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APPLYING A NONPARAMETRIC EFFICIENCY ANALYSIS TO MEASURE CONVERSION EFFICIENCY IN GREAT BRITAIN

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APPLYING A NONPARAMETRIC EFFICIENCY ANALYSIS TO MEASURE CONVERSION EFFICIENCY IN GREAT BRITAIN

Abstract

In the literature on Sen's capability approach, studies focussing on the empirical measurement of conversion factors are comparatively rare. We add to this field by adopting a measure of "conversion efficiency" that captures the efficiency with which individuals convert their resources into achieved functioning. We use a nonparametric efficiency procedure borrowed from production theory and construct such a measure for a set of basic functionings, using data from the wave 2006 of the British Household Panel Survey (BHPS). In Great Britain, 49.88% of the individuals can be considered efficient while the mean of the inefficient individuals reaches one fifth less functioning achievement. An individual's conversion efficiency is positively affected by getting older, being self-employed, married, having no health problems and living in the London area. On the other hand, being unemployed, separated/divorced/widowed and (self-assessed) disabled decrease an individual's conversion efficiency.

Keywords: conversion efficiency, welfare measurement, robust nonparametric efficiency analysis, functioning production

JEL-classification: I12, I31, R15

1 Introduction

Amartya Sen's capability and functionings approach (Sen, 1984, 1985a,b, 1992) has been recognized as a theoretically elaborate and differentiated contribution to conceptualize and measure human welfare and development. Despite doubts about whether the approach can indeed be empirically useful and made operable (see Slesnick (1998) or the ongoing debate in Comim et al. (2008)), the capability approach has spawned a large literature of different methods of dealing with the empirical measurement of "achieved functionings" (see Sen's own work, e.g. Sen (1985a) and see Kuklys (2005, pp. 25-8) for a comprehensive overview).

The present paper wants to add to the empirical functioning measurement literature in focussing on a different and complementary measure besides achieved functioning. We argue that the absolute measurement of functioning achievement (and capability to function) should be complemented by a measure more familiar to most economists, namely the "*(conversion) efficiency*" with which individual resources are transformed into achieved functioning. Individual differences in converting resources into achieved functioning have been stressed in theoretical contributions to the approach (in the form of "conversion factors") but are notoriously difficult to capture empirically (cf. Chiappero-Martinetti and Salardi, 2007). A natural approach to deal with differences in conversion factors would be measuring how efficiently individuals convert resources into functionings by drawing on the efficiency analysis methodology used in production theory (Lovell et al., 1994; Deutsch et al., 2003). The present paper wants to add to this strand of literature. The order-*m* efficiency method we suggest allows us to compute for a given sample of individuals an efficient frontier on which are individuals who are most efficient in transforming their resources into achieved functioning. The distribution of individual efficiency scores relative to that frontier allows some additional insights regarding the assessment of welfare in the space of achieved functionings. Based on the idea that inefficiencies are undesirable also in the context of the capability approach, we discuss the theoretical relevance of the concept of conversion efficiency and argue that such a measure reflects the effects of diverse welfare-reducing institutional constraints on the individuals. Moreover, we show how some of these constraints related to individual conversion factors can be empirically analyzed with a robust nonparametric efficiency analysis methodology.

The paper is structured as follows. Section 2 gives a short overview of the capability and functionings approach. In section 3, we discuss our idea of conversion efficiency as a complementary measure of welfare within the capability framework. We then proceed in section 4 to discuss the nonparametric efficiency analysis approach. We are using a non-convex order-*m* frontier estimation in a two-stage framework. To highlight our approach, in section 5, we employ the suggested method for a set of “basic functionings” (Sen, 1993), namely for the functionings “being happy”, “being educated”, “being healthy”, “being well-sheltered”, “being nourished” and “having satisfying social relations”. We use the efficiency method to assess the conversion efficiency of this set of functionings for the British Household Panel Survey (BHPS) data set (BHPS, 2007; Taylor, 2007), thus working with micro level data. Section 6 concludes.

2 Theoretical Background

Amartya Sen’s capabilities and functionings approach (Sen, 1984, 1985a,b, 1992) is an evaluative framework to assess individual welfare. In this account, living is seen as consisting of a *set of functionings*, which could be described as different aspects of life, or the achievements of an individual. They give us information about what a person is and what he does. For an assessment of a person’s well-being, Sen proposes not only “being happy” (as in the utilitarian tradition) but other intrinsic values as well: Other functionings are for example “being nourished”, “avoiding premature mortality” (Sen, 1992, p. 39) or “being in good health”, “being well-sheltered”, “being educated” or “moving about freely” (Kuklys, 2005, p. 10), making the approach *multi-dimensional* as a person’s state of being (and his individual activities) is a vector of functionings.

This intuition has been formalized by Sen (1985a):[1] A vector of functionings can be described in set-theoretic notation as

$$\vec{b} = f_i(c(\vec{x}) | \vec{z}_i, \vec{z}_e, \vec{z}_s) \quad (1)$$

where $\vec{b}$, the vector of functionings is defined by the following elements: $\vec{x} \in X$ is a vector of commodities out of the set of all possible commodities (or more generally: resources) X. This includes *expressis verbis* non-market goods and services as well. $\vec{x}$ is mapped into the space of characteristics (Lancaster, 1966) via the conversion function $c(\bullet)$ so that $\vec{c} = c(\vec{x})$ would be a characteristics vector of a given commodity vector $\vec{x}$. The characteristics of a commodity do not vary across individuals, i.e. they are the same for everyone. What does vary, however, is the way individuals can benefit from the characteristics of a commodity. Think of a person who possesses a loaf of bread. Someone suffering from a parasitic disease would benefit less from the characteristic “caloric content” than someone being well-fed (Sen, 1985a, p. 9). This is reflected by the conversion function of an individual $f_i \in F_i$ that maps a vector of characteristics into the space of functionings (F is the set of all possible conversion functions). This conversion is influenced by the conversion factors $\vec{z}_k$, where we can distinguish individual $(\vec{z}_i)$, social $(\vec{z}_s)$ and environmental $(\vec{z}_e)$ influences (Kuklys, 2005, p. 11). Individual factors could be gender, intelligence, physical (dis)abilities, etc. Social influences are legal regulations, population density, etc. Examples for environmental factors include climate, environmental pollution and so on. These conversion factors can be seen as non-monetary constraints an individual faces. Note that selection of some of the conversion functions is part of an individual's capability to function (see Sen, 1985a, of course, some conversion functions are just not eligible, e.g. being female or male, and thus outside an individual's control).

When choosing what way of life to live, a person chooses, depending on his idiosyncratic preferences, from different functioning vectors. The set of all feasible functioning vectors for a person *i* is this person's *capability set* Q_i. It is a derived notion and represents the person's opportunities to achieve well-being, reflecting the various functionings that are potentially achievable (given his constraints $X_i, \vec{z}_k$). This set can now be defined as

$$Q_i(X_i) = \{\vec{b}_i \mid \vec{b}_i = f_i(c(\vec{x}_i) \mid \vec{z}_i, \vec{z}_e, \vec{z}_s) \quad \text{for some } f_i \in F_i \wedge \text{for some } x_i \in X_i\} \quad (2)$$

The capability approach has been devised with a certain openness regarding the selection of a set of valuable functionings. While Sen favours this openness and stresses the deliberative social dimension that is involved in choosing a set of valuable functionings, other authors have promoted lists of functionings that supposedly reflect a common consensus of what is valuable (e.g. Nussbaum, 2000). Note that this indeterminacy of the approach has resulted in an empirical measurement literature that often measures welfare over an *ad hoc* range of different functionings. Moreover, most of the empirical approaches do not work at an individual level but use macro level data. A second difficulty lies in measuring the actual *capability* to function (for an attempt to do so see Anand et al., 2005; Anand and Hees, 2006). But also the empirical examination of conversion factors and functions has received comparatively less attention in the literature (but see Chiappero-Martinetti and Salardi, 2007; Kuklys, 2005; Deutsch et al., 2003). Adding to the latter strand of literature we now turn to a discussion of "conversion efficiency".

