

On the plutocracy of cost benefit analyses

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Abstract

Revealed and stated preference techniques are widely used to assess individuals' non-market preferences, in particular in cost benefit analyses (CBA). However, individuals have first to satisfy subsistence needs through market good consumption, which affects their budget constraint. The impact of subsistence needs on the preference elicitation for and the pricing of a non-market good or service have not been extensively explored. In this paper, we first provide a methodological framework showing how both depend on the level of subsistence needs and income. We then quantify the importance of these impacts by comparing this framework with the standard framework, from a theoretical, a numerical and an empirical perspective. In particular, we consider the case of individual preferences for the non-market good that differ according to the level of income. Our findings confirm the relevance of accounting for budget constraints when relying on non-market valuation methods, especially in CBA.

Keywords:

JEL Codes:

1 Introduction

Cost-benefit analyses (CBA) have been increasingly used in all economic sectors to support public and private decision-making during the last century. Non-market components broke into CBA during the 50 last years, with considerations like improved recreation, visual amenities, odours, noise, loss of biodiversity, psychological aspects, or the valuation of premature deaths. Because these components cannot rely on economic prices provided by a marketplace, they require specific methods of valuation based on stated or revealed preferences. These methods elicit - directly for the former, indirectly for the latter - respondents' preferences for a given non-market good or service, derive the willingness to pay (WTP) for the corresponding welfare change and after statistical treatments, feed CBA from private and public decision-makers.

This process is apparently very democratic by directly relying on the preferences of the whole population in order to support decision-making. Nevertheless, it hides two methodological issues when preferences are elicited through the willingness to trade-off money (or a composite market good) for the non-market good or service provision. First, the budget constraint effect, that has already been empirically investigated, and for which solutions have been proposed to accurately reflect the preferences of low income respondents, using contributions in-kind or in work (Brouwer et al. 2009; Abramson et al. 2011, Hossack and An 2015) or an "equity adjusted WTP" (Brefle et al. 2015). Second, subsistence needs limit the realm of possibility when expressing preferences, and then WTP, more importantly for the poorest than for the richest. Therefore, subsistence needs exacerbate the problem of inequity in CBA through their effect on the marginal utility of income.

This paper investigates how subsistence needs distort the WTP-based expression of preferences, insidiously turning CBA into a plutocratic process. Their consequences on preference and WTP elicitation have, surprisingly, not been explored theoretically as far as we know. We propose to fill this gap by comparing the standard framework with one that accounts for subsistence needs. First, we show how preference elicitation for a non-market good or service is affected. Second, we show how the non-market implicit (or shadow) price is undervalued w.r.t. the standard framework. Finally, we provide both numerical and empirical illustrations of this undervaluation.

Our findings show that the preferences of individuals tend to less substitutability between market and non-market goods when subsistence needs are accounted for. This effect decreases as income increases or subsistence needs decrease. They also show that the WTP of the richest individuals is less impacted by the subsistence needs, and exceeds

the one of the poorest even for similar preferences towards the non-market good. Finally, in case of heterogeneous preferences, the richest are more prone to impose their views when decision-making relies on CBA.

We make two primary contributions to the existing literature.

First, our analysis contributes to the methodological literature on preference revelation. We propose a framework that allows the estimation of the impact of subsistence needs on both preferences of respondents and WTP elicitation for non-market goods. This impact depends on “true” unobserved preferences, income and the level of subsistence needs. It is worth noting that this contribution differs from the impact of the income distribution in CBA, which has been acknowledged for a long time (see [Ebert 1986](#); or [Adler 2016](#) for a recent overview). Because the WTP is the ratio of the marginal utility for the good valued over the marginal utility of income, heterogeneous preferences over the income distribution increase the likelihood of non-democratic outcomes in CBA. This issue can be overcome by assigning distributional weights. It differs also from the democratic / plutocratic antagonism acknowledged in consumer price indexes when households are weighted according to their total expenditures (see [Deaton and Zaidi 2002](#); [Ley 2002](#)), or in health when priorities depend on income or age ([Olsen and Donaldson 1998](#)). Recently, [Baumgärtner et al. \(2017a\)](#) study the impact of income inequality on the mean WTP and show that, depending on whether the non-market good is substitute or complement of the manufactured goods, more inequality can either decrease or increase the mean WTP.

Second, our analysis contributes to the empirical literature. To date, most of the stated and revealed preference applications consider that finding a positive and significant relationship between income and WTP is an indication that respondents’ behaviour is conform with the one observed on actual marketplaces: the level of income drives the level of consumption. We question this interpretation by offering another perspective on its implications, in particular regarding CBA, and by complementing the previous empirical literature on this “budget saturation effect”. [Brefle et al. \(2015\)](#) found that “when more than one program is necessary in order to provide a complete cleanup or improvements are required at one or more sites, then lower-income respondents simply run out of expressed WTP even though problems that extend beyond that WTP still impair them and their uses”. Along the same lines, [Smith \(2005\)](#) was interested in the role of the budget constraint in scale sensitivity of WTP. He found “an increasing ‘relevance’ of the budget constraint as the value of the good (relative to income) increases: as the benefit increases, WTP for that benefit rises and consequently the budget constraint becomes an increasingly significant determinant of WTP”. Budget saturation also implies that, due to the narrowing of their set of choices, the WTP of the poorest respondents will

have little or no variation, irrespective of the strength of their preferences. Therefore, an implicit ranking of different programs based on their WTP would misleadingly suggest indifference between programs for these respondents. [Olsen et al. \(2005\)](#) compared the implicit ranking inferred from the ordinal differences in WTP values with the explicit ranking of the same programs. They showed that a large share of respondents who stated indifference through WTP has stated a clear ranking based on the preference elicitation exercise, but unfortunately this study does not link it to the level of income.

