,511
33	1,524	0	-341	-4,132	4,132	3,587	33	359	1,159	6,320

Figure 4.3. Accumulated welfare change per household.



8. Sensitivity Analysis

In this section, three types of sensitivity analysis are presented. The first one affects the inequality index employed. The second one deals with alternative ways of financing the investment, either through a commercial bank or through public funds, instead of considering that funds come from a savings bank. The third one modifies the distribution of the toll return variable.

Other inequality indices

Although the Gini index is probably the inequality indicator most widely applied in the literature, there are several other inequality indices that could likewise be used in the construction of the EDCBA. Other relative indices of inequality should yield similar results. In order to verify this, the next subsections introduce the results when computed with the Atkinson index of inequality and with the generalised entropy index.

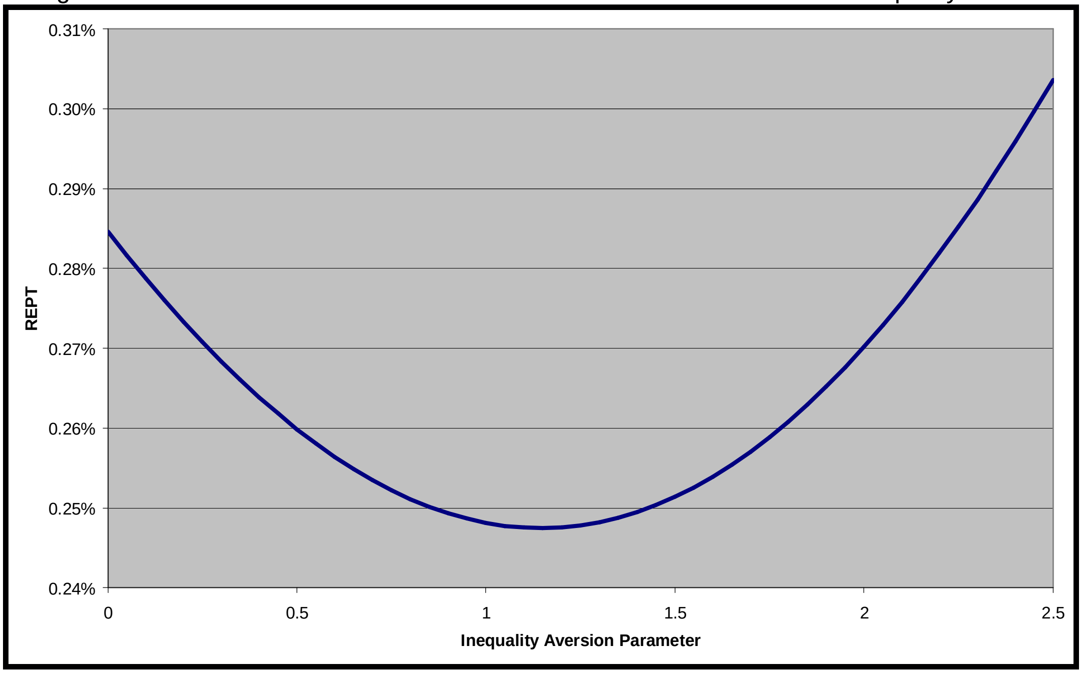
The Atkinson index.

Figure 4.4 shows the project's total redistributive effect and total welfare change using the Atkinson index with different values of the aversion to inequality parameter (ε).

The redistributive effects of the project remain positive for different values of ε, as with the Gini index, ranging from 0.24% to 0.30%

While the effect of the project is always positive, it increases as the aversion to inequality parameter adopts more extreme values (notice the U shape in figure 4.4). A minimum of the REP_T measure (accumulated redistributive effect) is found around ε=1.1 (figure 4.4 and table7.5 in appendix 1). It would be interesting to explore the implications of the REP_T and the ΔWP_T measures increasing as the ε parameter moves away from these values (the U shape).

Figure 4.4. Horta's tunnel redistributive effect estimated with the Atkinson inequality index.

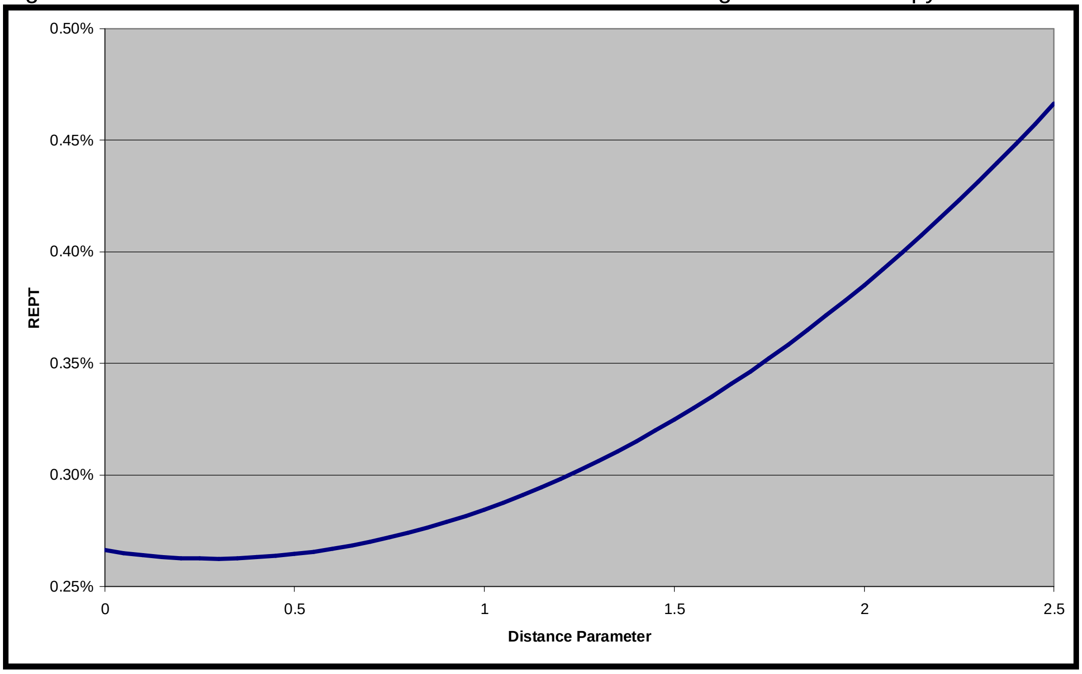


Generalized Entropy Index.

The other inequality index used to estimate the effects of the investment project was the generalised entropy index. This is, in fact, a family of indices. Under certain values of the parameter of distance (θ), this index takes the form of the coefficient of variation (θ = 2) and the Theil index (θ = 1). Figure 4.5 shows the results when computing the REP_T using this index, and for different values of the distance parameter.

Similarly to what happened with the Gini and Atkinson indices, results are positive in the whole range of variation of the distance parameter. Thus, it results that the redistributive effect varies between 0.26% and 0.46%.

Figure 4.5. Horta's tunnel redistributive effect estimated with the generalised entropy index.



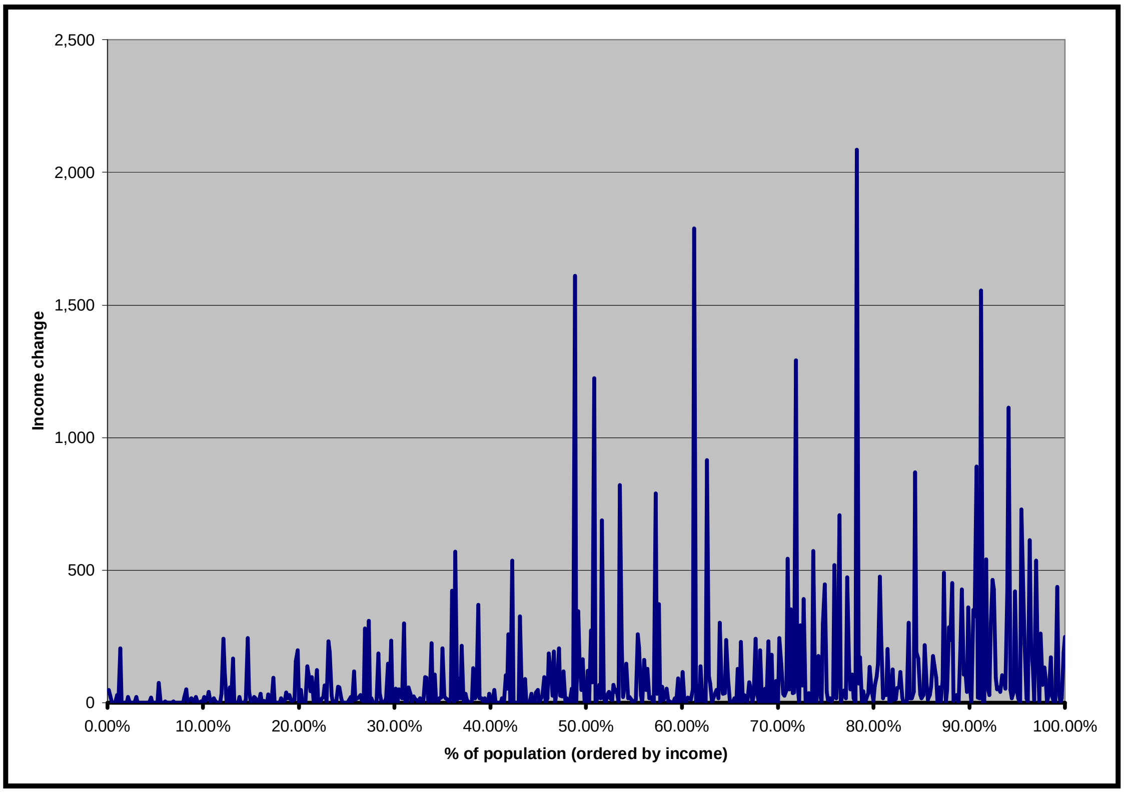
The three indices considered show that results are in the same line, with a positive redistributive effect. However, regarding the welfare change, results divert a little. There is a wide variation in the welfare variations. There is some variation in the welfare indicators. The Atkinson and Gini indices yield an IRR of 9.90%, while Entropy index results in an IRR of 10.03%. These differences are consistent with the fact that even though there is an ordinal equivalence between the Atkinson and entropy indices (Cowell 1998), cardinality does not hold for ASWF (Salas, 1996).

Investment Scenarios

The results of a DCBA were found to be sensitive to the way investments, maintenance costs, and toll returns were distributed. Two alternative scenarios to the savings bank assumption are introduced.