3 The Interpretation of Conversion Efficiency

Above we have seen that the conversion of a vector of resources into achieved functionings depends on the conversion function of the individual, which is influenced by individual, social and environmental conversion factors. While the concept of conversion factors is theoretically quite clear, it is much more difficult to address empirically (Brandolini and D'Alessio, 1998). In empirical functioning measurement exercises, differences in conversion factors are often indirectly accounted for through the use of equivalence scales (Lelli, 2005; Kuklys, 2005, p. 81). A more direct approach (using macro level data) has been suggested by Chiappero-Martinetti and Salardi (2007) who use an ordered probit framework and suggest interpreting the coefficients of a set of independent variables ("public resources") to reflect the conversion rates as these capture, on average and if disaggregated to different subgroups of individuals, the differing impact of the variables on the probability of having higher functioning achievement. In other words, Chiappero-Martinetti and Salardi (2007) measure to what extent higher resources lead to a higher probability of functioning achievement (controlling for conversion factors), remaining on the level of conversion rates. Only if such kind of analysis is repeated for different subgroups, the differences in these sub-groups' functioning achievement can then be indirectly attributed to differences in the efficiency of converting resources into functionings between these sub-groups.

A more natural approach to deal with differences in conversion factors would be to directly measure how efficiently individuals convert resources into functionings by drawing on the efficiency analysis methodology used in production theory (Lovell et al., 1994; Deutsch et al., 2003).[2] Previous work in this field has successfully transferred empirical techniques originally developed in production theory to the measurement of welfare (in the space of functionings and otherwise). Distance functions are well-suited to collapse multi-dimensional information into only one dimension, without making any reference to the efficiency of the conversion process (Ramos 2008, Ramos and Silber 2005). Only two studies have used the efficiency analysis methodology to also compute a conversion efficiency measure (Deutsch et al., 2001, 2003): In the latter study, Deutsch et al. (2003) have used translog distance functions to aggregate individuals' resource vectors as well as their functioning vectors to scalar measures. On this basis, a Malmquist productivity index can be computed to measure the "efficiency with which individuals convert their resources into functionings" (Deutsch et al., 2003, p. 104).

We want to add to this strand of literature as it can be considered to be a more direct way of estimating conversion efficiency than the indirect (and macro) approach of Chiappero-Martinetti and Salardi (2007). However, none of the studies mentioned so far has engaged in a theoretical discussion of the conceptual interpretation and policy relevance of conversion *efficiency*. One contribution of our paper lies in providing an argument for its relevance, the aim of this section. We suggest an order-*m* efficiency method that allows us to compute for a given sample of individuals an efficient frontier on which are individuals who are most efficient in converting their resources into achieved functioning. This concept builds on the assumption that individuals need resources (which can be income and market goods but also public goods and social services) to increase their levels of functioning achievement. The efficient frontier we suggest reflects at a given time the societal optimum which can be reached for given levels of resources (i.e. some individuals have actually reached it). This idea of relative efficiency means we are evaluating individuals' efficiency not with respect to a theoretically derived maximum, but to the maximum of functioning achievement observed in the data given a certain level of resources. Given the difficulties in defining the theoretical maximal functionings achievement for a certain level of resources this seems to be a sound approach. On such a relative frontier can be individuals with low functioning achievement and low resources (but these low resources are converted very efficiently) and individuals with high achievements and high resources (but also with an efficient conversion). Individuals on the efficiency frontier constitute in this case the best-practice in conversion efficiency. Other, less efficient individuals are now evaluated relative to these role models and their distance to the frontier is interpreted as a measure of how inefficient these individuals are in converting their resources into achieved functioning.

Moreover, the more individuals are falling short of this efficiency (as measured by the distribution of the efficiency scores for a group of individuals and their distance to the frontier), the less favourable are the overall societal conditions for the conversion of given resources into functioning achievement. In that respect, a distribution of efficiency scores offers the analyst valuable information (regarding the number of efficient individuals as well as the mean distance to the frontier of the inefficient individuals) whether there exist obstacles in the conversion of resources into functionings achievement. Based on the idea that inefficiencies are undesirable also in the context of the capability approach, we argue that a measure of conversion efficiency reflects the effects of diverse welfare-reducing constraints on the individuals. Controlling for known differences in the conversion process (i.e. using control variables for individual conversion factors), we can interpret the remaining inefficiencies as reflecting institutional (and environmental) shortcomings that create a barrier for a certain group of people. While there may exist constraints for all individuals, from the point of view of our approach, we are interested in these constraints that result in inequality, i.e. in constraints which affect only subgroups of people (and here rather the less well-off subgroups).

This type of analysis might lead in extreme cases to results that very poor individuals have very low levels of functioning achievement but are efficient in terms of resource conversion. This case would be problematic in a restricted view solely centred on conversion efficiency because absolute poverty would be masked behind relative efficiency. Therefore we argue that conversion efficiency can only be a complement to the absolute functioning measures. What we claim is that focusing only on the absolute levels of functioning achievement neglects important welfare information that could be put to good use (Sen has been always promoting the idea of a richer informational structure to assess welfare). Basically low scores in conversion efficiency can show sub-groups of individuals that are vulnerable in the sense that they need more resources to achieve similar functionings levels as less vulnerable individuals. This relative measure complements the use of absolute measures in analyzing how these absolute levels of resources are used (or possibly wasted). Such a measure can be tracked over time to monitor progress in abolishing existing inequalities or to examine progress being made by instituted policies. It also offers insights to the policy maker how conversion factors exactly influence the conversion process, so that for example if absolute resource levels cannot be changed, maybe policies can influence conversion factors that would at least increase the conversion efficiency of given resources.

One last qualification is in order. The method suggested here becomes a bit more problematic in the less ideal case of considering as output only a small subset of functionings, i.e. using a non-comprehensive welfare measure (as is usually done in the literature). Consider the example of below, where we examine the conversion of given resources into achieved functioning regarding happiness, health, education, shelter, social relations and nourishment. One could imagine a case where an individual scores low in efficiency for the set of these basic functionings because that individual has chosen a different functioning vector from his capability set. The individual's chosen vector might be efficient in the *overall* conversion of resources into achieved functioning but not regarding the subset of functionings examined in the analysis (for example one could imagine a person being focused on one functioning and pouring inefficient amounts of resources here).

When analyzing a subset of functionings as output, this line of criticism cannot be excluded completely. Therefore, we argue that this kind of analysis should at least be conducted for special subsets of functionings such as "basic functionings" (Sen, 1993), which can be argued to be part of everyone's chosen functionings vector and where (consequently) everyone should be interested in the efficient conversion of resources into these functionings. While it is not the aim of this paper to solve the problem of list selection (a problem which is heavily discussed within the capability approach, cf. Nussbaum, 2003; Robeyns, 2003; Sen, 2004; Vizard and Burchardt, 2007), it might be an interesting suggestion to connect basic functionings to the fulfilment of “basic needs”. The attractive feature of functionings relating to basic needs is that everyone has these basic needs, and they have to be met in order to survive and/or lead a healthy life. Basic functionings defined on basic needs would be a set of functionings that is “inescapable” (Thomson, 1987), i.e. they are givens for everyone because the underlying needs are biologically fixed.[3] A set of such basic functionings would indeed (with usual genetic variance) be shared by everyone and one has a good justification for the argument that these are therefore also valued by everyone (a similar argument was made by Ruggeri Laderchi, 2008, p. 210).