The remainder of the paper proceeds as follows. Section 2 describes the relevant models and Section 3 analyses the impacts of the introduction of subsistence needs. Section 4 presents numerical illustrations and we present an empirical analysis in Section 5. We finally discuss and conclude in Section 6.

2 Models

We present the standard model and the model with subsistence needs before comparing them in terms of elicitation of preferences and shadow prices.

2.1 Standard model

Consider an individual whose preference relation is continuous, monotonic and convex. Let us consider that this preference relation is represented by a two good utility function $u(x, q)$, where x represents the quantity of a composite market good and q the quantity of a non-market good. $u(x, q)$ is assumed to be twice continuously differentiable, strictly increasing and strictly quasi concave in x and q , with $x, q \geq 0$.

The preferences of the individual for the non-market good depends on the substitutability of the composite market good for this non-market good, which is measured thanks to the elasticity of substitution $\sigma(x, q)$. We choose [Hicks \(1932\)](#)'s original definition of the elasticity of substitution for two factors:

$$\sigma(x, q) = \frac{\partial \ln(\frac{x}{q})}{\partial \ln(MRS)}$$

where MRS is the marginal rate of substitution, i.e. $\frac{\partial u(\cdot)}{\partial q} / \frac{\partial u(\cdot)}{\partial x}$.

We are also interested in the relation between the WTP for the non-market good, this elasticity of substitution and the income of the individual. We follow the main trend in the literature on non-market valuation ([Hanemann 1991](#); [Lankford 1988](#); [Ebert 2003](#)) by defining the marginal WTP as the shadow price for q :

$$\pi(p, q, y) = \frac{\partial V(p, y, q) / \partial q}{\partial V(p, y, q) / \partial y} \quad (1)$$

where $V(p, y, q)$ is the indirect utility function which is obtained from the following maximization problem:

$$\text{Max}_x u(x, q) \text{ subject to } px = y \text{ and } q \text{ fixed} \quad (2)$$

In this problem, the individual pays for the quantity of the non-market good q at the shadow price π and the shadow income $y + \pi q$. The individual's income is compensated so that all his real income is spent in market goods. We then have the following equivalence with the inverse Hicksian demand: $\pi(p, q, y) = \pi(p, q, v(p, q, y))$. It is clear from Eq. (1) that the shadow price of the non-market good only depends on the individuals' preferences represented by the parameters characterising $V(\cdot)$, the quantity of non-market goods q and the income y .

2.2 Model with subsistence needs

Let us consider that individuals face minimum subsistence needs obtained with the level of consumption x_s of the composite good. We adapt Baumgärtner et al. (2017b)'s and Drupp (2016)'s approaches for a subsistence requirement in terms of environmental services, by introducing these subsistence needs in u as follows:

$$\begin{cases} u(x, q) = u^l(x) & \text{for } x \leq x_s \\ u(x, q) = u^h(x, q) & \text{else} \end{cases} \quad (3)$$

We assume that u^l is strictly increasing in x and u^h has the same properties as u (see above). We also adopt Baumgärtner et al. (2017b)'s assumption that individuals always prefer to be in the domain where the subsistence needs are satisfied, i.e.:

$$\inf_{x > x_s, q \geq 0} u^h(x, q) > \sup_{x_s \geq x \geq 0} u^l(x) \quad (4)$$

Hence, below the minimum subsistence needs, nobody is willing to trade-off the composite good for the non-market good. The elasticity of substitution between x and q is then obviously set to $\sigma(x, q) \equiv 0$ when $x_s \geq x$ because q does not enter u^l , and π is consequently also set to 0. We will no longer consider this case in the following. Above the minimum subsistence needs, $\sigma(x, q)$ and π are defined as in a general model but based on the $u^h(x, q)$ function that accounts for these subsistence needs.

2.3 Defining the two models under a CES utility function

In order to be able to determine explicit relationships between the standard and the minimum subsistence frameworks, we need to start from a functional form as flexible as possible regarding the preferences over x and q . A relevant, easy to interpret, tractable and well

known specification of $u(x, q)$ is the Constant Elasticity of Substitution (CES) function first proposed by [Arrow et al. \(1961\)](#):

$$u(x, q) = [\alpha x^\theta + (1 - \alpha)q^\theta]^{\frac{1}{\theta}} \text{ for } \theta \in] - \infty; 1] ; 0 < \alpha < 1 \quad (5)$$

Note that the elasticity of substitution $\sigma(x, q) \equiv \frac{1}{1-\theta}$, and that the CES function covers the range from perfect complement ($\theta \rightarrow -\infty$; $\sigma(x, q) \rightarrow 0$) to perfect substitute ($\theta \rightarrow 1$; $\sigma(x, q) \rightarrow \infty$), as well as Cobb Douglas ($\theta = 0$; $\sigma(x, q) = 1$).¹ α represents the preference for the market good x relative to the preference of the non-market good q .

