Conversion Efficiency as a Complementing Measure of Welfare in Capability Space

Binder, Martin and Broekel, Tom

Max Planck Institute of Economics, Evolutionary Economics Group, Department of Economic Geography, Faculty of Geosciences, Utrecht University

9 March 2008

Conversion Efficiency as a Complementing Measure of Welfare in Capability Space

Martin Binder [#] [§] Tom Broekel [$] [*]

[#] Max Planck Institute of Economics, Germany

[$] Department of Economic Geography,
Faculty of Geosciences, Utrecht University, The Netherlands

9th March 2008

Abstract

In the capability literature, studies on the empirical measurement in the functionings space are abundant and a few studies even measure capability to function. We suggest adopting a third measure of welfare relevant to economists, namely the "conversion efficiency" measuring the efficiency with which individuals convert their resources into achieved functioning. We use a nonparametric efficiency procedure and construct such a measure for a basket of basic functioning achievement, using data from the British Household Panel Survey (BHPS).

Keywords: conversion efficiency, welfare measurement, robust nonparametric efficiency analysis, functioning production
JEL-classification: I12, I31, R15

[§] *Corresponding author:* Martin Binder, Evolutionary Economics Group, Max Planck Institute of Economics, 07745 Jena, Germany. *Phone*: +49 3641 686 828. *Fax*: +49 3641 686 868. *E-mail*: binder@econ.mpg.de

[*] The authors would like to thank the participants of a seminar at the Evolutionary Economics Group of the Max Planck Institute of Economics for helpful comments and suggestions. We are also grateful for having been granted access to the BHPS data set, which was made available through the ESRC Data Archive. The data were originally collected by the ESRC Research Centre on Micro-social Change at the University of Essex (now incorporated within the Institute for Social and Economic Research). Neither the original collectors of the data nor the Archive bear any responsibility for the analyses or interpretations presented here. All errors are ours.

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 welfare measurement. Despite doubts about whether the approach can indeed be empirically useful and made operable (Sugden, 1993, p.1953), the capability approach has spawned a large literature of different approaches toward empirically capturing 'achieved functionings' (see Sen's own work, e.g. Sen (1985a) and see Kuklys (2005, pp.25-8) for a comprehensive overview). In contrast, measuring 'capability to function', i.e. the freedom and possibility to achieve certain functionings, is much more difficult. To the authors' knowledge, there are only very few studies on this subject (e.g. Anand and Hees, 2006).

The present paper wants to add to the empirical functioning measurement literature in adding a complementary measure beside the two strands of measures mentioned above. 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 *efficiency* with which individual resources are transformed into achieved functioning. The order-m efficiency method we suggest 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 effiency scores relative to that frontier allows some additional insights regarding the assessment of welfare in capability space (subject to some qualifications to be discussed later). Based on the idea that inefficencies are undesirable also in capability based welfare assessements, we argue that a measure of 'conversion efficiency' reflects diverse welfare-reducing institutional constraints on the individuals.

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 in capability space. We then proceed in section 4 to discuss the nonparametric efficiency analysis approach. The method is borrowed from the production efficiency literature.[1] 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 basket of "basic functionings" (Sen, 1993), namely for the functionings 'being happy', 'being educated' and 'being healthy'. We use the efficiency method to assess the conversion efficiency of this basket of functionings for the British Household Panel Survey (BHPS) dataset (BHPS, 2007; Taylor, 2007). Section 6 concludes.

[1]We are aware of the fact that one can be in principle skeptical as to 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 in this context (cf. Kuklys, 2005; Farina et al., 2004; Michael and Becker, 1973). In the remainder of the paper, we thus abstract from this fundamental objection.

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. Functionings thus describe the achievement of an individual. They give us the information about what a person is and what she does. Note that 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). This approach is *multi-dimensional* as a person's state of being (and her individual activities) is a vector of functionings. When choosing what way of life to live, a person chooses from different functioning vectors. The set of all feasible functioning vectors for a person is this person's *capability set*. It is a derived notion and represents the person's opportunities to achieve well-being (cf. Sugden, 1993, p.1951), reflecting the various functionings that are potentially achievable. It furthermore includes the person's freedom to choose between different ways of living. Note that we can distinguish between these two dimensions of functionings and capabilities. While there is a number of promising applications to measure functioning achievement, it is more difficult to actually measure the potentially achievable functionings (viz. the capabilities). Thus, most empirical accounts today focus on the narrower notion of functionings (but see Anand and Hees, 2006).