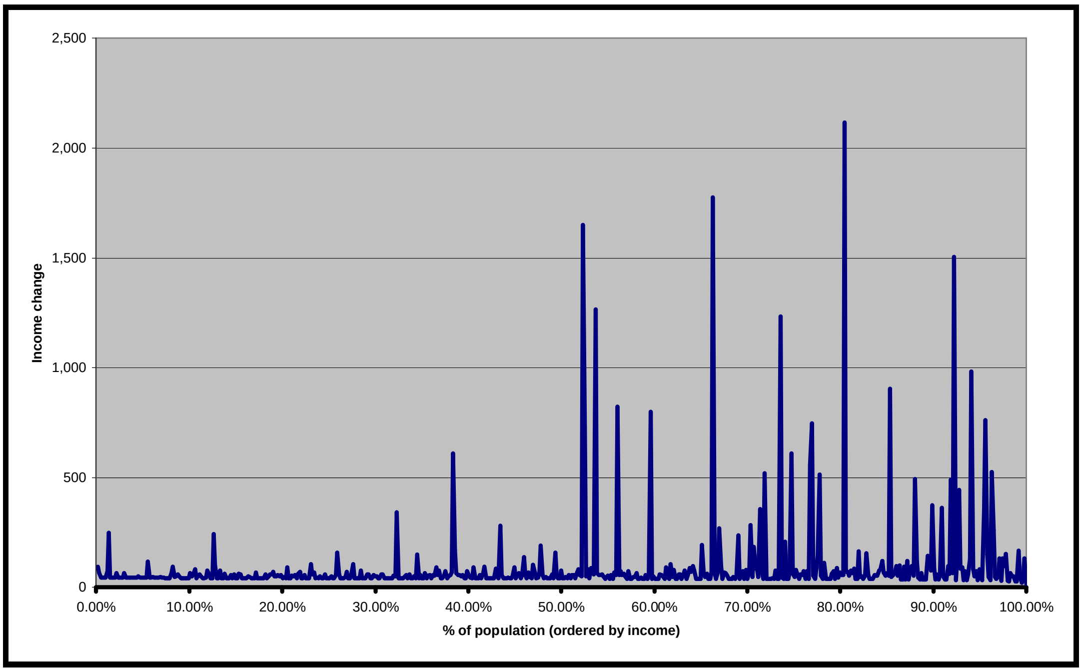
Scenario 1: Commercial banks. When the investment is assumed by a commercial bank, the benefits from toll returns are not invested in public goods, but distributed to shareholders. The costs and returns were assigned to individuals in proportion to their income from stocks and shares according to information included in the expenditure survey (INE, 1993). According to the survey, stocks and shares in Spain are luxury goods. The redistributive effect under the commercial bank assumption was of -0.0545%, and the consolidated welfare IRR was of 9.47%. Figure 4.6 shows the distribution of winners and losers for this scenario. As in the basic scenario, there are no losers, but there are many households which income remains unaltered.

Figure 4.6. Winners and losers for scenario 1. A commercial bank finances the toll road.



Scenario 2: Public sector. If the investment is undertaken by the public sector, but the money is borrowed from a commercial bank, the effects on investment, maintenance costs, and the recovering of the expenditures with a normal profit follow the patterns described in scenario 1. However, the extra benefits of toll returns once the costs have already been recovered are supposed to be distributed in the form of public goods, as in the base scenario. Under this combination, the redistributive percentage is of 0.3793% and the welfare IRR 10.41%. Figure 4.7 shows the distribution of income winners and losers for this scenario.

Figure 4.7. Distribution of income winners and losers scenario 2. The public sector invests, but borrows from a commercial bank.



As well as in the base scenario, all individuals in the society are winners, although their individual net benefit is lower.

These results reinforce the importance for the decision maker of taking into account the financial source when proposing an investment. The difference is seen when performing an EDCBA, in contrast to the unimportance this information has in the traditional CBA.

Toll return scenarios

Results of the EDCBA are found to be sensitive to the assumptions made in the distribution of the toll returns once the expenditure on the initial investment and maintenance is recovered (after the 22nd period). A new scenario appears when toll returns are provided as a public good with unitary income elasticity. This implies that while all agents consume all the amount of the public goods provided, their willingness to pay for different amounts vary in proportion to their own income.

In this case, toll returns have neutral effects in inequality for the 33 years of study (see tables 7.3 and 7.4 in appendix 1). Under this setting, the redistributive effect of the project is of -0.0524%, while the social welfare IRR is of 9.51%.

9. Conclusions

The application developed in this chapter shows the feasibility of the implementation of the DCBA and EDCBA approaches in practice.

The triple matrix system proposed begins with the classical efficiency based CBA matrix. A second matrix, based on equality concepts was added. Finally, a third matrix is constructed that accounts for and weights the first two matrices. The latter has the advantage of providing a single indicator that summarizes the social desirability of a project.

Although it was assumed in the application that the status quo did not change, this framework allows for such changes. Also, although not necessarily related to the EDCBA triple matrix system, a winners and losers analysis was added.

The EDCBA results seemed to be dependent upon changes in the distributional assumptions of the different variables of the CBA, and to the inequality index used in the second matrix. To analyze how changes in these parameters affect the general results, some sensitivity analysis was applied.

The sensitivity analysis showed that by using different relative inequality indices, the qualitative results of the DCBA and EDCBA remain valid, but are not cardinally equivalents. In the case of variations in some of the distributional assumptions, it was shown that outcomes are very sensitive to those changes. This result underlines the importance of considering the financial source of the investment, unlike in the traditional CBA.

V. GENERAL CONCLUSIONS

Traditionally, the evaluation of efficiency and equity effects of public projects has not been considered altogether, either from a theoretical or an applied point of view. This dissertation was devoted to advance in the combined consideration of efficiency and equity impacts.

Two main contributions can be stressed. Firstly, it is proposed to incorporate equity (or equality) effects of public projects into the well known CBA methodology, by adding two matrices of a similar structure in the analysis, the EDCBA. Secondly, the thesis raised the issue of the convenience of using a discount rate to the value of future equity changes caused by project investments. The following sections highlight the main conclusions.

1. The EDCBA triple matrix system

The first matrix of the triple matrix system is the efficiency based typical CBA. The second and third matrices constitute innovations in the public projects evaluation.

The second matrix, the DCBA, fits in the effects occurring in the income distribution due to the implementation of public policies. It is expressed in terms of redistributive effects, which are decomposed by income sources associated to variables of the project under consideration. In the current thesis, only relative inequality indices have been considered, such as the well known Gini or Atkinson index. However, this can be extended to absolute and mixed inequality indices or horizontal equity indices. This is left as an open line of research.

Additionally, only a few examples of inequality index decomposition were provided. Other types of decompositions can be used in this second matrix, like subpopulations. This is appealing when the agent making social choices is interested in the effects happening to a particular population group (for example, those of lower income or users of a specific infrastructure).

The third matrix, called EDCBA, combines the results of the previous CBA and DCBA matrices into a single indicator of the change in social welfare. This is the abbreviated social welfare function. The objective of this third matrix is to provide the social decision-maker with a unique and summarizing indicator of the social desirability of a project, so that both efficiency and equity concepts are combined. From this perspective, the synthesizing intention in the abbreviated social welfare function would be somehow attained for the evaluation of investment projects.

EDCBA makes explicit the social judgments behind equality values, since the abbreviated social welfare function takes a specific functional form. This implies a better understanding of the outcome of the appraisal, as well as its limitations and implications. This methodology is also compatible with the distributional weights when applied.

2. Discounting equity changes

It is a common practice to discount future values in CBA using a discount rate. However, the decision to accept a public project could be made dependant on its equity implications, too. Regarding the equity impacts of an investment project, it was argued that future changes in the inequality levels should be discounted. This is because they represent variations in the utility of individuals, the utility derived from belonging to a more egalitarian society. The extent to which individuals benefit from such changes is an empirical matter, though.

This question is addressed in chapter three of the thesis. Based on stated preference methods, a procedure is developed aimed at deriving the *equity* social rate of discount. This procedure is illustrated with an empirical application undertaken in Catalonia, Spain, dealing with forest subsidies.

The outcome of the application suggests that people show time preferences on equity, and that if more equality is to be achieved during a limited period, this is preferred to happen sooner rather than later. The resulting rate of discount from the exercise was 0.00253% when the Atkinson index is considered, and 0.00397% for the 1-Gini index. There are several lines for further research to be done –like the use of different indices, different discount functional forms, or the specificities of the equity discount rates in comparison to efficiency rates–, for which the work presented here ought to be regarded as a first step of research in this direction.

3. The empirical application

An empirical exercise was developed in which the EDCBA together with the use of a discount rate on equity. Thus, the application illustrated the feasibility of the methodology and concepts proposed.

A toll tunnel road to be developed in the province of Barcelona, Spain, was the project being evaluated. In short, the tunnel road had an internal rate of return of 9.78%. The total redistributive effect of the project was of 0.1035%, resulting in a more equitable society. When discounted with a 0.00397% rate, the redistributive effect reduced to 0.1034%. Finally, in terms of the abbreviated social welfare function, the IRR was of 9.95% at the assumed end life of the project.

Several sensitivity analyses were undertaken. These affected some of the distributional assumptions and the chosen inequality indices. The results highlight the importance of some of the distributional assumptions, namely the nature of the agent performing the investment. In the case of the inequality indices, results do not change qualitatively, but they differ in magnitude. It is then important to notice that abbreviated social welfare functions are not cardinally equivalent for distinct indices.

The EDCBA analysis can be further enhanced, though. Next section outlines some of the steps that could be undertaken to improve the new presented methodology.

4. Further research

Regarding the integrated evaluation of efficiency and equity effects, here are the proposed ideas for further research.

Some lines of future research could focus on the development of a directly additively decomposable inequality index upon which to build the DCBA matrix. A second string of research could be centered in the adaptation of this framework to several other kinds of inequality indices such as the absolute, mixed or horizontal equity indices. Thirdly, research could be directed to the different characteristics of the abbreviated social welfare function itself, including its functional form as well as the diverse inequality indices it makes use of.

With respect to the derivation of a social discount rate for equity, there are also several open lines of research. A deeper theoretical foundation of equity discount might be needed. Secondly, as stated in chapter one, different stated preference methods provide slightly different results, so there is ample room for experimental economics in this field. Thirdly, in this thesis an exponential type discount rate was derived; however, a number of different functional forms can be explored.

Finally, it seems appealing to consider equity and efficiency altogether in the evaluation of social projects, in such a way that social decision-making agents are provided with a unique but decomposable indicator of the social desirability of projects.

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VII. APPENDIX 1. SUPPORT TABLES FOR THE APLICATION IN CHAPTER IV.

Pseudo Gini and redistributive effects for the DCBA variables

Table 7.1 Pseudo Gini of the DCBA variables (If each variable is considered to be the only income variation in every period) for the basic scenario.