This is not to imply that the capability approach is a version of the basic needs approach. The latter is centered only on outcomes, and often much narrower and more focussed on needs for commodities (see Sen, 1993, p. 40 fn. 30). Nevertheless, focussing on functionings that relate to basic needs offers a solution to the problem of list selection, i.e. which functionings should be selected to be constitutive of human welfare (cf. Binder (forthcoming) for a more detailed account of this argument). Referring to a broader notion of basic needs that is linked to human biology can also explain why many approaches of multidimensional welfare or human development show similar and often overlapping dimensions (or lists) of what is constitutive of welfare (see Alkire, 2002a,b) and why there seems to be a “bedrock” of shared common human values (Qizilbash 2002, p. 474).

If we can assume that in the case of basic functionings, everyone has the same preferences for them (as they are related to basic needs), the differences in conversion efficiency can be attributed to constraining factors such as argued above. In such a case, the analyst would not need to fear that someone would achieve low efficiency scores because that individual is not interested in (efficiently) converting given resources into achieved functioning (the idea of different efficiencies and their relevance for welfare economics has already been expressed in a similar fashion in the context of Becker’s household production theory, cf. Michael and Becker, 1973). If a shared valued set of functionings is the normative maximand for the welfare analyst, he can safely attribute differences in efficiencies to result from the above-mentioned constraints which could then be the aim of welfare policies.

4 A Nonparametric Approach to Efficiency Measurement

Having discussed the theoretical foundations of the capability approach and the idea of a "conversion efficiency" measure, we now turn to the empirical measurement with a robust nonparametric efficiency analysis. In production theory efficiency means to produce a maximum of output from a certain level of input (Farrell, 1957).[4] In order to evaluate if a firm is efficient it is essential to define an appropriate benchmark. In the best case there are either theoretical intuitions of a maximum level of output that can be derived from a given set of inputs, or at least some commonly accepted standards. In production as well as in welfare evaluation this is rarely the case, though. For this reason empirical approaches are necessary. Instead of comparing a firm's output to a theoretical maximum the comparison is done with respect to that of other similar firms for which input and output levels have also been observed. Different approaches have been developed of how to empirically identify such benchmarks.

Parametric approaches are employed most commonly in the literature. In essence, a function is specified (production frontier) that relates to all input levels a maximum feasible output. With econometric techniques the parameters of this function are then fitted such that it envelops the data and no observation lies on its left or above, i.e. for each level of input there is no firm achieving more output than "predicted" by this function. If a firm produces less than what is predicted it is deemed inefficient because other firms (which are approximated by the production frontier) are able to produce relatively more output from similar inputs. The distance between the predicted and the actually realized output expresses the degree of inefficiency, for which the name "distance function approach" is also frequently used. The inverse of this distance however serves most often as indicator of (in-) efficiency in practice.

Note that the estimation usually considers some stochastic noise so that not all of the difference between predicted and realized output is considered as inefficiency. Some of it is attributed to random deviation.

We have pointed out before that we follow other authors like Deutsch et al. (2003) in transferring this idea of efficiency from production theory to the measurement of welfare. However, so far these authors have only used the previously discussed parametric approach. We share the concerns about parametric efficiency analysis brought forward by Ravallion (2005): Having to specify a functional form is only one of the pertinent problems (see also Daraio and Simar, 2007). Although the translog specification of the "production" frontier used by Deutsch et al. (2003) is very general and flexible, there is no justification for why there should be this particular functional relationship and why the functional form should be assumed to be identical for all individuals. The latter implies that the estimated set of coefficients, reflecting the weights given to the resources and functionings, are assumed to be identical for all individuals. Moreover, parametric efficiency analyses on the basis of COLS or maximum likelihood estimations commonly require assumptions on the distribution of conversion efficiency and on a statistical noise term. While the latter is often assumed to be normally distributed, other distributions such as exponential, truncated normal (usually half-normal), or gamma distributions are proposed for the conversion efficiency (see, e.g., Cummins and Zi, 1997). In most cases it is difficult to justify these assumptions although they have considerable impact on the empirical results.

We argue therefore that a different type of empirical approach to measure efficiency is much better fitting for welfare assessment because the strict assumptions of the parametric approach are not necessary.[5] In these so-called "mathematical approaches", the frontiers are fitted by linear programming techniques that do not require the specification of a parametric model, i.e. it is not necessary to a priori define a "production" frontier function.

The most prominent nonparametric efficiency analysis approaches are the Data Envelopment Analysis (Charnes et al., 1978) and the Free Disposal Hull (Deprins et al., 1984).
Both differ mainly with respect to the assumption of convexity, i.e. whether the frontier is convex or concave. Convexity implies that linear combinations of two observations can serve as benchmarks and that inputs and outputs are arbitrarily divisible. In other words, every input (and every output) can be substituted by a combination of other inputs (or outputs). With respect to the context of this paper this assumption seems problematic. For this reason we use the Free Disposal Hull (FDH) approach, which does not assume convexity and compares observations only on the basis of other observed observations, i.e. only real input/output relations are considered.

While an FDH based distance function can be estimated by linear programming techniques, Tulkens (1993) shows that it can also be computed by a simple vector comparison procedure. Let x_0 and y_0 be the input (resources) and output (achieved functionings) vectors of an individual belonging to a sample of observations $\Psi = \{(X_i, Y_i), i = 1,...,n\}$. The set of observations dominating an individual (x_0, y_0) is defined as

$$D_0 = \{i | (X_i, Y_i) \in \Psi, X_i \leq x_0, Y_i \geq y_0\}. \quad (3)$$

The "output-oriented" FDH efficiency (inverse of output distance function) can be computed as:

$$\hat{\lambda}(x_0, y_0) = \max_{i \in D_o} \{\min_{j=1,...,q} (\frac{Y_i^j}{y_0^j})\} \quad (4)$$

with j as the j^{th} component (different measures of the functioning achievement) of Y_i and y_0, respectively. If $Y_i \leq y_0$ then $\hat{\lambda} \geq 1.$ Verbally this means that we examine for each individual whether there is any individual in the sample (including the same individual) that has equal or less resources available and achieves an equal or higher level of functioning achievement. The comparison of input and output vectors is done on the basis of the principle of weak dominance. The efficiency measure is then defined as the necessary (relative) increase in the output component, whose value is closest to the value of the frontier (best-practice) individual.

Note that we only present the efficiency analysis from an output-oriented way, i.e. efficiency refers to a necessary increase in the achieved functionings to become efficient. In contrast one could also look for the necessary decrease in the resources. We argue that the output-orientation is more appropriate because our aim is to identify obstacles that hinder people in achieving "maximal" functioning achievement. It is hence evaluated whether they score lower in terms of functioning achievement than what can be expected given their resources.

While such an efficiency measure is frequently used, it is apparent that the FDH-frontier can be strongly biased by outliers and noise in the data (see, e.g., Wilson, 1993). The reason is that all variations between the empirical observations are attributed to differences in their efficiency and not to a stochastic element. This drawback has been overcome by the introduction of *robust* nonparametric frontier techniques (see Daraio and Simar, 2007, for an introduction). One of the *robust* versions of the FDH approach is the order-*m* frontier approach developed by Cazals et al. (2002).