Let us have a closer look at the specification of the functionings as a measure of a person's well-being. In set-theoretic notation,[2] we can describe a vector of functionings as

$$\vec{b} = f_i(c(\vec{x})|\vec{z_i}, \vec{z_e}, \vec{z_s}) \tag{1}$$

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 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

[2] We follow Kuklys (2005, pp.10-1) in notation.

($\vec{z_e}$) influences. Individual factors could be sex, intelligence, physical (dis)abilities, etc. Social influences are legal regulations, population density, etc. Examples for environmental factors include climate, environmental pollution and so on (Kuklys, 2005, p.11). 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).

We can easily see how Sen has extended the standard welfare economic calculus to include relevant other factors which are often neglected: Functioning achievement depends on commodities ($\vec{x}$) *and* non-monetary constraints ($\vec{z_k}$).

In a second step, to evaluate individual welfare, we are interested in the capability set Q_i of an individual i. This set can now be defined as

$$Q_i(X_i) = \left\{ \vec{b_i} \,\middle|\, \vec{b_i} = f_i(c(\vec{x_i})\,|\vec{z_i}, \vec{z_e}, \vec{z_s}\,)\ \forall f_i \in F_i \wedge \forall \vec{x_i} \in X_i \right\} \tag{2}$$

It represents the set of all potential functionings an individual i can achieve given his constraints (X_i, $\vec{z_k}$).

The capability approach offers a genuine alternative to the empirical measurement of human welfare with a multi-dimensional measure. Though critics doubt that this approach might be operationalized (e.g. Sugden, 1993, p.1953), there has emerged a quite extensive literature on the empirical measurement of valuable functionings (Kuklys, 2005, pp.25-8, gives a survey).

However, Sen's approach has been devised with a certain openness regarding the selection of a set of valuable functionings. While Sen favors 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 measures welfare in capability space over an *ad hoc* range of different functionings. A different strategy to construct a set of valuable functionings that are supposedly valued by (virtually) all persons could lie in a basket of "basic functionings" (Sen, 1993): Such a basket would contain all these functionings that cater to 'basic needs'. As we will discuss in the following section, these basic needs share interesting features and can help to somewhat remedy this list selection problem. First, however, we will introduce the idea of 'conversion efficiency', relating to the conversion function discussed above.

3 On the Interpretation of Efficiency in Capability Space

We want to add to the empirical capability measurement literature a complementing measure beside functioning achievement and capability to function. We argue that the absolute measurement of capability (and functioning achievement) should be complemented by a measure more familiar to most economists, namely the *efficiency* with which individual resources are transformed into achieved functioning. Above we have seen that the transformation of a vector of commodities into achieved functionings depends on the conversion function of the individual, which is influenced by individual, social and environmental factors. As has been noted, this conversion function plays an important role in defining an individuals capability set and in determining the level of functioning achievement an individual can reach. It would be therefore interesting to examine the role and effects of the conversion factors.

Let us illustrate the idea of *conversion efficiency* with a small example. Consider two individuals who are similar with respect to their resources (measured by their income, i.e. with identical purchasing power). For both individuals information about their functioning achievement is available. In practice, this requires that a commonly agreed on definition of a vector of functionings is available which can be empirically measured (this holds similarly for the resource vector).