Period	X_{t-1}	Investment	Maintenance	Tolls Payments	Tolls Returns	Users' Time Savings	Non users' Time Savings	Accidents Savings	Running Costs Savings	Total Inequality level
0	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158
1	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158
2	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158
3	0.29158	0.29158	0.29158	0.29156	0.29158	0.29160	0.29158	0.29158	0.29159	0.29159
4	0.29159	0.29159	0.29159	0.29156	0.29159	0.29161	0.29159	0.29159	0.29159	0.29159
5	0.29159	0.29159	0.29159	0.29157	0.29159	0.29162	0.29159	0.29160	0.29160	0.29160
6	0.29160	0.29160	0.29160	0.29157	0.29160	0.29162	0.29160	0.29160	0.29161	0.29160
7	0.29160	0.29160	0.29160	0.29158	0.29160	0.29163	0.29160	0.29161	0.29161	0.29161
8	0.29161	0.29161	0.29161	0.29158	0.29161	0.29163	0.29161	0.29161	0.29162	0.29162
9	0.29162	0.29162	0.29162	0.29159	0.29162	0.29164	0.29162	0.29162	0.29162	0.29162
10	0.29162	0.29162	0.29162	0.29160	0.29162	0.29164	0.29162	0.29162	0.29163	0.29163
11	0.29163	0.29163	0.29163	0.29160	0.29163	0.29165	0.29163	0.29163	0.29163	0.29163
12	0.29163	0.29163	0.29163	0.29161	0.29163	0.29165	0.29163	0.29163	0.29164	0.29164
13	0.29164	0.29164	0.29164	0.29161	0.29164	0.29166	0.29164	0.29164	0.29165	0.29164

14	0.29164	0.29164	0.29164	0.29162	0.29164	0.29166	0.29164	0.29165	0.29165	0.29165
15	0.29165	0.29165	0.29165	0.29163	0.29165	0.29167	0.29165	0.29165	0.29166	0.29165
16	0.29165	0.29165	0.29165	0.29163	0.29165	0.29167	0.29165	0.29166	0.29166	0.29166
17	0.29166	0.29166	0.29166	0.29164	0.29166	0.29168	0.29166	0.29166	0.29167	0.29166
18	0.29166	0.29166	0.29166	0.29164	0.29166	0.29168	0.29166	0.29167	0.29167	0.29167
19	0.29167	0.29167	0.29167	0.29165	0.29167	0.29169	0.29167	0.29167	0.29168	0.29167
20	0.29167	0.29167	0.29167	0.29165	0.29167	0.29169	0.29167	0.29168	0.29168	0.29168
21	0.29168	0.29168	0.29168	0.29166	0.29168	0.29170	0.29168	0.29168	0.29169	0.29168
22	0.29168	0.29168	0.29168	0.29166	0.29168	0.29170	0.29168	0.29169	0.29169	0.29169
23	0.29169	0.29169	0.29169	0.29167	0.29164	0.29171	0.29169	0.29169	0.29169	0.29165
24	0.29165	0.29165	0.29165	0.29163	0.29160	0.29166	0.29165	0.29165	0.29165	0.29160
25	0.29160	0.29160	0.29160	0.29159	0.29156	0.29162	0.29160	0.29161	0.29161	0.29156
26	0.29156	0.29156	0.29156	0.29155	0.29152	0.29158	0.29156	0.29157	0.29157	0.29152
27	0.29152	0.29152	0.29152	0.29151	0.29148	0.29154	0.29152	0.29153	0.29153	0.29149
28	0.29149	0.29149	0.29149	0.29147	0.29145	0.29150	0.29149	0.29149	0.29149	0.29145
29	0.29145	0.29145	0.29145	0.29143	0.29141	0.29146	0.29145	0.29145	0.29145	0.29141
30	0.29141	0.29141	0.29141	0.29140	0.29137	0.29143	0.29141	0.29141	0.29142	0.29138
31	0.29138	0.29138	0.29138	0.29136	0.29134	0.29139	0.29138	0.29138	0.29138	0.29134
32	0.29134	0.29134	0.29134	0.29133	0.29131	0.29136	0.29134	0.29135	0.29135	0.29131
33	0.29131	0.29131	0.29131	0.29130	0.29128	0.29133	0.29131	0.29131	0.29132	0.29128

Table 7.2 Redistributive Effects of the DCBA variables (in thousands) for the basic scenario.

Period	X_{t-1}	Investment	Maintenance	Tolls Payments	Tolls Returns	Users' Time Savings	Non users' Time Savings	Accidents Savings	Running Costs Savings	Total Redistributive Effect
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0263	0.0000	-0.0227	0.0007	-0.0022	-0.0073	-0.0055
4	0.0000	0.0000	0.0000	0.0262	0.0000	-0.0227	0.0006	-0.0022	-0.0073	-0.0055
5	0.0000	0.0000	0.0000	0.0262	0.0000	-0.0227	0.0006	-0.0022	-0.0073	-0.0056
6	0.0000	0.0000	0.0000	0.0264	0.0000	-0.0228	0.0005	-0.0022	-0.0073	-0.0056
7	0.0000	0.0000	0.0000	0.0265	0.0000	-0.0229	0.0005	-0.0022	-0.0074	-0.0057
8	0.0000	0.0000	0.0000	0.0265	0.0000	-0.0229	0.0005	-0.0023	-0.0074	-0.0058
9	0.0000	0.0000	0.0000	0.0265	0.0000	-0.0229	0.0004	-0.0023	-0.0074	-0.0058
10	0.0000	0.0000	0.0000	0.0261	0.0000	-0.0226	0.0004	-0.0022	-0.0073	-0.0057
11	0.0000	0.0000	0.0000	0.0256	0.0000	-0.0221	0.0004	-0.0022	-0.0071	-0.0056
12	0.0000	0.0000	0.0000	0.0252	0.0000	-0.0218	0.0004	-0.0021	-0.0070	-0.0056
13	0.0000	0.0000	0.0000	0.0249	0.0000	-0.0215	0.0003	-0.0021	-0.0069	-0.0055
14	0.0000	0.0000	0.0000	0.0243	0.0000	-0.0210	0.0003	-0.0021	-0.0068	-0.0054
15	0.0000	0.0000	0.0000	0.0237	0.0000	-0.0206	0.0003	-0.0020	-0.0066	-0.0053
16	0.0000	0.0000	0.0000	0.0234	0.0000	-0.0202	0.0003	-0.0020	-0.0065	-0.0052
17	0.0000	0.0000	0.0000	0.0229	0.0000	-0.0198	0.0002	-0.0020	-0.0064	-0.0051
18	0.0000	0.0000	0.0000	0.0224	0.0000	-0.0194	0.0002	-0.0019	-0.0063	-0.0050
19	0.0000	0.0000	0.0000	0.0219	0.0000	-0.0190	0.0002	-0.0019	-0.0061	-0.0049
20	0.0000	0.0000	0.0000	0.0213	0.0000	-0.0185	0.0002	-0.0018	-0.0060	-0.0048
21	0.0000	0.0000	0.0000	0.0209	0.0000	-0.0181	0.0001	-0.0018	-0.0058	-0.0047
22	0.0000	0.0000	0.0000	0.0204	0.0000	-0.0177	0.0001	-0.0018	-0.0057	-0.0047
23	0.0000	0.0000	0.0000	0.0199	0.0476	-0.0173	0.0001	-0.0017	-0.0056	0.0430
24	0.0000	0.0000	0.0000	0.0195	0.0462	-0.0169	0.0001	-0.0017	-0.0054	0.0417
25	0.0000	0.0000	0.0000	0.0191	0.0449	-0.0165	0.0001	-0.0016	-0.0053	0.0405
26	0.0000	0.0000	0.0000	0.0186	0.0436	-0.0161	0.0001	-0.0016	-0.0052	0.0393
27	0.0000	0.0000	0.0000	0.0181	0.0423	-0.0157	0.0001	-0.0016	-0.0051	0.0381
28	0.0000	0.0000	0.0000	0.0176	0.0411	-0.0153	0.0001	-0.0015	-0.0049	0.0370
29	0.0000	0.0000	0.0000	0.0173	0.0399	-0.0149	0.0001	-0.0015	-0.0048	0.0359
30	0.0000	0.0000	0.0000	0.0168	0.0388	-0.0146	0.0000	-0.0015	-0.0047	0.0349
31	0.0000	0.0000	0.0000	0.0165	0.0377	-0.0143	0.0000	-0.0014	-0.0046	0.0338
32	0.0000	0.0000	0.0000	0.0160	0.0366	-0.0139	0.0000	-0.0014	-0.0045	0.0328

33	0.0000	0.0000	0.0000	0.0156	0.0355	-0.0135	0.0000	-0.0013	-0.0044	0.0319
							Total Redistributive Effect			**0.301884**
							Total Redistributive Effect %			**0.1035%**

Table 7.3 Pseudo Gini of the DCBA variables (If each variable is considered to be the only income variation in every period) for the scenario of toll returns being devoted to public goods of unitary income elasticity.

Period	X_{t-1}	Investment	Maintenance	Tolls Payments	Tolls Returns	Users' Time Savings	Non users' Time Savings	Accidents Savings	Running Costs Savings	Total Inequality level
0	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158
1	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158
2	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158	0.29158
3	0.29158	0.29158	0.29158	0.29156	0.29158	0.29160	0.29158	0.29158	0.29159	0.29159
4	0.29159	0.29159	0.29159	0.29156	0.29159	0.29161	0.29159	0.29159	0.29159	0.29159
5	0.29159	0.29159	0.29159	0.29157	0.29159	0.29162	0.29159	0.29160	0.29160	0.29160
6	0.29160	0.29160	0.29160	0.29157	0.29160	0.29162	0.29160	0.29160	0.29161	0.29160
7	0.29160	0.29160	0.29160	0.29158	0.29160	0.29163	0.29160	0.29161	0.29161	0.29161
8	0.29161	0.29161	0.29161	0.29158	0.29161	0.29163	0.29161	0.29161	0.29162	0.29162
9	0.29162	0.29162	0.29162	0.29159	0.29162	0.29164	0.29162	0.29162	0.29162	0.29162
10	0.29162	0.29162	0.29162	0.29160	0.29162	0.29164	0.29162	0.29162	0.29163	0.29163
11	0.29163	0.29163	0.29163	0.29160	0.29163	0.29165	0.29163	0.29163	0.29163	0.29163
12	0.29163	0.29163	0.29163	0.29161	0.29163	0.29165	0.29163	0.29164	0.29164	0.29164
13	0.29164	0.29164	0.29164	0.29161	0.29164	0.29166	0.29164	0.29164	0.29165	0.29164
14	0.29164	0.29164	0.29164	0.29162	0.29164	0.29167	0.29164	0.29165	0.29165	0.29165
15	0.29165	0.29165	0.29165	0.29163	0.29165	0.29167	0.29165	0.29165	0.29166	0.29165
16	0.29165	0.29165	0.29165	0.29163	0.29165	0.29168	0.29165	0.29166	0.29166	0.29166

17	0.29166	0.29166	0.29166	0.29164	0.29166	0.29168	0.29166	0.29166	0.29167	0.29167
18	0.29167	0.29167	0.29167	0.29164	0.29167	0.29168	0.29167	0.29167	0.29167	0.29167
19	0.29167	0.29167	0.29167	0.29165	0.29167	0.29169	0.29167	0.29167	0.29168	0.29168
20	0.29168	0.29168	0.29168	0.29165	0.29168	0.29169	0.29168	0.29168	0.29168	0.29168
21	0.29168	0.29168	0.29168	0.29166	0.29168	0.29170	0.29168	0.29168	0.29169	0.29168
22	0.29168	0.29168	0.29168	0.29166	0.29168	0.29170	0.29168	0.29169	0.29169	0.29169
23	0.29169	0.29169	0.29169	0.29167	0.29169	0.29171	0.29169	0.29169	0.29170	0.29169
24	0.29169	0.29169	0.29169	0.29167	0.29169	0.29171	0.29169	0.29170	0.29170	0.29170
25	0.29170	0.29170	0.29170	0.29168	0.29170	0.29172	0.29170	0.29170	0.29170	0.29170
26	0.29170	0.29170	0.29170	0.29168	0.29170	0.29172	0.29170	0.29170	0.29171	0.29171
27	0.29171	0.29171	0.29171	0.29169	0.29171	0.29172	0.29171	0.29171	0.29171	0.29171
28	0.29171	0.29171	0.29171	0.29169	0.29171	0.29173	0.29171	0.29171	0.29172	0.29172
29	0.29172	0.29172	0.29172	0.29170	0.29172	0.29173	0.29172	0.29172	0.29172	0.29172
30	0.29172	0.29172	0.29172	0.29170	0.29172	0.29173	0.29172	0.29172	0.29172	0.29172
31	0.29172	0.29172	0.29172	0.29171	0.29172	0.29174	0.29172	0.29172	0.29173	0.29173
32	0.29173	0.29173	0.29173	0.29171	0.29173	0.29174	0.29173	0.29173	0.29173	0.29173
33	0.29173	0.29173	0.29173	0.29172	0.29173	0.29174	0.29173	0.29173	0.29174	0.29173

Table 7.4 Redistributive Effects of the DCBA variables (in thousands) for the scenario of toll returns being devoted to public goods of unitary income elasticity.