In contrast to the traditional mathematical programming approaches, robust nonparametric frontier approaches conceive of the transformation of inputs into outputs as a probabilistic process. The interest lies in the probability with which an observation (x_0, y_0) is dominated by other observations. According to Cazals et al. (2002), an observation's benchmark (frontier) can be the average of the maximal value of output of *m* randomly drawn observations with equal or less levels of input (output-oriented order-*m* frontier). In the context of this paper, this frontier represents the expected maximum functioning achievement level for individual (x_0, y_0) among *m* individuals.[6]

Practically, the efficiency measure of order-*m* can be computed in the following way: $Y_1,...,Y_m$ are the *m* random observations (individuals) drawn from the conditional distribution function of *Y* given $X \leq x_0$, i.e. only individuals with equal or less resources than individual

(x_0, y_0) are considered. The output-oriented order-*m* efficiency measure $\tilde{\lambda}_m(x_0, y_0)$ is defined for observation (x_0, y_0) as

$$\tilde{\lambda}_m(x_0, y_0) = \max_{i=1,\dots,m}\{\min_{j,\dots,q}(\frac{Y_i^j}{y_0^j})\} \quad (5)$$

with $Y_i^j(y_0^j)$ being the j^{th} component of Y_i (of y_0 respectively). Note that $\tilde{\lambda}(x_0, y_0)$ is a random variable because the Y_i, individuals against which (x_0, y_0) is compared, are randomly drawn. In order to obtain the final $\hat{\lambda}_m(x_0, y_0)$, we follow Cazals et al. (2002) in using a simple Monte-Carlo algorithm in which $\tilde{\lambda}_m(x_0, y_0)$ is estimated *B* times, where *B* is large (*B=200*). The order-*m* efficiency measure of individual (x_0, y_0) is then defined as

$$\hat{\lambda}_m(x_0, y_0) = E[\tilde{\lambda}_m(x_0, y_0) | X \le x_0] = \frac{1}{B}\sum_{b=1}^{B}\tilde{\lambda}_m^b(x_0, y_0). \quad (6)$$

Since not all observations are enveloped, the order-*m* frontier function is a partial frontier making it less sensible to outliers and statistical noise. In contrast to the FDH, the order-*m* efficiency scores can take values smaller than one (they can range from > 0 to + inf). Values smaller or equal to one indicate efficiency, while values larger than one represent inefficiency.

In order to analyze whether individual characteristics (i.e. differences in individual conversion factors) have an influence on the conversion efficiency, we have to rely on a second stage. In a similar manner as Deutsch et al. (2001), we regress the individual characteristics on the previously estimated efficiencies. As the efficiency scores are always positive and do not have an upper bound, a standard OLS model seems to be appropriate for this second stage regression.

5 Data and Findings

5.1 Data Set and Functioning Selection

The British Household Panel Survey (BHPS) is a longitudinal survey of private households in Great Britain, undertaken by the ESRC UK Longitudinal Studies Centre with the Institute for Social and Economic Research at the University of Essex, UK (BHPS, 2007). Its aim is to track social and economic change in a representative sample of the British population (for the following and more information on the data set, cf. Taylor, 2007, sections A2 & A4). The BHPS started as a nationally representative sample of 5,000 households, where adults (being of age sixteen and over) were interviewed and tracked over the years. The sample comprises of about 15,000 individual interviews. Starting in 1991, up to now, there have been 15 waves of data collected with the aim of tracking the individuals of the first wave over time (there is a percentage of rotation as some individuals drop out of the sample over time and others are included, but attrition is quite low, cf. Taylor, 2007). The BHPS data contains information on various areas of the respondents' lives, ranging from income to jobs, household consumption, education, health, but also social and political values. Opposed to many approaches in the capability literature, we are thus using micro level data in our analysis.

We have already hinted at the theoretical problems related to selecting a list of functionings. From an empirical point of view, it has to be noted that there is a quite large amount of overlap between the different lists of functionings that are suggested in the literature (Qizilbash 2002; what often differs are indicators selected to capture functioning achievement, due to different data availability). This might also explain the finding by Ramos and Silber (2005) that the exact specification of a set of functionings does not seem overly critical for the resulting multidimensional welfare measure (at least in an efficiency analysis framework). The authors have demonstrated a great (empirical) similarity of the different approaches in their study (also using the BHPS data set).

To construct a set of "basic functionings" we choose different indicators for the six functionings "being happy", "being educated", "being healthy", "being nourished", "being well-sheltered" and "having satisfying social relations". While education, shelter, nourishment, social relations and health have been always prominent candidates in empirical studies on the capability approach and figure in many multidimensional welfare measures (Alkire, 2002a,b), "being happy" has been somewhat neglected and only gained some more interest in the capability literature recently (e.g., Anand et al., 2005, Burchard, 2005, Anand and Hees, 2006). We want to make a case for including this functioning in more studies since it can be considered a central dimension of human well-being. On the resource side, we take income to be the proxy for the commodity vector in the capability framework (see section 2). Subject to the conversion function and given conversion factors, an individual's resources are assumed to be transformed into achieved functioning in the six dimensions named above.

Let us now discuss the indicators we chose to measure inputs, outputs and individual conversion factors. Table 1 gives an overview of the input income and our six outputs and the proxies we use to measure them. We are using a recent wave of the BHPS for the year 2006. As of now, we just consider this year and do not use the BHPS as a panel to examine trends in the development of our measure. The sample size is 13,480 individuals. This includes all individuals of the BHPS that report a positive (however small) income (after transformation, see below).[7]

While the mean gross income of our sample in 2006 is 15,329.62 GBP (standard deviation of 17,158.99 GBP), we think that some correction is appropriate here. The sample contains individuals who report very small incomes but who cannot be considered poor. Under these category fall spouses who do not work, adolescent children living with their parents etc. The commodity vector which is at their disposal is thus poorly reflected in their reported in-

Income, adjusted (GBP)	Min	Max	Mean	SD
	.2	504,991.90	12,054.57	10,137.70
Well-being (GHQ-12)	Min	Max	Mean	SD
	1	37	25.71	5.50
Satisfaction with housing	Min	Max	Mean	SD
	1	7	5.36	1.45
Satisfaction with social relations	Min	Max	Mean	SD
	1	7	4.83	1.49
Being nourished (weekly bill)	Min	Max	Mean	SD
	1	12	6.85	2.20
Health status last 12 months	absolute	%	Mean	SD
			3.83	0.92
very poor	242	1.80		
poor	934	6.93		
fair	2,765	20.51		
good	6,438	47.76		
excellent	3,101	23.00		
Highest academic qualification	absolute	%	Mean	SD
			3.21	1.76
none of these	3,701	27.46		
cse	669	4.96		
o level	3,508	26.02		
a level	2,693	19.98		
hnd,hnc,teaching	950	7.05		
1st degree	1,548	11.48		
higher degree	411	3.05		

Table 1: Descriptive statistics - input & output indicators

come as it depends on the income of the household. In order to account for this, we have chosen to simply use per capita income as our proxy. As equivalence scales are used (partly) to account for differences in conversion factors (cf. Kuklys, 2005, ch. 5), applying these scales to further adjust disposable income would run counter to the idea of identifying the role of conversion factors on the efficiency in transforming resources into functioning achievement. Mean income per capita of a household is according to our calculation 12,054.57 GBP (s.d. 10,137.70 GBP).[8] In future work, this proxy could definitively be extended using other data on public resources and other non-market goods and services.

Concerning our first functioning achievement "being happy" we have chosen the individual's assessment of mental well-being as an indicator. It is an index from the widely used "General Health Questionnaire" of the BHPS, composed of the answers to 12 questions that assess happiness, mental distress and well-being.[9] This subjective assessment is measured on a Likert scale from 0 to 36, which we have recoded to values of one (lowest well-being) to 37 (highest scores in mental well-being). Mean well-being is 25.71 (s.d. 5.50). Although subjective well-being or happiness functionings have not been widely used in the capability literature, in the context of conversion efficiency, Deutsch et al. (2001) have considered happiness as relevant. Note that we have chosen a somewhat broader indicator than the one being generally used in happiness research.

To measure functioning achievement "being healthy" we have chosen to use an individual's subjective assessment of health as an indicator (during the last 12 months). This is ordinally scaled on a five point Likert scale, ranging from "excellent" (five) to "very poor" (one). This proxy is similar to the one employed in other studies on functioning achievement (cf. Kuklys, 2005; Chiappero-Martinetti and Salardi, 2007). Subjective assessments of health seem to predict objective health quite well in some cases (e.g. regarding morbidity). Whether objective health is sufficiently well-reported by subjective health assessments is still debated within and without the capability approach (cf. Kuklys, 2005; Johnston et al., 2007). Nevertheless, although a more detailed indicator set would certainly be welcome, we think that for our expositional measurement exercise, this single indicator will do.[10] Mean health is 3.83 (s.d. 0.92).