Given this information, let us assume that one individual shows lower values than the other individual in the level of achievement in one or more functionings. Both can spend the same resources for their functionings achievement (they have the same income). *Conversion efficiency* captures the difference in the functionings achievement that does not come from differences in these individuals' resources (incomes). Conversion efficiency thus captures the difference in functioning achievement that is caused by differences in the personal, social and environmental conversion factors.[3]

So what can be the reasons for these two individuals' levels of achieved functionings to differ despite their identical resources? Can they spend their income on things that do not increase functioning achievement? This would be the case if the *definition of the functionings vector* does not cover all functionings that are relevant to these two individuals (we will take up this question again below). The same can be argued for the resource vector. Maybe for some functionings, one would need other resources than the commodity vector. Might not be education be an individual's input when it comes to resources needed to achieve high 'material well-being'?! Indeed, this question points to a circularity in Sen's framework because some achieved functionings might be relevant resources to be transformed into other functionings. Or some functionings might be relevant conversion factors in the transformation of resources into achieved functioning ('being healthy' would influence 'being happy' according to findings in happiness research, and maybe vice versa).[4]

Consider the given commodity vector that is transformed into functioning achievement

[3]Obviously, this concept builds on the assumption that it takes resources (measured as income) for people to increase their levels of functionings.

[4]In this respect, variance in the individual levels of functionings achievement can be a result of improper definitions of the *functionings* as well as the *resource* vectors. This seems to be mainly an empirical problem and hence, it is abstracted from this at this stage.

(equation 1) subject to conversion factors. If we control for such personal conversion factors as age or gender, we still find other environmental or institutional conversion factors that determine how much of the commodities are needed to reach a given level of functioning achievement. We argue that it is these remaining conversion factors which we can capture with a measure of 'conversion efficiency'.

Let us discuss this in more detail. An efficiency measure as the one we are talking about basically reflects how efficient given inputs are transformed into outputs. In our case, output is 'achieved functioning' and input is income, understood as a proxy for the goods vector in the Senian framework. An efficiency analysis then is done for a given group of individuals. A frontier of efficient individuals is calculated. On this frontier, one finds these individuals that are efficient in reaching the highest level of achievement with given different levels of resources. Note that this reflects the idea of a relative efficiency, i.e. 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 very sound approach. On such a relative frontier can be individuals with low achievements and low resources (but these low resources are transformed very efficiently) and individuals with high achievements and high resources (but also with an efficient transformation).

Based on this, we argue that some individuals at a given time are efficient in their use of their income (of whatever level) in achieving valuable functionings. Others are not efficient (to varying degrees, as measured by their distance to the efficient frontier). But what does that mean? Let us consider first the ideal case of a comprehensive functioning measure that includes all valuable functionings which constitute welfare. This would be a comprehensive measure of welfare in capability space and encompass all that makes a human life go well according to the capability definition (it would capture all that is valued by the individuals). Some people are efficient in transforming their resources into such a comprehensive output measure.

Our argument is that regardless of the absolute height of functioning achievement, inefficiency in transformation is undesirable from an economic point of view. This inefficiency is reflected in our measure of conversion efficiency. Of course, this measure should be understood as a complement to the other two capability measures of welfare because of its relative nature. 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).

In that respect, a distribution of efficiency scores offers the analyst valuable information whether there exist obstacles in the conversion of resources into functionings achievement. Given that a set of suitable controls is included in the analysis, it is thus possible to single out these obstacles as not being individual differences but (for example) institutional (or environmental) constraints. Individuals on the efficiency frontier constitute in this case the best-practice in functioning achievement. Note that such a reference group does not constitute an ideal maximum of functioning achievement but the *realiter* existing best group in terms of conversion efficiency. Other 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 transforming their resources into achieved functioning.

The frontier here thus 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). The more people falling short of this (as measured by the distribution of distance to the frontier and controlling for individual factors), the less favorable are the overall societal conditions for the transformation of given resources into functioning achievement. We interpret this as institutional shortcomings that create a barrier for a certain group of people.[5] Naturally, these distributions could be evaluated in cross-country comparisons or one could analyze their change over given time spans.[6]

There are two important extreme cases that are worth our attention. Consider on the one hand the very rich person who has a maximal achieved functioning and excess income. Whether it is indeed possible to achieve maximum functionings is matter of debate which has been never addressed in the capability literature (especially since it often aims at applications for measuring poverty and since it is not clear what the complete set of functionings would be). If so, such a rich individual could turn out to be inefficient in his resource use despite maximum achievement. We think that although this might seem *prima facie* counter-intuitive, the wealth here is inefficiently distributed from a societal perspective. From this aggregate perspective, there seems nothing wrong with arguing that this individual is not efficient in the conversion of resources into functioning achievement (i.e. that individual has too much resources given the level of achieved functionings). From an egalitarian point of view, the excess resources could be used somewhere else. Furthermore, regarding the comprehensive capability welfare measure, it is unlikely to find many cases of individuals who have maximal functioning achievement in all functionings (considering the many conceivable functionings in that set).