Period	X_{t-1}	Investment	Maintenance	Tolls Payments	Tolls Returns	Users' Time Savings	Non users' Time Savings	Accidents Savings	Running Costs Savings	Total Redistributive Effect
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0262	0.0000	-0.0227	0.0006	-0.0023	-0.0073	-0.0055
4	0.0000	0.0000	0.0000	0.0261	0.0000	-0.0227	0.0006	-0.0023	-0.0073	-0.0056
5	0.0000	0.0000	0.0000	0.0262	0.0000	-0.0227	0.0005	-0.0023	-0.0073	-0.0056

6	0.0000	0.0000	0.0000	0.0263	0.0000	-0.0229	0.0005	-0.0023	-0.0074	-0.0057
7	0.0000	0.0000	0.0000	0.0265	0.0000	-0.0230	0.0005	-0.0023	-0.0074	-0.0058
8	0.0000	0.0000	0.0000	0.0264	0.0000	-0.0229	0.0004	-0.0023	-0.0074	-0.0058
9	0.0000	0.0000	0.0000	0.0265	0.0000	-0.0230	0.0004	-0.0023	-0.0074	-0.0058
10	0.0000	0.0000	0.0000	0.0260	0.0000	-0.0226	0.0004	-0.0023	-0.0073	-0.0058
11	0.0000	0.0000	0.0000	0.0256	0.0000	-0.0222	0.0003	-0.0022	-0.0072	-0.0057
12	0.0000	0.0000	0.0000	0.0251	0.0000	-0.0218	0.0003	-0.0022	-0.0071	-0.0056
13	0.0000	0.0000	0.0000	0.0248	0.0000	-0.0215	0.0003	-0.0022	-0.0070	-0.0055
14	0.0000	0.0000	0.0000	0.0243	0.0000	-0.0211	0.0003	-0.0021	-0.0068	-0.0054
15	0.0000	0.0000	0.0000	0.0237	0.0000	-0.0206	0.0002	-0.0021	-0.0066	-0.0053
16	0.0000	0.0000	0.0000	0.0234	0.0000	-0.0203	0.0002	-0.0020	-0.0065	-0.0053
17	0.0000	0.0000	0.0000	0.0229	0.0000	-0.0198	0.0002	-0.0020	-0.0064	-0.0052
18	0.0000	0.0000	0.0000	0.0224	0.0000	-0.0194	0.0002	-0.0019	-0.0063	-0.0051
19	0.0000	0.0000	0.0000	0.0219	0.0000	-0.0190	0.0002	-0.0019	-0.0061	-0.0050
20	0.0000	0.0000	0.0000	0.0213	0.0000	-0.0185	0.0001	-0.0019	-0.0060	-0.0049
21	0.0000	0.0000	0.0000	0.0209	0.0000	-0.0181	0.0001	-0.0018	-0.0059	-0.0048
22	0.0000	0.0000	0.0000	0.0204	0.0000	-0.0177	0.0001	-0.0018	-0.0057	-0.0047
23	0.0000	0.0000	0.0000	0.0199	0.0000	-0.0173	0.0001	-0.0017	-0.0056	-0.0046
24	0.0000	0.0000	0.0000	0.0194	0.0000	-0.0169	0.0001	-0.0017	-0.0054	-0.0045
25	0.0000	0.0000	0.0000	0.0190	0.0000	-0.0165	0.0001	-0.0017	-0.0053	-0.0044
26	0.0000	0.0000	0.0000	0.0185	0.0000	-0.0161	0.0001	-0.0016	-0.0052	-0.0043
27	0.0000	0.0000	0.0000	0.0180	0.0000	-0.0157	0.0001	-0.0016	-0.0051	-0.0042
28	0.0000	0.0000	0.0000	0.0176	0.0000	-0.0152	0.0001	-0.0015	-0.0049	-0.0041
29	0.0000	0.0000	0.0000	0.0172	0.0000	-0.0149	0.0000	-0.0015	-0.0048	-0.0040
30	0.0000	0.0000	0.0000	0.0168	0.0000	-0.0146	0.0000	-0.0015	-0.0047	-0.0039
31	0.0000	0.0000	0.0000	0.0164	0.0000	-0.0142	0.0000	-0.0014	-0.0046	-0.0038
32	0.0000	0.0000	0.0000	0.0159	0.0000	-0.0138	0.0000	-0.0014	-0.0045	-0.0037
33	0.0000	0.0000	0.0000	0.0156	0.0000	-0.0135	0.0000	-0.0014	-0.0044	-0.0036

Total Redistributive Effect	**-0.152940**
Total Redistributive Effect %	**-0.0524%**

Redistributive effects and welfare changes using Atkinson inequality index and generalized entropy index

Table 7.5 Total redistributive effects and total welfare changes (in thousands euros) using Atkinson inequality index and generalized entropy index for Horta tunnel.

	Atkinson Inequality index		Generalized Entropy index	
Aversión to inequality parameter	Total Redistributive Effect	Total Welfare Change	Total Redistributive Effect	Total Welfare Change
0	0.2846%	150,043	0.2664%	146,860
0.05	0.2816%	149,932	0.2651%	146,782
0.1	0.2788%	149,802	0.2641%	146,720
0.15	0.2760%	149,655	0.2634%	146,673
0.2	0.2733%	149,493	0.2628%	146,641
0.25	0.2708%	149,316	0.2626%	146,624
0.3	0.2684%	149,126	0.2625%	146,620
0.35	0.2661%	148,925	0.2627%	146,631
0.4	0.2639%	148,714	0.2631%	146,656
0.45	0.2618%	148,494	0.2637%	146,694
0.5	0.2599%	148,268	0.2646%	146,745
0.55	0.2581%	148,035	0.2657%	146,810
0.6	0.2564%	147,799	0.2669%	146,889
0.65	0.2549%	147,560	0.2684%	146,981
0.7	0.2535%	147,320	0.2701%	147,086

0.75	0.2522%	147,080	0.2720%	147,205
0.8	0.2511%	146,841	0.2741%	147,338
0.85	0.2501%	146,606	0.2765%	147,485
0.9	0.2493%	146,375	0.2790%	147,647
0.95	0.2487%	146,149	0.2817%	147,823
1	0.2481%	145,931	0.2846%	148,014
1.05	0.2478%	145,722	0.2877%	148,221
1.1	0.2475%	145,523	0.2911%	148,443
1.15	0.2475%	145,334	0.2946%	148,682
1.2	0.2476%	145,159	0.2983%	148,939
1.25	0.2478%	144,997	0.3022%	149,213
1.3	0.2482%	144,851	0.3063%	149,505
1.35	0.2488%	144,720	0.3106%	149,817
1.4	0.2495%	144,608	0.3152%	150,148
1.45	0.2504%	144,514	0.3199%	150,501
1.5	0.2514%	144,440	0.3248%	150,876
1.55	0.2526%	144,387	0.3299%	151,273
1.6	0.2539%	144,357	0.3352%	151,695
1.65	0.2554%	144,349	0.3408%	152,142
1.7	0.2571%	144,366	0.3465%	152,615
1.75	0.2589%	144,409	0.3524%	153,117
1.8	0.2608%	144,477	0.3586%	153,648
1.85	0.2629%	144,573	0.3649%	154,210
1.9	0.2652%	144,697	0.3714%	154,804
1.95	0.2676%	144,850	0.3782%	155,434
2	0.2702%	145,033	0.3852%	156,100
2.05	0.2729%	145,247	0.3923%	156,804
2.1	0.2758%	145,491	0.3997%	157,549
2.15	0.2788%	145,768	0.4073%	158,337
2.2	0.2819%	146,077	0.4151%	159,171

2.25	0.2852%	146,419	0.4231%	160,053
2.3	0.2887%	146,795	0.4313%	160,985
2.35	0.2922%	147,205	0.4398%	161,972
2.4	0.2959%	147,649	0.4484%	163,016
2.45	0.2997%	148,128	0.4573%	164,121
2.5	0.3036%	148,642	0.4664%	165,290

VIII. APPENDIX 2. INTERVIEW SAMPLE

CUESTIONARIO

Código	**1**				

Buenos días/tardes, soy de la Universidad Autónoma y estamos haciendo una encuesta de opinión sobre el medio ambiente. ¿Me podría contestar a unas preguntas?

[*Si no accede, pasar a la siguiente persona*]

Muy amable.

1.- Para comenzar voy a leerle una lista con distintos temas y le pediré su opinión sobre la importancia que cada uno de ellos tiene para usted. Me tiene que dar un número entre 1 y 10, donde el 1 quiere decir que no le importa nada, el 5 que es importante y el 10 que es *muy* importante para usted. [*Mostrar tarjeta 1*]

Tema	No es un tema importante				Es un tema importante					Es un tema muy importante	No sé
El paro	1	2	3	4	5	6	7	8	9	10	99
El ruido del tráfico	1	2	3	4	5	6	7	8	9	10	99
La contaminación del aire	1	2	3	4	5	6	7	8	9	10	99
La contaminación de lagos y ríos	1	2	3	4	5	6	7	8	9	10	99
La seguridad en la calle	1	2	3	4	5	6	7	8	9	10	99
La calidad de los bosques	1	2	3	4	5	6	7	8	9	10	99

PARTE BOSQUES

Ahora nos centraremos en los bosques.

2.a.- ¿Cuándo estuvo en un bosque por última vez?

1. Cuando:_______________________________ [*Si hace menos de 1 año pasar a la pregunta 2.b*]
2. No lo sé, no recuerdo

2.b.- [*Sólo si hace menos de 1 año que estuvo en el bosque*]¿Y cuántas veces habrá ido al bosque, más o menos, durante los últimos 12 meses?

1. Veces:_________________________________
2. No lo sé, no recuerdo

2.c.- Mire, cada vez que usted va al bosque le cuesta dinero. Por ejemplo, si va al bosque en coche tiene que pagar la gasolina y a lo mejor el peaje, o quizás tenga gastos extras en comida, alojamiento u otros, además del tiempo que le dedica al viaje. ¿Cuánto cree que en promedio gasta en un día, más o menos, cada vez que va al bosque?