At equilibrium, the shadow price for q in the standard CES model is (from Eq. (1) and Eq. (5)):

$$\pi = \frac{(1 - \alpha)q^{\theta-1}}{(\alpha/p)(\frac{y}{p})^{\theta-1}} \quad (6)$$

Following the modification proposed by [Geary \(1950\)](#) and [Stone \(1954\)](#) to account for minimum levels of consumption and known as Stone-Geary function, and its extension to CES proposed by [Baumgärtner et al. \(2017b\)](#) or [Drupp \(2016\)](#), we define the extended CES above the minimum subsistence level as follows:

$$u^h(x, q) = [\alpha(x - x_s)^\theta + (1 - \alpha)q^\theta]^{\frac{1}{\theta}} \text{ for } x > x_s \text{ for } \theta \in] - \infty; 1] ; 0 < \alpha < 1 \quad (7)$$

When $x > x_s > 0$, the elasticity function of the CES is no longer $\sigma(x, q) \equiv \frac{1}{1-\theta}$ but ([Baumgärtner et al. 2017b](#); proposition 1):

$$\sigma_s(x, q) \equiv \frac{1}{1 - \theta} [1 - F(x_s, x, q; \alpha, \theta)] \quad (8)$$

$$\text{where } F(.) = \frac{(1 - \alpha) \frac{x_s}{x}}{\alpha [\frac{x - x_s}{q}]^\theta + (1 - \alpha)}$$

The shadow price for q in the CES model with subsistence needs is (from Eq.(1) and Eq.(7)):

$$\pi_s = \frac{(1 - \alpha)q^{\theta-1}}{(\alpha/p)(\frac{y}{p} - x_s)^{\theta-1}} \quad (9)$$

3 Impacts of the introduction of subsistence needs

3.1 Impact on the elicitation of preferences

[Baumgärtner et al. \(2017b\)](#) proved that $F(.) > 0$ for all x and q in Eq. (8). Hence, the elasticity of substitution with minimum subsistence needs is always lower than the one without, which induces a shift towards complementarity in the relationship between the composite market good and the non-market good. Whatever their true unobserved

¹Indeed, $u(x, q) = x^\alpha q^{(1-\alpha)}$ when $\theta = 0$.

preferences, individuals are less prone to trade-off market goods for a non-market good when they face subsistence needs, hence expressing a lower preference towards the non-market good.

Baumgärtner et al. (2017b) also proved that $F(\cdot) \rightarrow 0$ when $x_s \rightarrow 0$ (absence of subsistence needs) and/or $x \rightarrow \infty$ (increase in the consumption of the composite market good). This means that the magnitude of the misrepresentation of preference for the non-market good decreases with income. Moreover, they proved that the elasticity of substitution $\sigma_s(x, q)$ increases with income although non monotonically for negative θ . This implies that preferences of the poorest are more inelastic w.r.t. the composite market good.

Finally, we can check how the misrepresentation evolves depending on the preference for the market good, α . The derivative of $F(\cdot)$ w.r.t. α is:

$$\frac{\partial F(\cdot)}{\partial \alpha} = \frac{\partial}{\partial \alpha} \frac{(1 - \alpha) \frac{x_s}{x}}{\alpha \left[\frac{x - x_s}{q} \right]^\theta + (1 - \alpha)} = - \frac{x_s \left[\frac{x - x_s}{q} \right]^\theta}{x \left(\left(\left[\frac{x - x_s}{q} \right]^\theta - 1 \right) \alpha + 1 \right)^2}$$

For $x > x_s$, and for all $\theta < 1$, it is negative as the numerator and the denominator are always positive. This means that the shift towards complementarity monotonically increases with the preference for the non-market good. *Ceteris paribus*, the higher the preferences for the non-market good are, the lower the trade-off of market goods for the non-market good is in the model with subsistence needs (compared to the standard model). This reinforces the magnitude of the underrepresentation of preference towards the non-market good.

Overall, the poorer an individual, the higher the under-estimation of his/her true unobserved preferences for the non-market good.

3.2 Impact on the relationship between preferences and shadow prices

We examine the derivative of π with respect to θ . From Eq.(6), we have:

$$\begin{aligned} \frac{\partial \pi}{\partial \theta} &= \frac{\partial}{\partial \theta} \frac{(1 - \alpha)}{(\alpha/p)} \left(\frac{q}{y/p} \right)^{\theta-1} = \frac{(1 - \alpha)}{(\alpha/p)} \frac{\partial}{\partial \theta} \exp \left(\log \left(\frac{q}{y/p} \right) \right)^{\theta-1} \\ &= \frac{(1 - \alpha)}{(\alpha/p)} \exp \left(\log \left((\theta - 1) \frac{q}{y/p} \right) \right) \log \left(\frac{q}{y/p} \right) \\ &= \frac{(1 - \alpha)}{(\alpha/p)} \left(\frac{q}{y/p} \right)^{\theta-1} \log \left(\frac{q}{y/p} \right) \end{aligned}$$

Because the first two terms are always positive, the sign of the expression is determined by the third term. From Eq. (9), we find the derivative of π_s with respect to θ to be similar, except that y/p is replaced by $(y/p - x_s)$ in the expression above. For π (resp.

π_s), it is positive when $q > y/p$ (resp. $q > y/p - x_s$) and negative when $q < y/p$ (resp. $q < y/p - x_s$). Consequently, it depends on the relative quantity of the market and the non-market goods. An increase in the substitutability is then going to have an effect on the shadow price of the non-market good that depends on these relative quantities, but for given y, p , would be negative for smaller values of q in presence of subsistence needs.