The other extreme case concerns the very poor individual having very low but very efficient functioning achievement. Again, in a restricted view on conversion efficiency, this case is problematic since absolute poverty would be masked behind relative efficiency. Therefore we argue that conversion efficiency can only be a complement to the absolute functioning measures. The aim of our measure is to identify inefficiencies ('slack') for given levels of functioning achievement. This has been always an important aim in economics but seems to have been somewhat

[5] There may exist constraints even for the efficient individuals. However, from the point of view of our approach, we are interested in these constraints that result in inequality, i.e. which affect only subgroups of people (and here rather the less well-off subgroups). The analysis suggested here is thus well suited in examining relative inequalities.

[6] Both ideas are not exercised in this paper but kept for future work.

neglected in the capability literature. We aim at capturing these inefficiencies which are at an institutional level by correcting for individual effects coming from personal characteristics such as age, gender etc.

One last qualification is in order. The method becomes a little more problematic in the less ideal case of considering as output only a 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 transformation of given resources into achieved functioning regarding happiness, health and education. One could imagine a case where an individual having many resources scores low in efficiency for these functionings because only a subset of functionings is examined. Maybe that individual has picked an overall capability set that is efficient in the overall transformation of resources into achieved functioning but not regarding the subset of functionings examined (one could imagine a resourceful person not having much interest in his health and thus neglecting this field, or someone being focused on one functioning and pouring inefficient amounts of resources here).

Indeed, when focusing on a subset of functionings as output in the analysis, this line of criticism cannot be excluded completely. Therefore, we argue that this kind of analysis should only be conducted for subsets of functionings such as "basic functionings" (Sen, 1993), where one can argue that everyone is interested in the efficient transformation of resources into these functionings. By basic functionings, one could understand all these functionings that relate to the fulfillment of 'basic needs'. In that sense, everyone has these basic needs in order to survive and/or lead a healthy life. These basic functionings defined on basic needs would be a set of functionings that is "inescapable" (Thomson, 1987), i.e. we all share them, for example because the underlying needs are biologically fixed (our argument here draws on the theory of Witt, 2001, who argues that such basic needs are identical to the biologically fixed primary reinforcers). A set of such basic functionings would indeed (with usual genetic variance) be shared by everyone and one has good arguments that these are valued by everyone.

If we can assume that in the case of basic functionings, everyone has the same preferences then the differences in conversion efficiency can be attributed to constraining factors such as argued above. In such a case, the analyst would not need fear that someone would achieve low efficiency scores because that individual is not interested in (efficiently) transforming given resources into achieved functioning (the idea of different efficiencies and their relevance for welfare economics has 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 constraints which should be the aim of welfare policies.

We will now turn to a detailed discussion of our nonparametric approach to measuring conversion efficiency. After this discussion, we then exemplify the method with an analysis of a limited set of functionings.

4 A Nonparametric Approach to Efficiency Measurement

Having discussed the theoretical foundations of the capability approach and our idea of a measure of ‘conversion efficiency’, we now turn to the empirical measurement with a robust nonparametric efficiency analysis. An efficiency analysis can be conducted in a parametric or nonparametric form. We share the concerns about parametric efficiency analysis brought forward by Ravallion (2005): Having to specify a functional form is only one of the problems noted by Ravallion that comes from adopting a parametric efficiency analysis. Similarly, in parametric models, the functional form of the transformation process of resources into functioning achievement is assumed to be identical for all individuals. Our approach differs in this respect since the nonparametric efficiency analysis does not require to specify the functional relationship *ex-ante*; nor do we need to assume that individuals transform their resources into functioning achievement in an identical manner. Thus, our approach is more general and does not require strong assumptions concerning the relationship of the variables. We are thus not affected by the main thrust of the Ravallion criticism.