Cantidad:____________________________ [*Anotar si es en euros o pesetas*]

3.- Muy bien. En un bosque se puede pasear, hacer un picnic o disfrutar del paisaje. En general, usted prefiere los paisajes con bosque, sin bosque, o con una mezcla de bosques, campos y quizás casas?

1. Sólo bosque
2. Sin bosque
3. Mixto
4. No lo sé, no estoy seguro

4.- Muy bien. Los bosques además producen madera, corcho y otras cosas, ¿ha ido usted alguna vez a buscar setas, hierbas aromáticas, frutos secos, o algún otro producto al bosque?

1. Si
2. No
3. No lo sé, no recuerdo

Además los bosques suelen prevenir en algo la erosión, absorben una parte de la contaminación del aire y ayudan a que algunos animales y plantas puedan vivir. Aunque, por el contrario, cuanto más bosque hay, se dejan de tener otros usos en esas tierras como por ejemplo la agricultura y la ganadería y también cambia el paisaje. ¿Me entiende?

Pues bien, en los últimos años se ha ido abandonando el cultivo de tierras y cuando esto pasa el bosque suele acabar extendiéndose de forma natural. Pero a veces, es el propietario quien planta los árboles en estas tierras abandonadas. Estos bosques que se plantan suelen estar más cuidados y tener árboles de mejor calidad que aquellos que se reproducen espontáneamente.

5.- Algunas personas prefieren que el bosque crezca por sí solo y otras que se plante. Si usted pudiera decidir, ¿preferiría que los propietarios de estos cultivos que se abandonan plantaran más bosque, o que estas tierras se dejasen sin hacer nada?

1. Que se plante más bosque
2. Que el bosque crezca por sí solo
3. Me da igual
4. No lo sé, no estoy seguro

[*Si responde 1. Que se plante más bosque, seguir con la entrevista normalmente*]
[*Cualquier otra opción, pasar a la parte de "Preguntas finales"*]

De acuerdo, mire, la cantidad de productos forestales, como la madera, las setas, y los otros beneficios de los bosques, como por ejemplo las actividades recreativas que se pueden realizar en ellos, podrían aumentar con un programa de plantación de más bosques en Cataluña.

6.- En una escala del 1 al 10, ¿qué le parece a usted la idea de aumentar así el bosque en Cataluña?. Uno es muy negativa, 10 es muy positiva y 5 no es ni positiva ni negativa. [*Mostrar tarjeta 2*]

Muy negativa	1
	2
	3
	4
Ni positiva ni negativa	5
	6
	7
	8
	9
Muy positiva	10

Muy bien, continuemos. Cuando la tierra se abandona porque deja de ser cultivada por su propietario es generalmente porque no le sale a cuenta seguir cultivando o ni siquiera plantar un bosque. Por eso, se suelen dar subvenciones, ya que esos propietarios hacen también un servicio a la sociedad manteniendo el bosque plantado. ¿Me entiende?

Bien. Hay una organización sin ánimo de lucro que quiere promover la plantación de bosques en estas tierras abandonadas. Esta organización recibe donaciones de la gente y por lo tanto cuanto más dinero recibe, más bosque puede subvencionar y plantar. [*Mostrar tarjeta con mapa*] Esta organización se ha propuesto que la superficie total de bosque en Cataluña pase del 40% actual al 45% en los próximos 20 años.

7.- ¿Considera usted que ésta es una buena iniciativa?

1. Sí
2. No
3. No lo sé, no estoy seguro

De acuerdo, ahora necesitamos saber cuánto estaría dispuesto a aportar usted cada año para estas subvenciones durante los próximos 20 años, a partir del año que viene, asegurándole que el dinero que usted aporte sería utilizado sólo con el fin de plantar más bosques. Por favor, ¿podría mirar esta tabla? [*Mostrar tarjeta 3*] Como ve, tiene una lista con cantidades de dinero, estas cantidades están calculadas anualmente, pero se cobrarán a plazos durante cada año.

8.- Para responder a lo que le voy a preguntar, dígase a sí mismo, “Si el programa de subvenciones me cuesta 0,6 euros extra por año en los próximos 20 años, ¿estaría yo a favor de esta plantación de bosques?”

[*Si dice que sí, pasar a la pregunta 9*]
[*Si dice que no, pasar a la pregunta 10*]

9.- [*Sólo si respondió afirmativamente a la pregunta 8*] Muy bien, ahora podemos avanzar. Mire la tabla hacia abajo y por favor indíqueme si usted estaría todavía a favor de la plantación de bosques. Cuando lleguemos a una cantidad que usted no esté dispuesto a pagar o no esté seguro de hacerlo, diga “no”.

[*Si llega hasta el final, casilla “más de”, preguntar por cuánto pagaría entonces como máximo y anotarlo*]

Plantación de bosque (euros)

Cantidad (anual)	**Dispuesto a pagar? si/no**
0	
0,6	
1,2	
3	
6	
9	
12	
15	
18	
21	
24	
27	
30	
36	
42	
48	
54	
60	

66	
72	
78	
84	
90	
108	
120	
150	
180	
más de 180	

10.- [*Sólo si no quiere pagar nada*] ¿Por qué motivo no quiere pagar nada por la plantación de bosques?

Motivo:____
____
____

PARTE EQUIDAD

Ahora pasemos a hablar acerca de cómo se repartiría el total de estas aportaciones.

Actualmente, la ley sólo permite repartir las subvenciones por igual entre todos los propietarios. Por favor, mire esta tarjeta *[Mostrar tarjeta E-A y explicar:]* De esta manera, **del total de los propietarios, la mitad que tiene menor renta** recibe el 50% de las subvenciones, y el resto de los propietarios, es decir, los que tienen mayor renta, reciben también el 50% de las subvenciones.

Sin embargo, existe la posibilidad de que se pueda cambiar esta ley para repartir las subvenciones de manera distinta a la actual de acuerdo con la renta de los propietarios (si son más pobres o más ricos). A continuación le enseñaré unas tarjetas con distintas alternativas para repartir las subvenciones y le pediré que elija, de entre ellas, la que le parezca mejor.

Recuerde que su respuesta afectaría **únicamente** al reparto de las subvenciones y **no a la superficie total de bosque plantado**.

[***Sólo si pregunta****, explicar que para que la superficie de bosque plantado no varíe, el grupo de propietarios que reciba más dinero plantará más bosque. De esta forma, si el dinero se reparte hacia los pobres, entonces serán ellos los que planten más bosque, y si el dinero se reparte como ahora, los ricos y los pobres plantan por igual*]

Por favor, mire esta tarjeta.[*Mostrar tarjeta E-11 y explicar:]* En esta tarjeta, la opción *A* significa que no se modifique la ley y que las subvenciones se sigan repartiendo por igual, como hasta ahora. La opción *B* significa que durante los dos primeros años, las subvenciones se repartan como ahora y que a partir del tercer año se reparta el 60% entre la mitad más pobre de los propietarios. La opción *C* significa que durante los primeros cuatro años se repartan las subvenciones como hasta ahora y que a partir del quinto año se reparta el 60% de las subvenciones a la mitad más pobre de los propietarios.

1.- Entre las 3 opciones que le estoy enseñando ¿Cuál de ellas preferiría usted que se llevara a cabo?

	Opción A		Opción B		Opción C

[si no contesta o no sabe]

¿Qué le motivó a no elegir ninguna de las tres opciones?

Bien, pasemos a la segunda tarjeta. [*Mostrar tarjeta E-12*] La interpretación de la tarjeta es exactamente igual que la anterior, pero note que pueden haber cambiado los años y el porcentaje de las subvenciones a repartir de las opciones *B* y *C*. Recuerde que la opción *A* se refiere a dejar la ley como hasta ahora, repartiendo la totalidad de las subvenciones por igual.

2.- ¿Cuál de estas 3 opciones de reparto preferiría que se llevara a cabo?

	Opción A		Opción B		Opción C

[sólo si no contesta o no sabe]

¿Qué le motivó no elegir ninguna de las tres opciones?

Pasemos ahora a la tercera tarjeta [*Mostrar tarjeta E-13*] Recuerde que la opción *A* se refiere a dejar la ley como hasta ahora, repartiendo las subvenciones por igual y que las opciones *B* y *C* han cambiado..

3.- En este caso ¿Cuál de estas 3 opciones de reparto preferiría que se llevara a cabo?

	Opción A		Opción B		Opción C

[sólo si no contesta opción A o no sabe]

¿Qué le motivó a no elegir ninguna de las tres opciones?

Pasemos ahora a la cuarta tarjeta [*Mostrar tarjeta E-14*] Recuerde que la opción *A* se refiere a dejar la ley como hasta ahora y que las opciones *B* y *C* han cambiado.

4.- Entre las 3 opciones que le estoy enseñando ¿Cuál preferiría que se llevara a cabo?

	Opción A		Opción B		Opción C

[sólo si no contesta o no sabe]

¿Qué le motivó a no elegir ninguna de las tres opciones?

Bien, pasemos a la quinta tarjeta. [*Mostrar tarjeta E-15*] La interpretación de la tarjeta es exactamente igual que las anteriores. De nuevo, recuerde que la opción *A* se refiere a dejar la ley como hasta ahora, repartiendo la totalidad de las subvenciones por igual y que las opciones *B* y *C* han cambiado.

5.- ¿Cuál de estas 3 opciones preferiría que se llevara a cabo?

	Opción A		Opción B		Opción C

[sólo si no contesta o no sabe]

¿Qué le motivó a no elegir ninguna de las tres opciones?

Para terminar con esta sección, por favor mire la última tarjeta [*Mostrar tarjeta E-16*] Recuerde que la opción *A* se refiere a dejar la ley como hasta ahora, repartiendo la totalidad de las subvenciones por igual y que las opciones *B* y *C* han cambiado.

6.- En este caso ¿Cuál de estas 3 opciones de reparto preferiría que se llevara a cabo?

	Opción A		Opción B		Opción C

[sólo si no contesta o no sabe]

¿Qué le motivó a no elegir ninguna de las tres opciones?

PARTE PREGUNTAS FINALES

1.- Muy bien. Ya para terminar, ¿pertenece usted a alguna organización, grupo, o entidad que tenga relación con la naturaleza o el medio ambiente?

1. Sí
2. No [*Pasar a la pregunta 3*]
3. No lo sé, no estoy seguro [*Pasar a la pregunta 3*]

2.- [*Sólo si respondió afirmativamente a la pregunta 1*]¿A qué tipo de organización pertenece? [*Mostrar tarjeta 7*]

Grupo ecologista	1
Entidad deportiva	2
Centro de estudios de la naturaleza	3
Otra (especificar)______________________________	4

3.- De acuerdo. ¿Podría decirme en qué año nació?