Then, we examine the derivative of π with respect to α :

$$\frac{\partial \pi}{\partial \alpha} = \frac{\partial}{\partial \alpha} \frac{(1-\alpha)}{(\alpha/p)} \left(\frac{q}{y/p} \right)^{\theta-1} = -\frac{p}{(\alpha^2)} \left(\frac{q}{y/p} \right)^{\theta-1}$$

Both derivatives are always negative, as expected: for given y, p , the lower the preference for the market good x is (i.e. α), the higher the shadow price for the non-market good is. Like above, the derivative of π_s with respect to θ is obtained by replacing y/p by $(y/p - x_s)$ in the expression above. Consequently, the effect of α on π is smaller in presence of subsistence needs; *ceteris paribus*.

3.3 Impact on shadow prices

We are interested in the spread between π_s (defined in Eq. (6)) and π (defined in Eq. (9)). It is obviously always strictly negative for $p, q > 0$, and null only for $x_s = 0$. Moreover, *ceteris paribus*, the spread is increasing (resp. decreasing) with income for θ positive (resp. negative) and constant for $\theta = 0$. This means that the true shadow price of the non-market good is under-estimated when subsistence needs are ignored, and that this spread is increasing (resp. decreasing) with income when preferences are expressing complementarity (resp. substitutability). However the ratio π_s/π is always decreasing with income, even for negative θ . Moreover, it can be shown that this ratio is independent of α, p, q .

We might think that the use of distributional weights (see [Adler 2016](#); or [Fleurbaey and Abi-Rafteh 2016](#)) based on the marginal value of individual's income, may properly correct the shadow prices to account for the effect of subsistence needs. The marginal utility of income is equal to:

$$\begin{aligned} \frac{\partial v(y, q, x_s)}{\partial y} &= \frac{\partial [\alpha(\frac{y}{p} - x_s)^\theta + (1-\alpha)q^\theta]^{\frac{1}{\theta}}}{\partial y} \\ &= [\alpha(\frac{y}{p} - x_s)^\theta + (1-\alpha)q^\theta]^{\frac{1-\theta}{\theta}} \frac{\alpha}{p} (\frac{y}{p} - x_s)^{\theta-1} \end{aligned}$$

If we weight the shadow prices in the model with subsistence needs (Eq. (9)) by the marginal utility of income, we obtain:

$$\pi_{w_s} = [\alpha(\frac{y}{p} - x_s)^\theta + (1-\alpha)q^\theta]^{\frac{1-\theta}{\theta}} (1-\alpha)(q)^{\theta-1}$$

The resulting weighted shadow price π_{w_s} still depends on the level of subsistence needs x_s , which means that accounting for the marginal utility of income might not fully correct for underestimation.

It would however be possible to apply a “social weight”, denoted SW , in order to obtain the same shadow price one would obtain in absence of subsistence needs but after weighting by the marginal utility of income and a utilitarian social welfare function. This social weight would be equal to:²

$$SW = \frac{[\alpha(\frac{y}{p})^\theta + (1 - \alpha)q^\theta]^{\frac{1-\theta}{\theta}}}{[\alpha(\frac{y}{p} - x_s)^\theta + (1 - \alpha)q^\theta]^{\frac{1-\theta}{\theta}}}$$

The shadow price weighted by the marginal utility of income and by SW would then be equal to:

$$\pi_{w_s,SW} = [\alpha(\frac{y}{p})^\theta + (1 - \alpha)q^\theta]^{\frac{1-\theta}{\theta}} (1 - \alpha)(q)^{\theta-1}$$

Regarding decision-making based on CBA, the consequences of this underestimation propagate through the benefits of any non-market good assessed thanks to shadow prices - derived from revealed or stated preference surveys. This would not only decrease the overall desirability of a project for a given cost, but also have consequences that differ depending on whether the preferences for the non-market good in the population (measured by $\sigma(x, q)$ and α in Eq. (5)) are homogeneous or heterogeneous regarding income. This is going to be explored in the next section.

4 Numerical illustrations

We provide numerical illustrations in order to show how the introduction of subsistence needs is going to affect both the substitutability and the shadow prices for non-market goods. Since we consider that an individual spends all his/her income buying market goods (see maximization problem (2)), we set $x \equiv y/p$ and $p \equiv 1$ in the following, therefore x can be seen as the numéraire and represents the income of the individual.

4.1 Elasticity of substitution

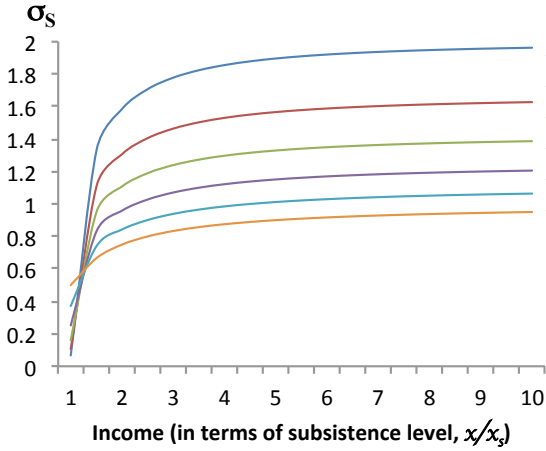
We first look at the way the introduction of subsistence needs affects the elasticity of substitution σ_s that is known to be no longer constant. From Eq. (8), we represent in Figure 1 the relation between the elasticity of substitution and income expressed in terms of $\frac{x}{x_s}$, for $\theta \geq 0$ and $\theta < 0$.³

We see that the elasticity of substitution σ_s is always lower compared to the standard case, but converges towards the value of standard case $\sigma \equiv \frac{1}{1-\theta}$ as income increases. Three