The order-m efficiency method we suggest allows us to compute an efficient frontier for a given sample of individuals. On the frontier are these individuals which are most efficient in transforming their resources into achieved functioning. The distribution of effiency scores relative to that frontier allows some additional insights regarding the assessment of welfare in capability space (subject to some qualifications to be discussed below). Based on the idea that inefficencies are undesirable also in capability based welfare assessements, we argue that such a measure of ‘conversion efficiency’ reflects diverse welfare-reducing institutional constraints on the individuals.

The specific non-convex, order-m nonparametric efficiency analysis employed in this paper, seems to be particularly appealing because of the comparatively few assumptions that have to be made. Its main idea is very simple: individuals are compared to each other on the basis of the principle of *weak dominance* with respect to their endowment with resources and observed functionings achievement. In the following this method is presented only briefly. For an extensive treatment of this method see, e.g., Daraio and Simar (2007) and for an introduction into efficiency analysis see, e.g., Cooper et al. (2004).

More precisely, in a first step, the *best-practice* individuals with respect to their levels of functionings achievement and levels of resources are identified. Using the principle of *weak dominance*, the *best-practice* individuals are characterized by that no other individual with an equal or lower level of resources, shows a higher level of functionings achievement. Thus, individuals are compared to other individuals having similar (i.e. equal or lower) levels of resources.[7] All individuals that fulfill this criteria form an individual’s *reference group*. Depen-

[7]This corresponds to an output-oriented efficiency analysis (see Cooper et al., 2004). In the context

dent on the individual's levels of resources this reference group differs for each individual.

If in comparison to this reference group an individual's level of functionings achievement is higher the individual becomes part of the best-practice frontier and it is declared efficient. If its level of functionings achievement is below that of the reference group, i.e. it is located below the best-practice frontier, it is declared inefficient. The distance to the efficiency frontier indicates its degree of inefficiency. In the presented approach this distance reflects the vertical (Euclidean) distance between the observations and the efficiency frontier. The larger the distance the more inefficient is an individual.

The described procedure has been formulated as the Free Disposal Hull (FDH) approach by Deprins et al. (1984). It is apparent that an efficiency frontier defined in this way is determined by the extreme positive (most efficient) observations making the efficiency analysis very sensitive with respect to the existence of outliers and noise in the data (see, e.g., Wilson, 1993). This drawback has been overcome by the introduction of *robust* nonparametric frontier techniques (see for an introduction Daraio and Simar, 2007). 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 FDH approach, the idea behind the order-m approach is that instead of evaluating an observation's efficiency with respect to the efficiency of *all* other observations, Cazals et al. (2002) propose to compare them to a randomly drawn (sub-) sample of observations.[8] This makes the nonparametric frontier function a *partial* frontier because not all observations are enveloped but only a sub-sample. Based on the partial frontier the evaluation of individuals' efficiencies as well as the estimation of the efficiency scores are done in an identical manner as presented above in case of the FDH approach. More precisely, it shows as the following.

For a multivariate case consider (x_0, y_0) as the resource vector x_0 and y_0 as the functionings achievement vector of individual 0. $X^1, ..., X^m$ are the m random variables drawn from the conditional distribution function of X given $Y \geq y_0$. $\tilde{\theta}_m(x_0, y_0)$ then measures the distance between point x_0 and the order-m frontier of $X^1, ..., X^m$. It can be written as:

$$\tilde{\theta}_m(x_0, y_0) = \underset{i=1,\ldots,m}{min} \left\{ \underset{j,\ldots,p}{max}(\frac{X^{i,j}}{x^{i_0}}) \right\} \tag{3}$$

with $X^{i,j}(x_0^j)$ being the jth component of X^i (of x_0 respectively). This frontier represents the expected minimum achievable input-level among m individuals drawn randomly (with replacement) from the population which show at least the functionings achievement level of unit 0.

here, an output-oriented framework seems to be appropriate as it is the aim of the analysis to identify obstacles that hinder people to achieve 'maximal' functionings achievement, i.e. it is evaluated whether they show less functioning achievement than what can be expected given their resource endowment.