1	9		

4.- ¿Cuál es el nivel máximo de estudios que terminó? [*Mostrar tarjeta 8*]

Primarios	1
EGB, ESO, Bachillerato elemental, FP1	2
Bachillerato superior, BUP, COU, FP2	3
Estudios medios (diplomaturas, peritaje)	4
Estudios superiores (licenciados, ingenieros, doctores)	5

5.- ¿Podría decirme cuál de estos montos se aproxima mejor a sus ingresos personales netos al mes? [*Mostrar tarjeta 9, en euros o pesetas según preferencia del entrevistado*]

(*En euros***)**

No tiene ingresos directos	1
Hasta 300 por mes	2
301 – 600 por mes	3
601 – 900 por mes	4
901 – 1.200 por mes	5
1.201 – 1.500 por mes	6
1.501 – 1.800 por mes	7
1.801 – 2.100 por mes	8
2.101 – 2.400 por mes	9
Más de 2.400 por mes	10
No sabe	99
No responde	999

(*En pesetas***)**

No tiene ingresos directos	1
Hasta 50.000 por mes	2
50.001 – 100.000 por mes	3
100.001 – 150.000 por mes	4
150.001 – 200.000 por mes	5

200.001 – 250.000 por mes	6
250.001 – 300.000 por mes	7
300.001 – 350.000 por mes	8
350.001 – 400.000 por mes	9
Más de 400.000 por mes	10
No sabe	99
No responde	999

6.- Muy bien. ¿Quién cree usted que ha encargado este estudio? [*Mostrar tarjeta 10*]

Un grupo ecologista	1
Una asociación forestal	2
Una organización de agricultores	3
Una empresa privada	4
La Generalitat de Cataluña	5
Alguien más (especificar)_________________	6

7.- ¿Quiere añadir alguna sugerencia o comentario respecto a los temas de la encuesta?
____
____
____
____
____
____

Nos hacen un control de calidad de las entrevistas, y un supervisor llama a algunas personas entrevistadas para saber como ha ido la encuesta. Le importaría darnos su número de teléfono, por si decidieran llamarlo?_____________________[*anotarlo*]

Muchas gracias por su colaboración y por su tiempo.

PARTE EVALUACION DEL ENCUESTADOR

1.- ¿La persona entrevistada era?

Hombre	1

Mujer	2

2.- ¿Diría que el grado de entendimiento de las preguntas por parte del entrevistado fue?

Alto	1
Medio	2
Bajo	3

3.- ¿Y la actitud ante la encuesta fue?

Buena	1
Indiferente	2
Poco dispuesta	3

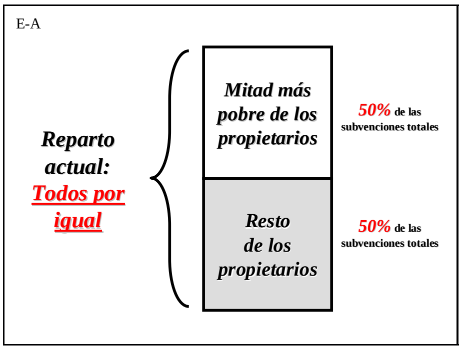
Sugerencias,
comentarios:____
____
____
____
____
____

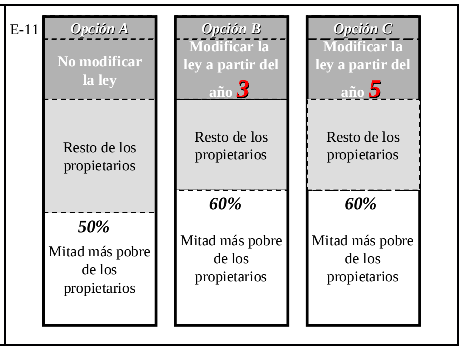
Fecha de la entrevista: _____/_____/2002

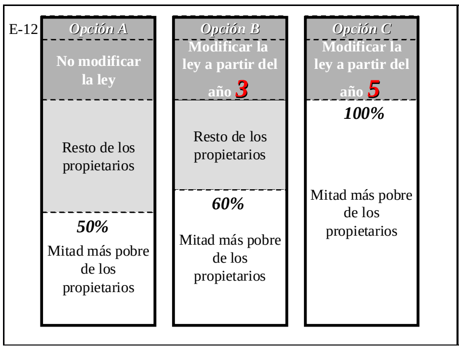
Duración aproximada: _____________

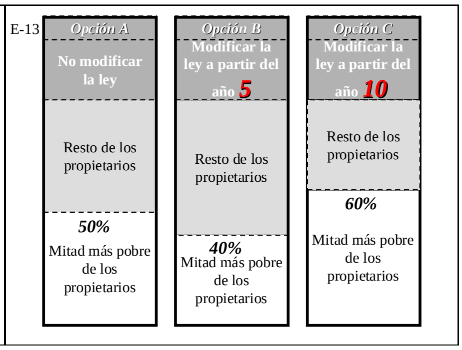
Lugar de la entrevista (municipio, barrio y esquina de calles más próxima):___________

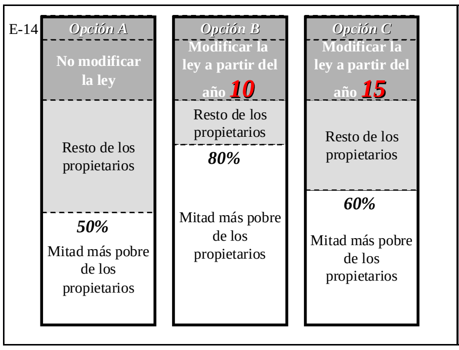
IX. APPENDIX 3. INTERVIEW CARDS FOR THE EQUITY SECTION

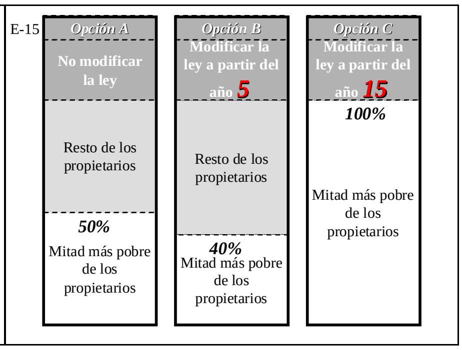


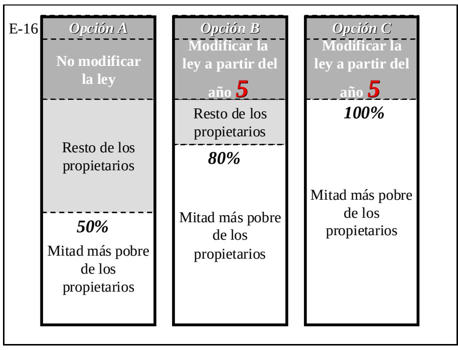


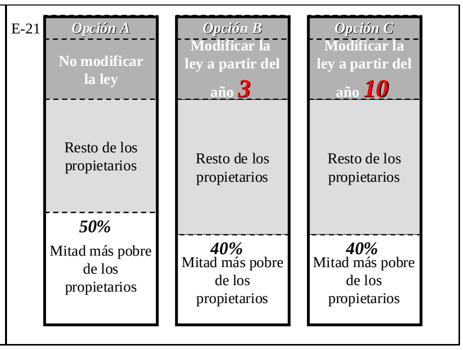


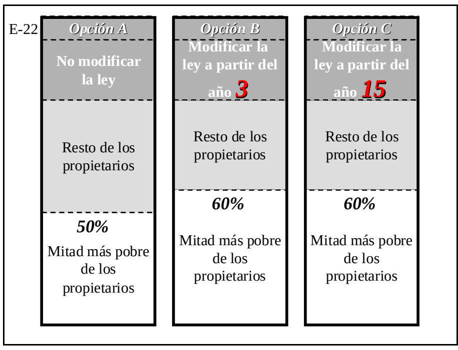


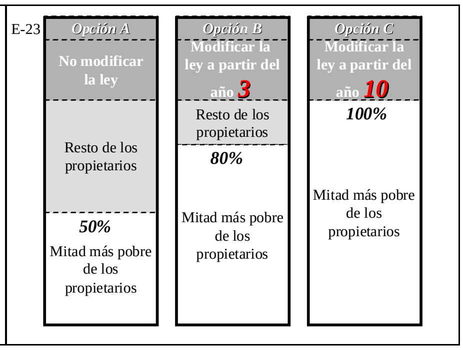


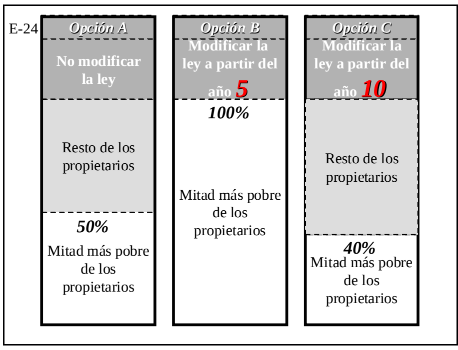


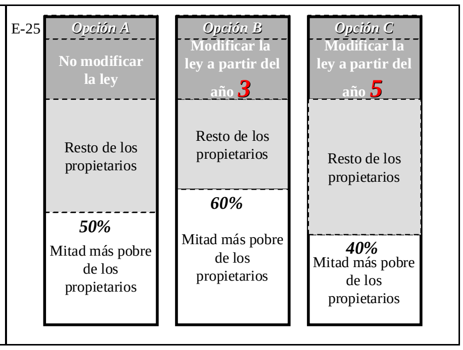

E-16
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 5
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 5
100%
Mitad más pobre de los propietarios

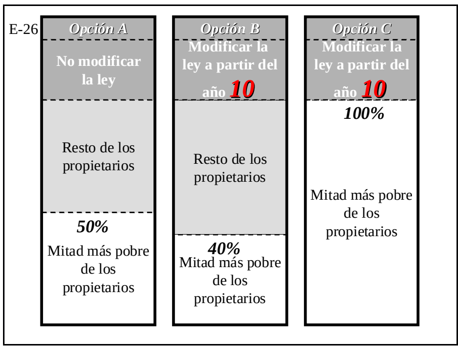

E-21
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
40%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
Resto de los propietarios
40%
Mitad más pobre de los propietarios

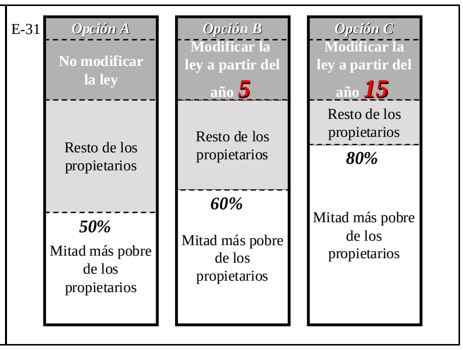

E-22
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
60%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
60%
Mitad más pobre de los propietarios


E-23
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
100%
Mitad más pobre de los propietarios


E-24
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 5
100%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
Resto de los propietarios
40%
Mitad más pobre de los propietarios

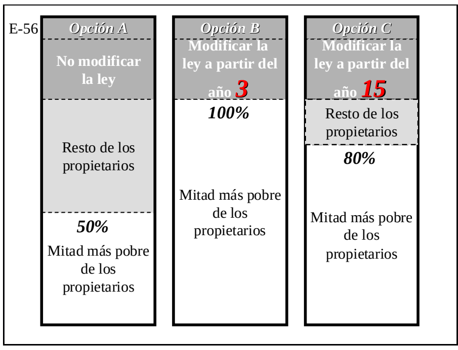

E-25
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
60%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 5
Resto de los propietarios
40%
Mitad más pobre de los propietarios