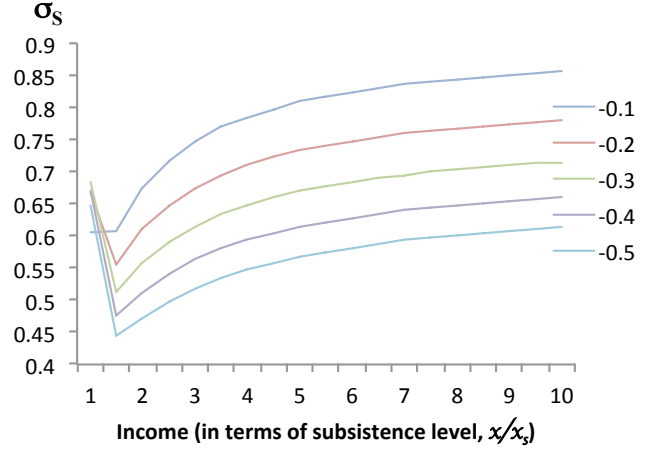
²The implied social welfare function is defined by the primitive of this social weight with respect to π .

³The other parameters are set to $q=1$, $\alpha=0.5$, $x_s=2$.

Figure 1: σ_s vs. Income for various values of θ
 $\theta \geq 0$



$\theta < 0$

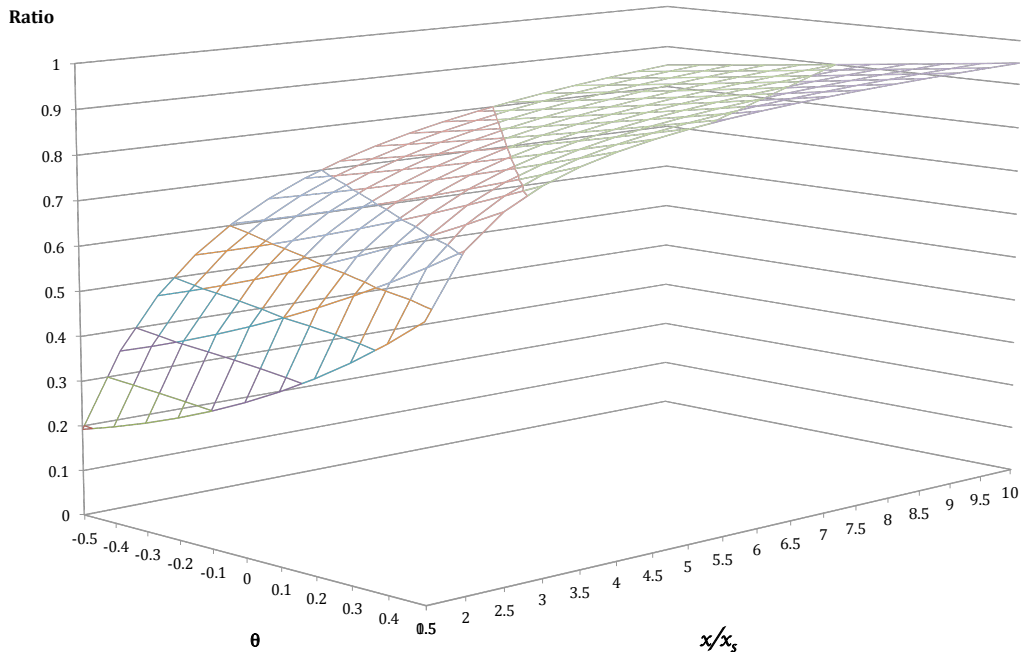


points deserve attention. First, when $\theta \geq 0$, the convergence towards σ is monotonic as the income increases, but we notice that despite the fact that x and q are substitute goods, σ_s is lower than 1 when the subsistence needs represent a large share of the income, hence exhibiting complementarity. This means that the subsistence needs push preferences toward complementarity. Second, when $\theta < 0$, σ_s always exhibits complementarity, but the convergence is no longer monotonic. For income just above the subsistence needs, complementarity increases before converging towards σ when income grows. Third, for low incomes, the ordering of the elasticity of substitution when measured by σ_s does not match the one measured by σ . This can be formally proven by scrutinizing the derivative of σ_s w.r.t. σ (details upon request) but is obvious on Figure 1. Close to the level of subsistence needs, for θ respectively equals to -0.5, 0 and 0.5 for instance, σ logically decreases (.2, 1 and .6667) whereas σ_s increases (.2, .5 and .6). This means that in presence of subsistence needs, preferences for substitutability ($\theta \geq 0$) are more pushed towards complementarity than preferences for complementarity ($\theta < 0$) for very low incomes, making them even more inelastic w.r.t. the composite market good.

4.2 Shadow Price

We are interested in the impact of the introduction of subsistence needs on the shadow price of the non-market good. Consequently, based on Eq. (6) and (9), we consider how the ratio π_s/π evolves when income changes. The use of a ratio removes the price level effect: the closer from 1, the smaller the under-evaluation due to the subsistence needs. We consider first the case of homogeneous preferences over the individuals and then the case of heterogeneous preferences that depend on income.