Achieved functioning "being educated" is measured by an individual's highest level of education, being measured ordinally, ranging from one ("none of these") to seven ("higher degree") and giving intermediate values to the middle education levels.[11] With this scale, we have chosen the same indicator as Kuklys (2005). Seeing "being educated" as important output in the functioning production has been also suggested by Chiappero-Martinetti and Salardi (2007) and Ramos (2008) and the importance of this functioning is also highlighted by its prominent role of being one of the indicators of development in the HDI (UNDP, 2006).

There is, however, a certain circularity inherent in the capability framework because an individual's education can also be seen as a resource that leads to higher levels of functioning achievement in other dimensions (such as health or income). The problem that achieved functionings might be also resources for the achievement of other functionings or conversion factors is a vexing problem in the approach that has not been solved yet in a satisfactory fashion and we do not pretend to have an answer to this problem (cf. similarly Anand et al., 2005,

p. 43). While we think that panel data methods might play a useful role in addressing this issue, possible endogeneity problems do not necessarily invalidate other empirical research methodologies.

For the fourth functioning "being well-sheltered", we use an individual's satisfaction with his housing situation as a proxy. This is measured on a seven point Likert scale, where 1 denotes "not satisfied at all" and 7 denotes the individual is "completely satisfied" (mean is 5.36, s.d. 1.45). We have decided against constructing an indicator based on a variety of possible housing problems of an individual. Such indicators are often used in the literature to approximate the underlying functioning (see Deutsch et al., 2003, Robeyns 2006, Roche, 2008). While the BHPS offers a rich source for assessing the quality of a person's home based on answers to questions concerning "lack of space", "rot in walls, floors etc.", "leaky roof" and so on, such an indicator has only a small variance and thus would not be suited for the analysis (the low variance might be due to overall quite favourable housing conditions in Great Britain).

The functioning "being nourished" can be approximated by the household weekly expenditure on food and grocery items. In the BHPS, this is measured in 12 categories (ranging from "under 10" to "160 or over" in GBP). This is admittedly a crude indicator (and moreover on the level of the household) but it nevertheless offers a first approximation of this functioning which is otherwise not easily captured in this data set (on the relevance of this functioning cf. also Qizilbash 2002, p. 468).

The last functioning we look at are "having satisfying social relations" and we use an individual's satisfaction with his social relations as an indicator for functioning achievement in this dimension. This is measured on a seven point Likert scale, where 1 denotes "not satisfied at all" and 7 denotes the individual is "completely satisfied" (mean is 4.83, s.d. 1.49). As in the case of health, further indicators could be used in later work to extend the range for this functioning, including e.g. objective indicators like number of activities in organizations or answers to questions on whether the individual has persons to rely on in times of stress (cf., e.g. the studies of Deutsch et al., 2003, Ramos and Silber, 2005).

The summary statistics of our output variables are depicted in table 1. All six output variables are correlated with our input measure of per capita income to varying degrees. The indicator income is only weakly correlated with "being nourished" ($r = 0.01$), "satisfying social relations" ($r = 0.04$), "well-sheltered" ($r = 0.05$) and "being happy" ($r = 0.08$), but higher correlated with "being healthy" ($r = 0.12$), and "educated" ($r = 0.31$, all Spearman rank correlations). Measures of (multidimensional) well-being are generally very low correlated with income in intra-country cross-sections (Bechtel, 2007). This has also been found in the empirical capability literature (cf. Lovell et al., 1994; Lelli, 2001; Ramos and Silber, 2005; Deutsch et al., 2003) and is thus not surprising to be found in our data as well.

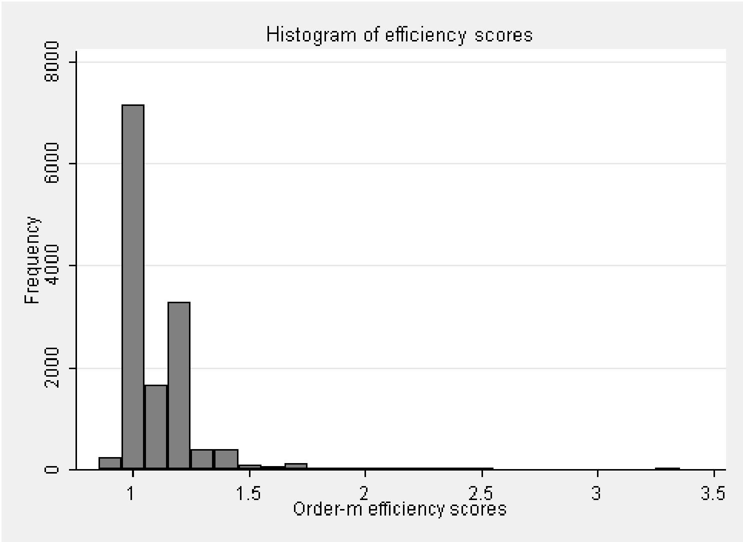
Age		Min	Max	Mean	SD
		15	99	45.53	18.32
Gender		absolute	%		
	male	6,099	45.24		
	female	7,381	54.76		
Job status		absolute	%		
	self-employed	930	6.90		
	unemployed	425	3.15		
Marriage status		absolute	%		
	married	7,071	52.46		
	separated, divorced, widowed	2,336	17.33		
London dummy		absolute	%		
	living in London area	588	4.36		
Disability		absolute	%		
	self-assessed disability	1,397	10.36		
No health problems		absolute	%		
	healthy	5,576	41.36		

Table 2: Descriptive statistics of control variables

The last category of variables concerns the (mostly individual) conversion factors, which we include in the second stage of the analysis. These comprise of gender, age (and age²: to be precise, we use the squared difference between age and mean-age instead of age² in order to avoid problems of multicollinearity) as well as some dummies regarding perceived disability, absence of health problems, job status and individual marriage status as a selection of some of the most important individual factors influencing achieved functioning (a similar set of factors was used also by Chiappero-Martinetti and Salardi, 2007). We have also added a regional dummy for the individual living in the London area. These factors and their descriptive statistics are summed up in table 2. Of course, one could include even more personal characteristics in the second stage of our approach. To illustrate the core idea, however, we deem these variables to be sufficient and capturing some of the most important individual conversion factors.

5.2 Findings and Discussion

The first impression on the results is that nearly half of the individuals in our sample transform their resources efficiently into functioning achievement: 6,724 individuals are found to be efficient in their conversion. In relation to the 13,480 valid observations, this is 49.88 percent. This indicates two things: First there are still quite a number of individuals showing inefficiency in Great Britain. 50.12 percent of the individuals in the sample are not able to convert their resources into functioning achievement as efficiently as the best 49.88 percent. Second, of interest is also the mean of the inefficient observations which is about 1.20. This shows that the average inefficient individual achieves about 20% less functioning achievement than an efficient individual with the same resources. Note that these values do not refer to the complete population, but only to the randomly drawn individuals that have equal or less resources as the individual under observation. While the magnitude of inefficiency found in our data is smaller than in the results of Deutsch et al. (2001), we are cautious about deeper comparisons because of the different models used.



The histogram of the efficiency scores (Fig. 1) reveals that the largest group of inefficient individuals has an efficiency score between 1.2 and 1.4, i.e. a score somewhat above the mean. While we observe a long tail of efficiency scores larger than 1.5 these represent only about 2 percent of the individuals in the sample. Hence, the degree of inefficiency here is rather small. Of course, more insightful results can be obtained by comparing the conversion efficiency to those of other countries, or inter-temporally. As more efficiency data do not exist, such comparisons would certainly be valuable extensions for future research.