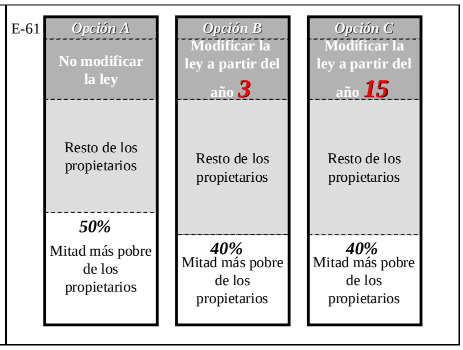

E-26
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 10
Resto de los propietarios
40%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
100%
Mitad más pobre de los propietarios

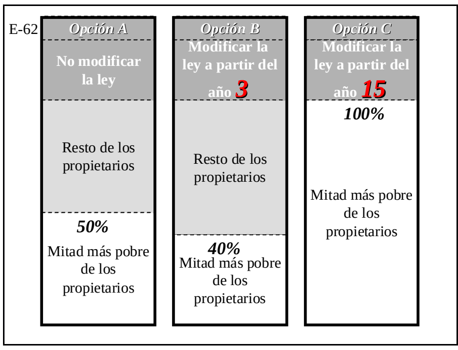

E-31
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 5
Resto de los propietarios
60%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
80%
Mitad más pobre de los propietarios

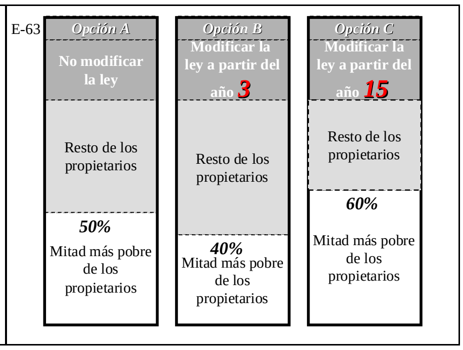

E-32
Opción A: No modificar la ley — Resto de los propietarios — 50% — Mitad más pobre de los propietarios
Opción B: Modificar la ley a partir del año 3 — Resto de los propietarios — 40% — Mitad más pobre de los propietarios
Opción C: Modificar la ley a partir del año 10 — Resto de los propietarios — 80% — Mitad más pobre de los propietarios
E-33
Opción A: No modificar la ley — Resto de los propietarios — 50% — Mitad más pobre de los propietarios
Opción B: Modificar la ley a partir del año 5 — Resto de los propietarios — 80% — Mitad más pobre de los propietarios
Opción C: Modificar la ley a partir del año 15 — Resto de los propietarios — 80% — Mitad más pobre de los propietarios
E-34
Opción A: No modificar la ley — Resto de los propietarios — 50% — Mitad más pobre de los propietarios
Opción B: Modificar la ley a partir del año 15 — Resto de los propietarios — 60% — Mitad más pobre de los propietarios
Opción C: Modificar la ley a partir del año 15 — Resto de los propietarios — 80% — Mitad más pobre de los propietarios
E-35
Opción A: No modificar la ley — Resto de los propietarios — 50% — Mitad más pobre de los propietarios
Opción B: Modificar la ley a partir del año 3 — Resto de los propietarios — 40% — Mitad más pobre de los propietarios
Opción C: Modificar la ley a partir del año 3 — Resto de los propietarios — 60% — Mitad más pobre de los propietarios
E-36
Opción A: No modificar la ley — Resto de los propietarios — 50% — Mitad más pobre de los propietarios
Opción B: Modificar la ley a partir del año 10 — Resto de los propietarios — 40% — Mitad más pobre de los propietarios
Opción C: Modificar la ley a partir del año 10 — Resto de los propietarios — 60% — Mitad más pobre de los propietarios
E-41
Opción A: No modificar la ley — Resto de los propietarios — 50% — Mitad más pobre de los propietarios
Opción B: Modificar la ley a partir del año 3 — Resto de los propietarios — 40% — Mitad más pobre de los propietarios
Opción C: Modificar la ley a partir del año 10 — Resto de los propietarios — 60% — Mitad más pobre de los propietarios
E-42
Opción A: No modificar la ley — Resto de los propietarios — 50% — Mitad más pobre de los propietarios
Opción B: Modificar la ley a partir del año 3 — 100% — Mitad más pobre de los propietarios
Opción C: Modificar la ley a partir del año 10 — Resto de los propietarios — 40% — Mitad más pobre de los propietarios
E-43
Opción A: No modificar la ley — Resto de los propietarios — 50% — Mitad más pobre de los propietarios
Opción B: Modificar la ley a partir del año 5 — 100% — Mitad más pobre de los propietarios
Opción C: Modificar la ley a partir del año 15 — Resto de los propietarios — 60% — Mitad más pobre de los propietarios

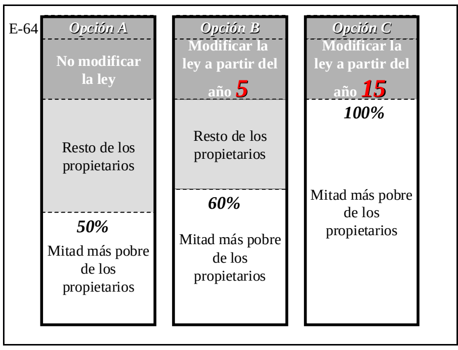

E-44
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 5
Resto de los propietarios
40%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
60%
Mitad más pobre de los propietarios
E-45
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
40%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 5
100%
Mitad más pobre de los propietarios
E-46
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 10
Resto de los propietarios
60%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
40%
Mitad más pobre de los propietarios
E-51
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
Resto de los propietarios
40%
Mitad más pobre de los propietarios
E-52
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 10
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
100%
Mitad más pobre de los propietarios
E-53
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
60%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
80%
Mitad más pobre de los propietarios
E-54
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
100%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 5
Resto de los propietarios
60%
Mitad más pobre de los propietarios
E-55
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 3
100%
Mitad más pobre de los propietarios

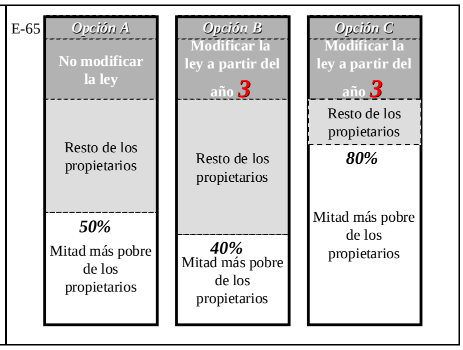

E-56
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
100%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
80%
Mitad más pobre de los propietarios

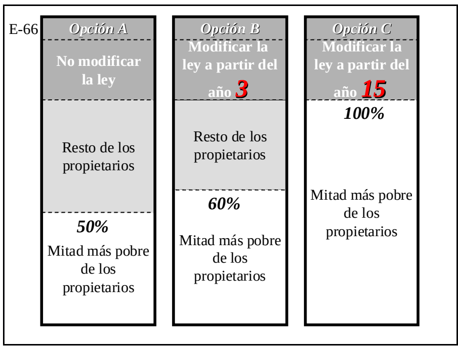

E-61
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
40%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
40%
Mitad más pobre de los propietarios

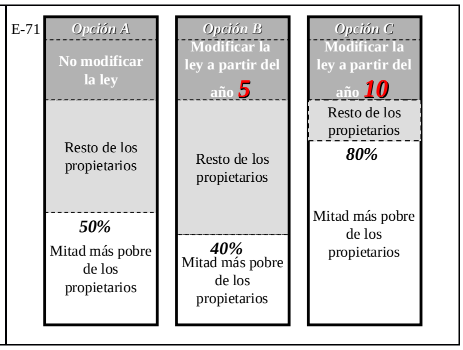

E-62
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
40%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
100%
Mitad más pobre de los propietarios

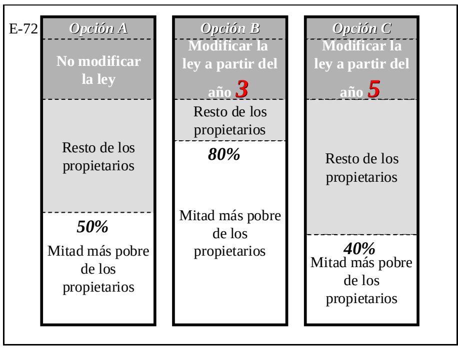

E-63
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
40%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
60%
Mitad más pobre de los propietarios

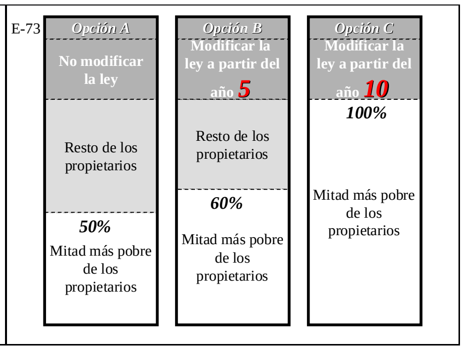

E-64
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 5
Resto de los propietarios
60%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
100%
Mitad más pobre de los propietarios

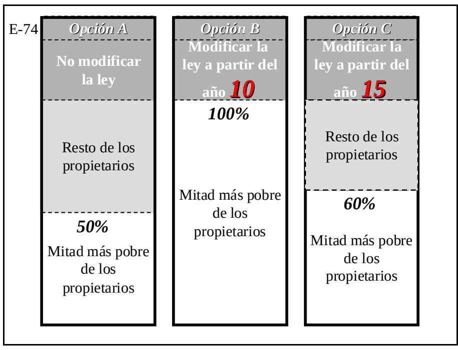

E-65
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
40%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 3
Resto de los propietarios
80%
Mitad más pobre de los propietarios

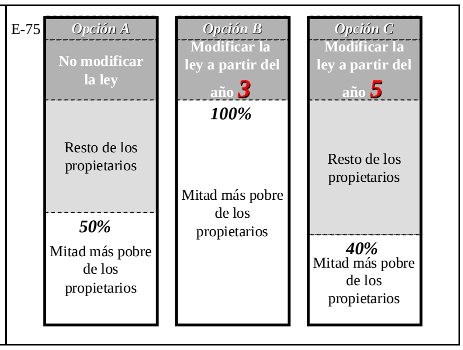

E-66
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
60%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
100%
Mitad más pobre de los propietarios

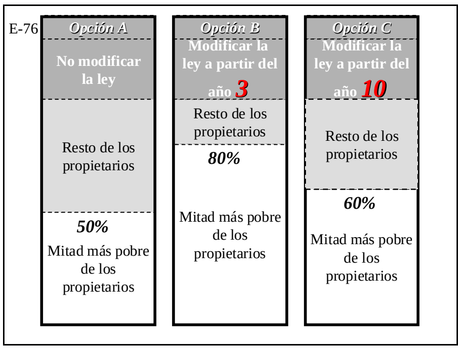

E-71
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 5
Resto de los propietarios
40%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
Resto de los propietarios
80%
Mitad más pobre de los propietarios

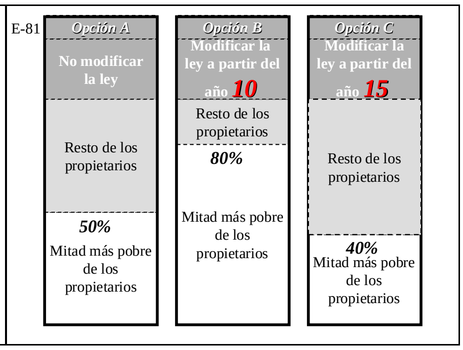

E-72
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 5
Resto de los propietarios
40%
Mitad más pobre de los propietarios