Figure 2: Ratio between shadow prices with and without accounting for subsistence needs (by θ and relative income)

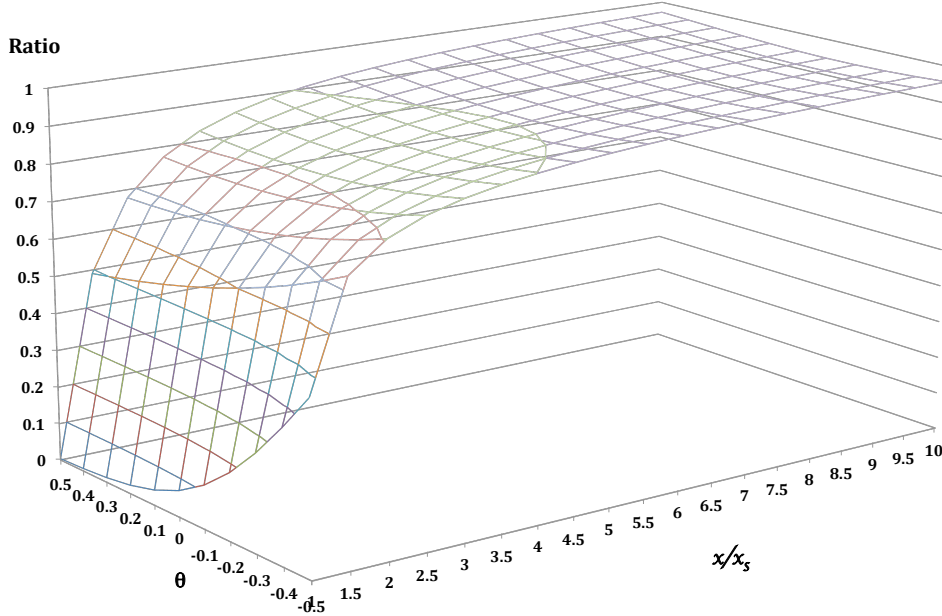


4.2.1 Homogenous preferences

If preferences are homogeneous in the population (i.e. same θ and α), ignoring the minimum subsistence level is going to underestimate the benefits measured with shadow prices, which decreases the overall desirability of a project for a given cost. Figure 2 illustrates the magnitude of the underestimation by computing the ratio for different θ and income combinations for $x_s = 2$ (the ratio does not depend on p, q nor α). We see that the lower the income, the smaller the ratio for any given value of θ , which is due to the fact that (π_s tends towards zero when income tends towards x_s . For an income seven times larger than x_s for instance, the ratio is about 0.8 (i.e. 20% under-evaluation) when θ exhibits complementarity ($\theta = -0.5$), but about 0.93 (i.e. 7% under-evaluation) for substitutability ($\theta = 0.5$). Note that, based on the actual distribution of income in the population, we can compute for any θ the “subsistence need-corrected” aggregated shadow price to properly assess non-market benefits in CBA (see an application in section 5).

We can also illustrate that accounting for the marginal utility of income does not fully correct for underestimation by considering the ratio of the weighted shadow price with subsistence needs over the shadow price without (π_{w_s}/π). Figure 3 shows that, although the ratio converges faster to one than in the unweighted case (see Figure 2), it is not always

Figure 3: Ratio between weighted shadow prices with and without accounting for subsistence needs (by θ and relative income)



equal to 1 and is smaller for low incomes.

4.2.2 Heterogenous preferences

If preferences are heterogeneous (i.e. income-dependent) regarding the non-market good, the overall desirability of a project is still downwardly biased, but the relative desirability is also biased in favour of the preferences of the richest fraction of the population. This is because the underestimation of the preferences for the non-market good is larger for the poorest fraction of the population than for the richest.

As an illustration, imagine (for sake of simplicity) a bi-modal income distribution: one half of the population has a low income (1.5 times the subsistence needs), and the other half a high income (10 times the subsistence needs). Let us consider that the preferences regarding the non-market good for each of the two subpopulations are measured by α , varying by stepsize .05, from .05 (strong preference for the non-market good) to .95 (strong preferences for the market good). We compute the ratio of the average elicited shadow price with minimum subsistence needs over the average true unobserved shadow price for all combinations of preferences. This tells us how far the valuation of non-market benefits in a CBA based on elicited shadow prices would be from the true unobserved shadow price. The closer from one the ratio is, the better

the non-market preferences of the population are respected. We compute this ratio for three values of elasticity of substitution ($\theta = 0.5, 0, -0.5$), and show the results in Figures 4.