As we have described above, obstacles in the conversion of a given commodity vector into achieved functioning can be caused by personal, environmental or social factors. These conversion factors determine why one individual achieves higher functioning output than someone else with the same commodities (or why someone achieves a similar output with lower resources). These inefficiencies can be caused by a wide range of other factors not included into the analysis. As pointed out before, we employ an ordinary-least-square regression to evaluate the effect of some individual conversion factors that are most commonly argued to influence an individual's ability to convert resources into achieved functionings. Note that a high efficiency score indicates inefficiency while a score close or equal to one implies efficiency in the conversion (i.e. negative regression coefficients refer to an efficiency-increasing effect). Table 3 shows the second-stage regression results for age, gender ("d_male"), being self-employed ("d_selfemployed"), being unemployed ("d_unemployed"), being married ("d_married"), being separated, divorced or widowed ("d_sepdivwid"), being disabled ("d_disabled"), having no health problems whatsoever ("d_nohealthprob") and living in the London area ("d_london").[12]

With the exception of gender, we find a highly significant (below 0.1% significance level) relationship with the order-*m* efficiency scores for all variables (only living in London is significant at the 5% level). In detail, we find that being older, self-employed, married, having no health problems and living in the London area increases the conversion efficiency (in the case of age, the relationship is quadratic). On the other hand, being unemployed, separated/divorced/widowed and (self-assessed) disabled decrease an individual's conversion efficiency.

Source	SS	df	MS	
Model	23.6497176	10	2.36497176	Number of obs = 13480
Residual	263.406791	13469	.019556522	F(10, 13469) = 120.93
Total	287.056509	13479	.021296573	Prob > F = 0.0000
				R-squared = 0.0824
				Adj R-squared = 0.0817
				Root MSE = .13984

efficiency	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
age	-.0003455	.0000986	-3.50	0.000	-.0005388	-.0001521
age^2	-.0000387	3.89e-06	-9.95	0.000	-.0000463	-.0000311
d_male	-.0030086	.0024816	-1.21	0.225	-.007873	.0018557
d_selfemployed	-.0202528	.0048737	-4.16	0.000	-.0298061	-.0106996
d_unemployed	.0472941	.006978	6.78	0.000	.0336162	.0609719
d_married	-.0166477	.0037375	-4.45	0.000	-.0239737	-.0093218
d_sepdivwid	.0233798	.0045984	5.08	0.000	.0143663	.0323933
d_disabled	.0675267	.004195	16.10	0.000	.0593039	.0757495
d_nohealthprob.	-.0565641	.0026748	-21.15	0.000	-.0618071	-.0513211
d_london	-.0116664	.0059182	-1.97	0.049	-.0232668	-.0000659
_cons	1.148821	.0041469	277.03	0.000	1.140692	1.156949

Table 3: Second-stage regression results

These findings extend several results from the literature not only related to conversion efficiency (the only directly relevant comparisons provide the measurement exercises by Deutsch et al., 2001, 2003; Chiappero-Martinetti and Salardi, 2007), going beyond what has been done so far: For example, it seems reasonable that individuals who are unemployed would be less efficient in the conversion of their income into achieved functioning than those with a similar income who are employed or even self-employed. Being self-employed on the other hand has a positive impact on the conversion of income into achieved functioning. Self-employed persons usually are reported to be happier (Benz and Frey, 2004). Our findings show in a complementary fashion that regarding two individuals with the same resources, the one being self-employed is also more efficient in the conversion of his resources into achieved functioning.

Similarly straightforward is the case of the positive coefficient for being no longer married (i.e. being separated, divorced or widowed). The negative experiences of being separated, divorced, or widowed are likely to be an obstacle in the conversion of the given commodities into achieved functioning. These findings go beyond Deutsch et al. (2001), who find no significant effects of marital status on conversion efficiency for their Israelian sample (1992-1993), although their output vector seems to be most similar to ours (including subjective happiness and health assessments).

In the literature, one can also find that elder people score lower in the achievement of absolute functionings levels (Chiappero-Martinetti, 2000). Our results add that being older nevertheless means being more efficient in the conversion of resources into functionings achievement to a certain extent. The quadratic age-term in the regression shows that the efficiency even increases quadratic with age. Such a finding could be explained with reference to individuals learning over their life-time to more fully use their eligible resources and hence achieve their functionings more efficiently. Here we contradict findings of Deutsch et al. (2001) who found that age decreases conversion efficiency to a certain point (in their study, ages above 57 led to an increase in conversion efficiency). Moreover, our findings diverge from those of Chiappero-Martinetti and Salardi (2007) who, using a different methodology to assess conversion efficiency as well as a mixture of micro and macro data, were led to the finding that being young (in Italy of 1999) is positively associated with higher conversion efficiency.

It is perhaps not very surprising to see that an individual conversion factor such as being disabled decreases the ability to efficiently convert resources into functioning achievement. This complements the findings that disabled individuals score lower in absolute functioning achievement than healthy individuals (Kuklys, 2005). Their absolutely lower levels could be explained in terms of a decreased efficiency of conversion, i.e. they score lower because their conversion is inefficient. Vice versa, being in a state of complete health (no health problems) increases the efficiency in converting resources into functioning achievement.

The last conversion factor examined is living in the area of London, and we find that this increases conversion efficiency. Probably, the infrastructure of a large metropolitan area and its corresponding advantages outweigh any negative effects and supply individuals with better opportunities to convert their resources into functioning achievement (Deutsch et al., 2001, also investigated the effects of living in a city but did not find a significant effect in their sample).

Lastly, we have to note that we did not find any effects of gender on conversion efficiency. While it is usually reported that female individuals score lower in absolute functionings achievements (Sen, 1985a; Chiappero-Martinetti, 2000), the subgroup analysis of Chiappero-Martinetti and Salardi (2007) reports that females are overall more efficient in converting resources into health, educational and living safely functioning achievement (although not all of the results for the authors' subgroups were significant). As Deutsch et al. (2001), we cannot report a significant effect of gender on conversion efficiency (although this absence of evidence is not to be mistaken as evidence of absence).

In general, it has been found that the poor seem to be more efficient in the conversion of their resources than more affluent individuals (Deutsch et al., 2001, 2003). One could argue that those who are disadvantaged as regards absolute levels of functioning achievement, were forced to learn to more efficiently convert their comparatively smaller amounts of resources into functioning achievement. Given lower absolute functioning achievement, such an explanation seems more likely than arguing that the deprived face less institutional barriers that hamper their conversion of resources into achieved functioning. This example illuminates the complementary nature of the method presented here: Using several dimensions of available welfare information gives a more complete picture of the individuals' welfare and helps ev-

	age	age^2	male	selfempl.	unempl.	married	sepd.	disabled	noheal.	london
age	1.0000									
age^2	**0.2642**	1.0000								
p-value	0.0000									
d_male	-0.0078	-0.0159	1.0000							
p-value	0.3659	0.0651								
d_selfemployed	-0.0042	**-0.1405**	**0.1495**	1.0000						
p-value	0.6225	0.0000	0.0000							
d_unemployed	**-0.1146**	-0.0091	**0.0322**	**-0.0491**	1.0000					
p-value	0.0000	0.2904	0.0002	0.0000						
d_married	**0.2902**	**-0.2958**	**0.0530**	**0.0616**	**-0.1028**	1.0000				
p-value	0.0000	0.0000	0.0000	0.0000	0.0000					
d_sepdivwid	**0.3286**	**0.1432**	**-0.1256**	**-0.0272**	0.0015	**-0.4809**	1.0000			
p-value	0.0000	0.0000	0.0000	0.0016	0.8604	0.0000				
d_disabled	**0.2636**	**0.1626**	-0.0079	**-0.0666**	**-0.0223**	**-0.0233**	**0.1549**	1.0000		
p-value	0.0000	0.0000	0.3616	0.0000	0.0095	0.0068	0.0000			
d_nohealthprob	**-0.3614**	**-0.1063**	**0.0839**	**0.0459**	0.0028	**-0.0700**	**-0.1350**	**-0.2446**	1.0000	
p-value	0.0000	0.0000	0.0000	0.0000	0.7489	0.0000	0.0000	0.0000		
d_london	-0.0030	-0.0100	-0.0037	**0.0236**	0.0093	**-0.0330**	**-0.0172**	**-0.0321**	-0.0046	1.0000
p-value	0.7293	0.2459	0.6694	0.0062	0.2817	0.0001	0.0462	0.0002	0.5940	

Table 4: Pearson correlation of control variables (significance levels of .05 or lower in bold)

aluating the results.