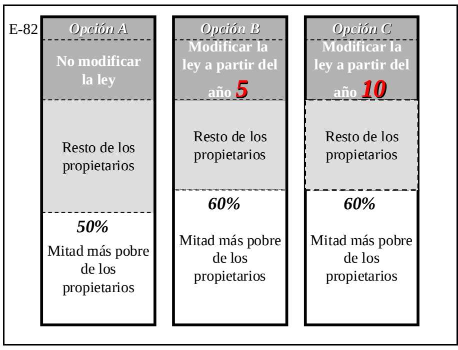

E-73
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 5
Resto de los propietarios
60%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
100%
Mitad más pobre de los propietarios

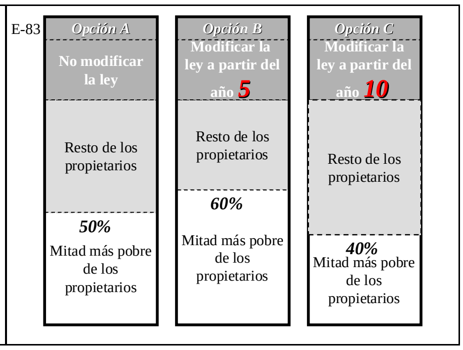

E-74
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 10
100%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
60%
Mitad más pobre de los propietarios


E-75
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
100%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 5
Resto de los propietarios
40%
Mitad más pobre de los propietarios

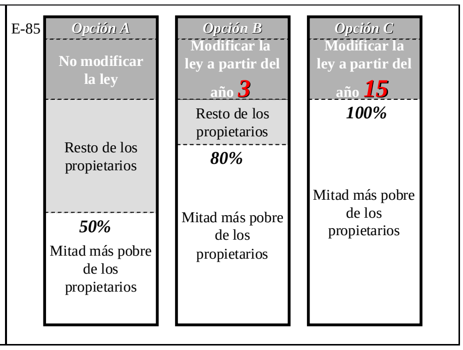

E-76
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
Resto de los propietarios
60%
Mitad más pobre de los propietarios

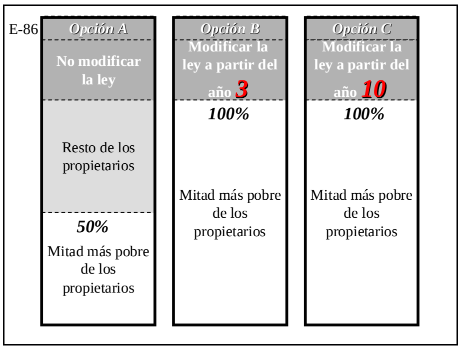

E-81
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 10
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
40%
Mitad más pobre de los propietarios

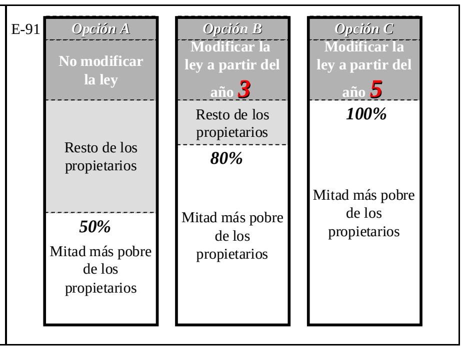

E-82
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 5
Resto de los propietarios
60%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
Resto de los propietarios
60%
Mitad más pobre de los propietarios

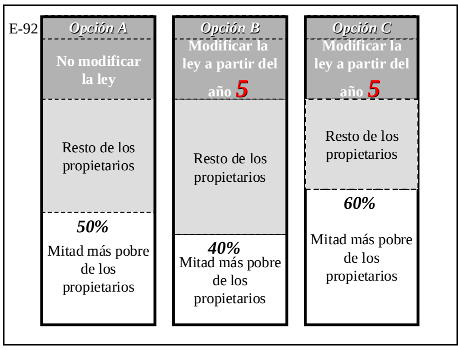

E-83
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 5
Resto de los propietarios
60%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
Resto de los propietarios
40%
Mitad más pobre de los propietarios

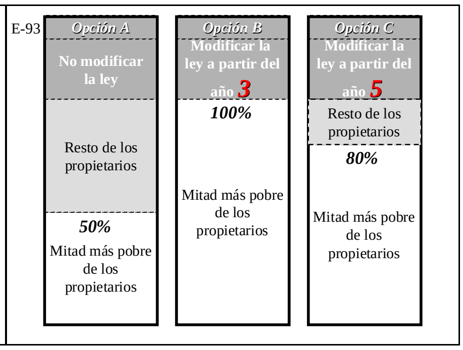

E-84
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 5
100%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
Resto de los propietarios
60%
Mitad más pobre de los propietarios

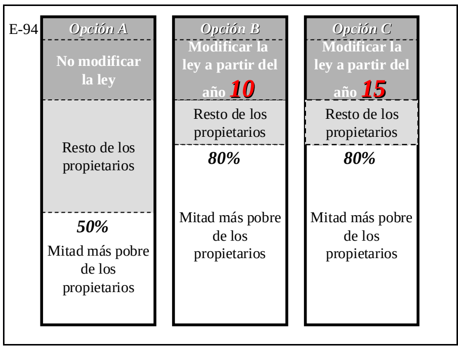

E-85
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
100%
Mitad más pobre de los propietarios

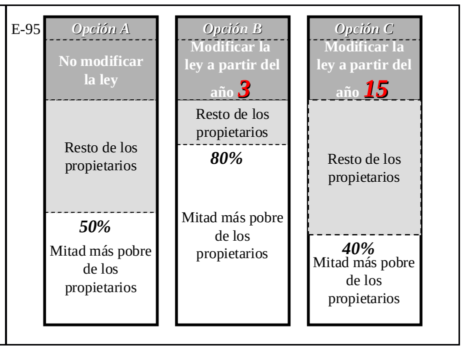

E-86
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
100%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
100%
Mitad más pobre de los propietarios

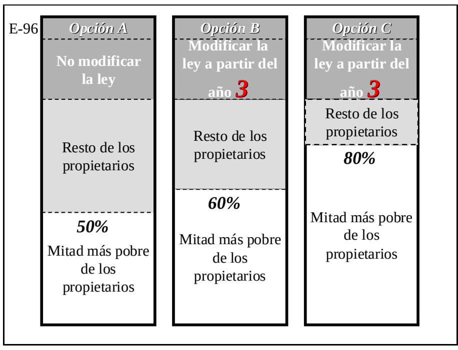

E-91
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 5
100%
Mitad más pobre de los propietarios

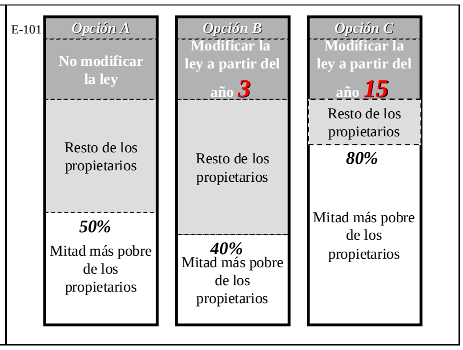

E-92
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 5
Resto de los propietarios
40%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 5
Resto de los propietarios
60%
Mitad más pobre de los propietarios

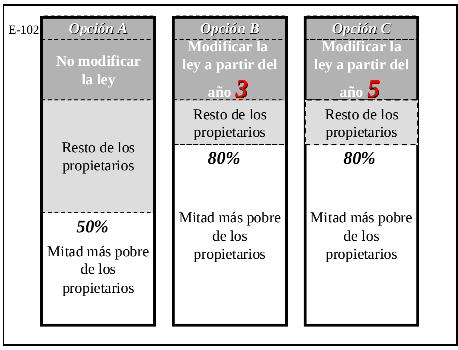

E-93
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
100%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 5
Resto de los propietarios
80%
Mitad más pobre de los propietarios

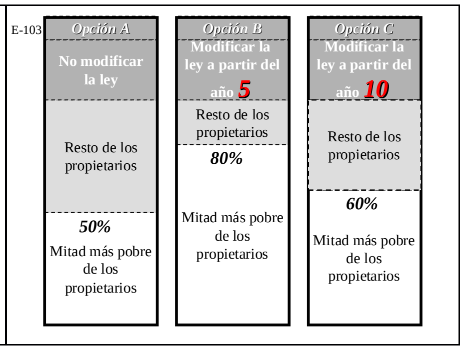

E-94
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 10
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
80%
Mitad más pobre de los propietarios

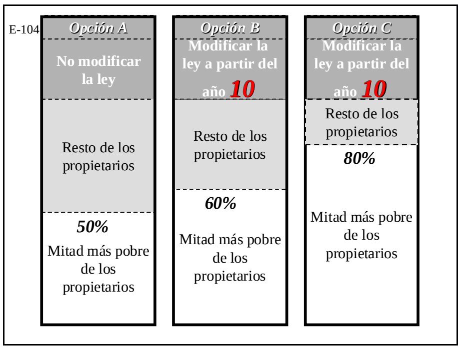

E-95
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
40%
Mitad más pobre de los propietarios

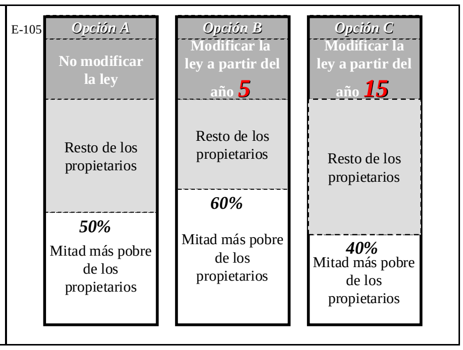

E-96
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
60%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 3
Resto de los propietarios
80%
Mitad más pobre de los propietarios

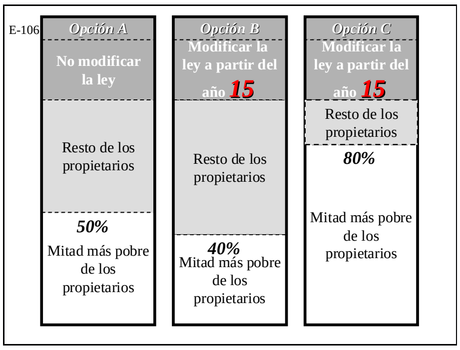

E-101
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
40%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
80%
Mitad más pobre de los propietarios


E-102
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 3
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 5
Resto de los propietarios
80%
Mitad más pobre de los propietarios


E-103
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 5
Resto de los propietarios
80%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
Resto de los propietarios
60%
Mitad más pobre de los propietarios


E-104
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 10
Resto de los propietarios
60%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 10
Resto de los propietarios
80%
Mitad más pobre de los propietarios


E-105
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 5
Resto de los propietarios
60%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
40%
Mitad más pobre de los propietarios


E-106
Opción A
No modificar la ley
Resto de los propietarios
50%
Mitad más pobre de los propietarios
Opción B
Modificar la ley a partir del año 15
Resto de los propietarios
40%
Mitad más pobre de los propietarios
Opción C
Modificar la ley a partir del año 15
Resto de los propietarios
80%
Mitad más pobre de los propietarios