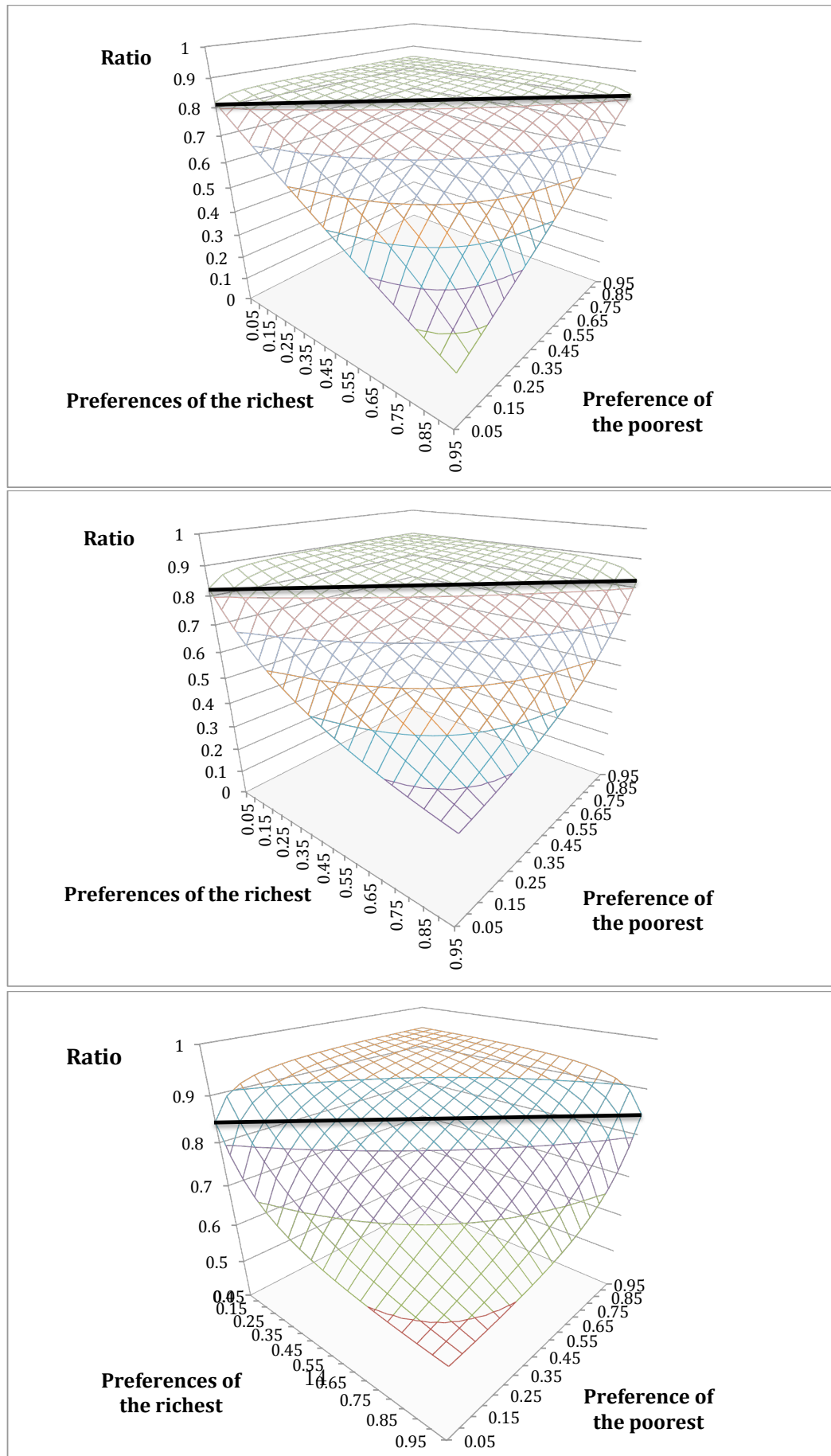
Whatever the value of the substitutability, we have the following results. For homogeneous preferences (represented by the horizontal black line segment on the three figures), the ratio is obviously constant and shows a spread lower than 15% w.r.t. the true unobserved average shadow price. As long as the preferences of the richest are more non-market oriented than those of the poorest, the spread is lower than the homogeneous case (back part of each figure), hence favouring the preferences of the richest. As long as the preferences of the richest are less non-market oriented than those of the poorest, the spread is higher than the homogeneous case (front part of each figure), hence favouring again the preferences of the richest. Overall, whatever the preferences of the richest, there are always better represented in CBA than those of the poorest, hence showing a plutocratic bias. In particular, the non-market preferences of the poorest would never be properly accounted for unless they are shared by the richest, whereas the non-market preferences of the richest would always be better accounted for, since their shadow prices would be not only higher but also less underestimated.

5 Empirical analysis on French income data

We explore the magnitude of the distortion of WTP-based expression of preferences when subsistence needs are accounted for. We rely on data regarding the French income distribution on the one hand and empirical studies that have elicited elasticities of substitution for various non-market goods on the other hand. This allows us to scrutinise the extend to which CBA might be affected by the subsistence needs issue.

Regarding the distribution of income, we first need to set a value for the subsistence needs x_s . It is different from the absolute monetary poverty, which is defined by the World Bank based on the minimum number of calories (about US\$ 1.9 in 2015). It is also different from the relative monetary poverty that accounts for the distribution of income in a given society. OCDE (and INSEE in France) consider for instance that the share of the population with an income lower than the percentile 50 (median) of the income is below the poverty threshold, whereas Eurostat considers the threshold to be at the percentile 60. We are actually interested in the minimum amount required to live in a given country, accounting for minimum expenditures in food, water, energy, housing, clothes, transportation ... A French survey estimates that it is about € 600 (in 2016) per month for one adult [Carrefour des Solidarités 2011](#)). This amount is slightly lower than the median standard of living for a person considered as poor (€ 705 in 2015, [Argouarc'h and Cazenave-Lacrouts 2017](#)) and slightly higher than the

Figure 4: Measure of how preferences are respected for heterogenous preferences (upper panel: $\theta = .5$, middle panel: $\theta = 0$, lower panel: $\theta = -.5$)



active solidarity revenue (RSA) paid by the French government to individuals with no resources (€ 545 in 2017). We then use it as a reasonable benchmark. Based on this revenue of subsistence per individual $x_s = € 600$, we use the French annual income distribution by individual ([Institut National de la Statistique et des Etudes Economiques 2017](#)) to express the French income distribution over the population in terms of x/x_s values.