Note also the correlation between the variables (see table 4). For example, not surprisingly, in our data the marriage and separation dummies are strongly negatively correlated (r =

-0.48). Similarly age and marriage status are positively correlated. Before concluding let us point out that the low R^2 of 0.08 and the significant intercept in our regression exercise indicate that there are other factors not considered in the regression (Deutsch et al., 2001, report an even somewhat lower level of R^2 of 0.04). A large part of the variance of conversion efficiency is yet unexplained, demanding further future research.

6 Conclusion

In the present paper, we have focussed on a comparatively neglected dimension of Sen's capability approach. We have argued that the absolute measurement of functioning achievement should be complemented by a measure of the efficiency with which individual resources are converted into achieved functioning, the so-called conversion efficiency. We have used a nonparametric efficiency procedure (that has some attractive features) and constructed such a measure of conversion efficiency for a set of basic functioning achievement (comprising of the functionings "being happy", "being healthy", "being educated", "being well-sheltered", "being nourished" and "having satisfying social relations"), using data from the British Household Panel Survey (BHPS). The order-*m* efficiency method we have suggested allows us to compute for a given sample of individuals an efficient frontier on which are these individuals who are most efficient in transforming their resources into achieved functioning. The distribution of efficiency scores relative to that frontier allows some additional insights regarding the assessment of welfare. Based on the idea that inefficiencies are undesirable and taking into account differences in individual conversion factors, we argue that a measure of conversion efficiency reflects diverse welfare-reducing institutional and environmental constraints on the individuals.

We have found that in our sample 49.88% of the individuals can be considered efficient while the mean of the inefficient individuals reaches one fifth less functioning achievement with similar resources as the efficient individuals. Adding to a better understanding of the relation between individuals' resources and achieved functionings, we found that for Great Britain, an individual's conversion efficiency is positively affected by getting older (quadratic relationship), being self-employed, married, having no health problems and living in the London area. On the other hand, being unemployed, separated/divorced/widowed and (self-assessed) disabled decrease an individual's conversion efficiency. We have hereby qualified results from the few similar studies that have focussed on different countries and partly also on different sets of functionings. In reporting the effects of employment and health on conversion efficiency, we have also extended the empirical findings of this strand of the literature.

A next step would be to extend the analysis over different countries or inter-temporally, where a key advantage of our method lies in its being independent of absolute values, units and price. That makes it well suited for comparisons of international conversion efficiency scores. As for most empirical studies, more and better data could improve the reliability of the findings.

Having discussed our findings, we want to address one last concern regarding the empirical measurement exercise conducted here. Critics could argue that if all relevant conversion constraints were included as control variables (or as relevant inputs) in our measurement, no inefficiencies should be found. This is true. However, if the policy maker would know all relevant constraints, he could focus on abolishing these which disadvantage some subgroups regarding the relevant functioning achievement. Since knowledge is not perfect, no policy maker can ever hope to attain this information. By excluding some of the known constraints (especially these which cannot be changed), we thus isolate in our analysis a set of unknown factors that lead to the observed inefficiencies. Our analysis can be understood as a first step in quantifying these unknown constraints, which could then be (qualitatively) identified and included in a second analysis of the type conducted in this paper and the analyst could thus assess whether the inclusion of the factor identified would lead to a more favourable distribution of conversion efficiency scores.

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References

Alkire, S. (2002a). Dimensions of human development. World Development, 30(2):181–205.

Alkire, S. (2002b). Valuing Freedoms - Sen's Capability Approach and Poverty Reduction. Oxford University Press, Oxford.

Anand, P. and Hees, M. v. (2006). Capabilities and achievements: An empirical study. Journal of Socio-Economics, 35:268–284.

Anand, P., Hunter, G., and Smith, R. (2005). Capabilities and well-being: Evidence based onthe Sen-Nussbaum approach to welfare. Social Indicators Research, 74:9–55.

Bechtel, T. G. (2007). The pursuit of happiness. Survey Research Methods, 1(2):109–120.

Benz, M. and Frey, B. S. (2004). Being independent raises happiness at work. Swedish Economic Policy Review, 12:95–134.

BHPS (2007). British household panel survey. http://www.iser.essex.ac.uk/ulsc/bhps/

Binder, M. (forthcoming), Elements of an Evolutionary Theory of Welfare. Routledge, London.

Bonaccorsi, A., Daraio, C., and Simar, L. (2005). Advanced indicators of productivity of universites. An application of robust nonparametric methods to Italian data. Scientometrics, 66(2):389-410.

Brandolini, A. and D'Alessio, G. (1998). Measuring well-being in the functioning space. Mimeo.

Burchardt, T. (2005), Are one man's rags another man's riches? Identifying adaptive expectations using panel data. Social Indicators Research, 74:57–102.

Cazals, C., Florens, J.-P., and Simar, L. (2002). Nonparametric frontier estimation: A robust approach. Journal of Econometrics, 106(1):1–25.

Charnes, A., Cooper, W. W., and Rhodes, E. (1978). Measuring the efficiency of decision making units. European Journal of Operational Research, 2(6):429–444.

Chiappero-Martinetti, E. (2000). A multi-dimensional assessment of well-being based on Sen's functioning theory. Rivista Internationale di Scienzie Sociali, 108(2):207–231.

Chiappero-Martinetti, E. and Salardi, P. (2007). Well-being process and conversion factors: An estimation of the micro-side of the well-being process. Mimeo.

Clark, A. E. and Oswald, A. J. (2002). A simple statistical method for measuring how life events affect happiness. International Journal of Epidemiology, 31:1139–1144.

Coelli, T. and Perleman, S. (1999). A comparison of parametric and non-parametric distance functions: With application to European railways. European Journal of Operational Research, 117:326–339.

Comim, F., Qizilbash, M., and Alkire, S., editors (2008). The Capability Approach: Concepts, Measures and Applications, Cambridge/UK. Cambridge University Press.

Cummins, J. D. and Zi, H. (1997). Measuring cost efficiency in the U.S. life insurance industry: Econometric and mathematical programming approaches. Wharton Financial Institutions Center Working Papers, 97-03.

Daraio, C. and Simar, L. (2007). Advanced Robust and Nonparametric Methods in Efficiency Analysis - Methodology and Applications. Kluwer Academic Publishers, Boston / Dordrecht / London.

Dasgupta, P. (1990). Well-being and the extent of its realisation in poor countries. Economic Journal, 100(400):1–32.

Deprins, D., Simar, L., and Tulkens, H. (1984). Measuring labor efficiency in post offices. In Marchand, M., Pestieau, P., and Tulkens, H., editors, The Performance of Public Enterprises: Concepts and Measurements, pages 345–367. Elsevier.

Deutsch, J., Ramos, X., and Silber, J. (2003). Poverty and inequality of standard of living and quality of life in Great Britain. In Sirgy, M. J., Rahtz, D., and Samli, A. C., editors, Advances in Quality-of-Life Theory and Research, chapter 7, pages 99–128. Kluwer Academic Publishers, Dordrecht.

Deutsch, J., Silber, J., and Yacouel, N. (2001). On the measurement of inequality in the quality of life in Israel. Mimeo.

Farina, F., Peluso, E., and Savaglio, E. (2004). Ranking opportunity sets in the space of functionings. Journal of Economic Inequality, 2:105–116.

Gardner, J. and Oswald, A. (2006). Money and mental wellbeing: A longitudinal study of medium-sized lottery wins. Journal of Health Economics, 26:49–60.

Johnston, D. W., Propper, C., and Shields, M. A. (2007). Comparing subjective and objective measures of health: Evidence from hypertension for the income/health gradient. CMP Working Paper Series, No.07/171, University of Bristol.

Kuklys, W. (2005). Amartya Sen's Capability Approach - Theoretical Insights and Empirical Applications. Springer, Berlin et al.

Lancaster, K. (1966). A new approach to consumer theory. Journal of Political Economy, 74(2):132–157.

Lelli, S. (2001). Factor analysis vs. fuzzy sets theory: Assessing the influence of different techniques on Sen's functioning approach. Center for Economic Studies Discussion Paper Series 01.21.

Lelli, S. (2005). Using functionings to estimate equivalence scales. Review of Income and Wealth, 51(2):255–284.

Lovell, C. A. K., Richardson, S., Travers, P., and Wood, L. (1994). Resources and functionings: A new view of inequality in Australia. In Eichhorn, W., editor, Models and Measurement of Welfare and Inequality. Springer-Verlag, Heidelberg.

Michael, R. T. and Becker, G. S. (1973). On the new theory of consumer behavior. The Swedish Journal of Economics, 75(4):378–396.

Nussbaum, M. C. (2000). Women And Human Development. Cambridge University Press, Cambridge.

Nussbaum, M. C. (2003). Capabilities as fundamental entitlements: Sen and social justice. Feminist Economics, 9(2-3):33–59.

Qizilbash, M. (2002), Development, Common Foes and Shared Values. Review of Political Economy, 14(4):463–480.

Ramos, X. (2008). Using efficiency analysis to measure individual well-being with an illustration for Catalonia. In Kakwani, N. and Silber, J., editors, Quantitative Approaches to Multidimensional Poverty Measurement, chapter 9, pages 155–175. Palgrave Macmillan, Basingstoke.

Ramos, X. and Silber, J. (2005). On the application of efficiency analysis to the study of the dimensions of human development. Review of Income and Wealth, 51(2):285–309.

Ravallion, M. (2005). On measuring aggregate "social efficiency". Economic Development and Cultural Change, 53(2):273–292.

Robeyns, I. (2003). The capability approach: An interdisciplinary introduction. Mimeo.

Robeyns, I. (2006). Measuring Gender Inequality in Functionings and Capabilities: Findings from the British Household Panel Survey. In Bharati, P. and Pal, M., editors, Gender Disparity: Its Manifestations, Causes and Implications, chapter 13, pages 236-277. Anmol, Delhi.

Roche, J. M. (2008), Monitoring Inequality among Social Groups: A Methodology Combining Fuzzy Set Theory and Principal Component Analysis. Journal of Human Development and Capabilities, 9(3):427–452.

Ruggeri Laderchi, C. (2008). Do concepts matter? An empirical investigation of the differences between a capability and a monetary assessment of poverty. In Comim, F., Qizilbash, M., and Alkire, S., editors, The Capability Approach: Concepts, Measures and Applications, chapter 7, pages 203–241. Cambridge University Press, Cambridge.

Sen, A. K. (1984). Rights and capabilities. In Resources, Values and Development, pages 307–324. Harvard University Press, Cambridge/Mass.

Sen, A. K. (1985a). Commodities and Capabilities. North-Holland, Amsterdam.

Sen, A. K. (1985b). Well-being, agency and freedom: The Dewey lectures 1984. The Journal of Philosophy, 82(4):169–221.

Sen, A. K. (1992). Inequality Reexamined. Clarendon Press, Oxford.

Sen, A. K. (1993). Capability and well-being. In Nussbaum, M. C. and Sen, A. K., editors, The Quality of Life, pages 30–53. Clarendon Press, Oxford.

Sen, A. K. (2004). Capabilities, lists, and public reason: Continuing the conversation. Feminist Economics, 10(3):77–80.

Simar, L. and Wilson, P. W. (2007). Estimation and inference in two-stage semi-parametric models of production processes. Journal of Econometrics, 136:31–64.

Slesnick, D. T. (1998). Empirical approaches to the measurement of welfare. Journal of Economic Literature, 36(4):2108–2165.

Taylor, M. F. E. (2007). British household panel survey user manual volume A: Introduction, technical report and appendices. edited with John Brice, Nick Buck and Elaine Prentice-Lane. Colchester: University of Essex.

Thomson, G. (1987). Needs. Routledge & Kegan Paul, London.

Tulkens, H. (1993). On FDH efficiency analysis: Some methodological issues and applications to retail banking, courts, and urban transit. Journal of Productivity Analysis, 4(1/2):183–230.

UNDP (2006). Human development report. http://hdr.undp.org/hdr2006/report.cfm

Vizard, P. and Burchardt, T. (2007). Developing a capability list: Final recommendations of the equalities review steering group on measurement. SSRN Working Paper No.1159352.

Wilson, P. W. (1993). Detecting outliers in deterministic nonparametric frontier models with multiple outputs. Journal of Business & Economic Statistics, 11(3):319–323.

Witt, U. (2001). Learning to consume - a theory of wants and the growth of demand. Journal of Evolutionary Economics, 11:23–36.

Notes

[1] We follow Kuklys (2005) in notation.

[2] We are aware of the fact that one can be in principle sceptical regarding the use of analogies from production theory in the present context. Do individuals really produce achieved functionings? Do we use our income to produce health or happiness? While being aware of this line of criticism, we feel justified in using it here since such approaches have turned out to be quite fruitful (cf. Ramos, 2008; Kuklys, 2005; Farina et al., 2004; Dasgupta, 1990; Michael and Becker, 1973). In the remainder of the paper, we thus abstract from this fundamental objection.

[3] Our argument here is inspired by the theory of Witt (2001), who argues that such basic needs are identical to the biologically fixed primary reinforcers.

[4] A different way of defining efficiency is to look for the minimum of inputs used to produce a given level of output (input-orientation). In this paper we focus only on the output-orientation as it seems to be more appropriate in our set-up.

[5] For an extensive discussion on the (dis-) advantages of parametric and nonparametric approaches see Coelli and Perleman (1999) and Daraio and Simar (2007).

[6] The value of m has to be specified by the researcher. It can be seen as a "trimming parameter" defining the sensibility of the estimation with respect to outliers in the data. We follow Bonaccorsi et al. (2005) in setting the level of robustness to below ten percent. This means that ten percent of the observations have efficiency values smaller than one. Given 13,480 valid observations this holds for $m = 1500$.

[7] Individuals without household-income have been dropped from the sample. The same applies to individuals who have not reported on one or more of the indicator variables we use in our analysis. This means we had to discard 13.74% of the data of the original sample (15,627 observations).

[8] Due to the nonparametric nature of the efficiency analysis we use, the question of whether using a linear or log income proxy does not arise, so that we opted for the simplest way.

[9] This proxy is widely used in the psychological literature (for more details on this indicator cf. e.g. Gardner and Oswald, 2006; Clark and Oswald, 2002). All twelve questions are answered on an ordinal four point scale (0 to 3) and are then added up to the overall measure of well-being used in our analysis.

[10] As in the case of well-being, we had to reverse the numerical order of the Likert scale for technical reasons. The original coding in the BHPS codes a value of one to be excellent health and five to be very poor health. For our efficiency analysis we have to use high values in the output indicators to denote high achievement in this indicator.

[11] For more information cf. Taylor (2007), App. 2, pp. 18-9

[12] In light of the discussion by Simar and Wilson (2007) we checked the robustness of the model by estimating a truncated and tobit regression as well. The results did not change substantially. We also additionally checked the VIF diagnostics for potential multicollinearity but these were all satisfactory.