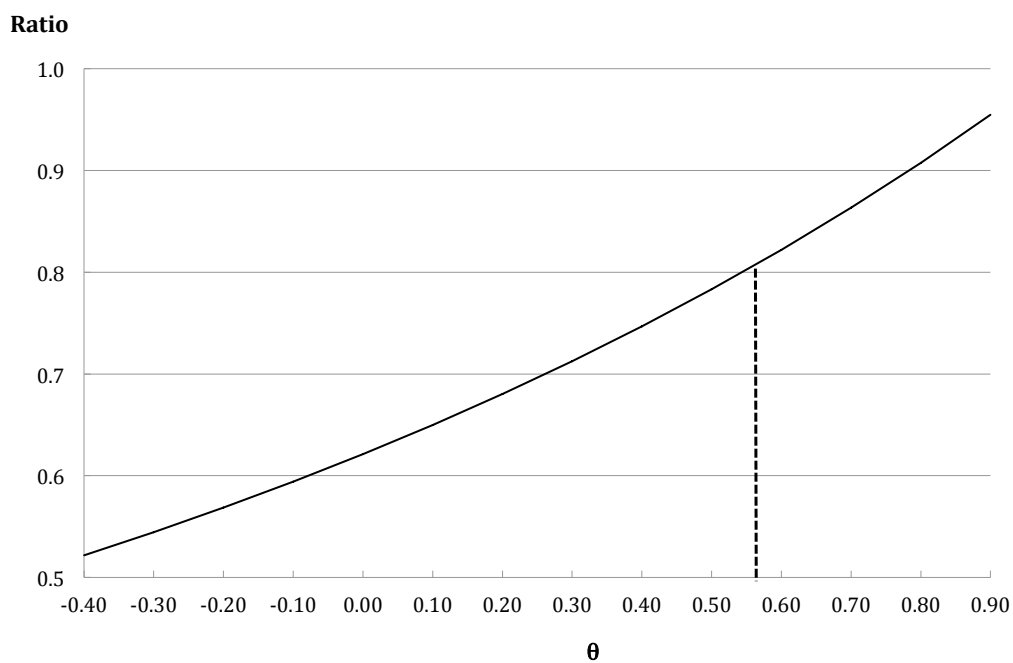
Regarding estimates of the substitutability of market goods for non-market goods, [Drupp \(2016\)](#) presents various estimations of θ for non-market services over the world (air or water quality improvements, forest or marine services, landscape or recreational amenities, biodiversity ...). He obtains a mean empirical estimate of $\theta = 0.57$ with a mean empirical error range of $(0.28 - 0.86)$. This means that, on average, individuals exhibit substitutability between market goods and non-market goods or services.

We assume that preferences regarding the non-market good are homogeneous (i.e. not income-dependent) by lack of relevant data on the actual distribution of preferences w.r.t. income in the population. [Figure 5](#) represents the ratio of the mean shadow price accounting for income distribution with minimum subsistence needs over the one of the standard model, for various values of θ . Remember from [section 5](#) that this ratio does not depend on p, q nor α . In particular, when $\theta = 0.57$ (see dotted segment line), the difference is about 20%. This means that, from a CBA perspective, non-market benefits of a project (assessed through survey-based shadow prices) would be under-evaluated by 20% on average compared to the “true” (unobserved) benefits, when the effect of subsistence needs is not accounted for. Consequently, because of the distortion of the benefit-cost test (benefits should be 20% larger than costs for a project to pass it), this rules out a fraction of socially desirable projects from the realm of possible choices. In addition, heterogeneous preferences by income would add a plutocratic bias, as shown in [Figures 4](#), in favour of the preferences of the richest. We cannot currently assess the extent of this bias by lack of specific data on the population’s distribution of preferences for the non-market good w.r.t. income.

6 Discussion

Our findings have important implications for theoretical and empirical research in economics as well as major policy implications. From a theoretical perspective, it questions the equity vs. equality issue. Should we increase the WTP elicited by the poorest when preferences for a non-market good are known to be income dependent? By doing so, we favour equity (an as fair as possible representation of preferences) to equality (a common representation of preferences). The introduction of subsistence needs may also be an interesting avenue of research when studying the scope / scale effect in contingent valuation. Indeed, the finding that WTP are not proportional to the scope or the scale of an improve-

Figure 5: Mean ratio between shadow prices with and without accounting for subsistence needs, based on French income distribution, by θ



ment proposed in a survey may partly be due to the constraint subsistence needs imposes to WTP. This constraint is not only more binding for the poorest individuals than the richest, but also worsen when they face large scale / scope valuation rather than smaller ones.

From an empirical perspective, our findings question the use of stated and revealed preference techniques in CBA when preferences for a non-market good are involved and measured through WTP. In case of income-independent preferences, the overall desirability of a project is under evaluated but the average preference of the population is accounted for. In case of income-dependent preferences, decision-makers should be aware that the preferences of the poorest individuals may be underrepresented and those of the richest overrepresented. Using other ways to account for preferences may be helpful to check for the likelihood of such a distortion. For instance, by using rankings among alternatives instead of WTP, or by applying normalised scenarios that elicit preferences for a given (hypothetical) income assumed equal for everyone.

In terms of policy implications, our findings raise important issues. Indeed, during its one-century long history, CBA have been used by national governments (via their various agencies), supra national organisations and private firms to assess the effectiveness of policies and prioritize them. They gradually extend to all economic sectors ([Swenson 2015](#)): beginning with the navigation in the 1900's, they first covered agricultural and land issues during the New Deal, then extended to public urban and transportation infrastructures after World War II, social, educational and health issues in the 1960's, occupational and environmental issues in the 1970's, were used to assess the interest of regulation / deregulation and the opportunity of central government interventions in various economic sectors during the 1980's and 1990's, helped compute various public profitability / efficiency ratios in the 2000's and are from then widely used in all sectors to support public and private decision-making. Hence, as soon as non-market values enter a CBA, we should pay attention to the plutocratic bias conveyed.

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