[8]The sub-sample's size has to be specified by the researcher and is denoted by m, giving the name to the procedure. In this respect m 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, i.e. ten percent of the units are outside the frontier. Given 13,773 valid observations this is true for $m = 1500$.

The order-*m* efficiency measure of individual (x_0, y_0) is defined as

$$\theta_m(x_0, y_0) = E[\tilde{\theta}_m(x_0, y_0)|Y \geq y_o] \ . \tag{4}$$

Cazals et al. (2002) show that this order-m efficiency measure is less sensitive to outliers and statistical noise in the data because the (partial) order-m frontier is not enveloping all observations.[9]

As pointed out before, the efficiency scores measure the distance of an individual to the efficiency frontier. In contrast to the traditional FDH approach, the order-m Farrell efficiency scores can take values smaller than one and hence, they can range from > 0 to $+\inf$. Values smaller or equal to one indicate efficiency, while values larger than one represent inefficiency.

Since individuals with *similar* resource endowments but different levels of functionings achievement are compared in this procedure, the effect of the variance in the resource endowments is excluded from the resulting efficiency measure (which is the motivation for the efficiency analysis in the first place).

But which factors effect an individuals' efficiency to transform resources into functioning achievement? This is subject to the second stage in which a number of factors are regressed on the obtained efficiency scores. This is motivated by the fact that there are some factors that are not under the control of an individual (for example, they might be set by the environment). Such exogenously fixed factors may however have an influence on the individual's ability to transform his resources into achieved functionings (Beguin and Simar, 2004). For example the previously mentioned obstacles fall into this category. In the second stage this influence is thus tested with regression analysis on the previously estimated efficiency scores. Furthermore, variables that cannot be a direct part of the efficiency analysis because of their dichotomous nature (the order-m frontier analysis requires at least ordinal-scaled variables) are included in this stage as well.

To see whether the dichotomous variables influence our results, we incorporate them into the second stage. In this second stage, we apply a standard OLS regression in which the environmental factors are regressed on the order-m efficiency scores. This type of two-stage approach has been recently criticized by Simar and Wilson (2007). Regarding traditional non-robust non-parametric frontier models (such as Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH) models), these authors argue that standard approaches to inference are invalid because of boundary problems (the efficiency scores are always larger than or equal to one in these approaches and an output-orientation) as well as because of the serial correlation of the efficiency scores. However, there are reasons for why this critique is less appropriate in our setting, i.e. when using the order-m approach. First, order-m efficiency scores can take on values smaller

[9] As suggested by Cazals et al. (2002), the order-m efficiency analysis is conducted by using a Monte-Carlo approximation. We follow Simar (2003) in using $B = 200$ replications for the Monte-Carlo approximation and refer there for further particulars.

than one and hence the boundary problem is of smaller relevance. Second, the serial correlation of the order-m efficiency scores is likely to be less strong because of its being a partial frontier approach. Third, in contrast to DEA or FDH models, the rate of convergence of the order-m efficiency corresponds to that of standard parametric models, namely $n^{-\frac{1}{2}}$ (Wheelock and Wilson, 2003). Hence, a standard OLS approach seems to be an appropriate choice.

5 Data and Findings

5.1 Data Set

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.

The first wave was created with a two-stage clustered probability design and systematic sampling. Sample units were selected with the small users Postcode Address File (PAF). 250 postcode sectors were first selected as Primary Sampling Units (PSU). These were stratified by region and socio-demographic variables derived from the 1981 census. In stage two of the process, addresses were selected in a similar fashion.

The aim of all further waves was to track the individuals of the first wave over time. 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.

5.2 Indicator Selection and Descriptive Statistics

To construct a basket of ‘basic functionings’ we choose different indicators for the three functionings ‘being happy’, ‘being educated’ and ‘being healthy’. We conceive of the individual as a locus of production where inputs factors are converted into output. In this case, the input is represented by an individual’s income. We take income to be the proxy for the commodity vector in Sen’s 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 three dimensions named above.

As in production analysis, two different kinds of variables can influence the output (Banker and Morey, 1986). These are input factors on the one hand and exogenously fixed other factors.

Characteristic of the input factors is that they are sufficiently under an individual's control. In the case of income, the individual can choose how to transform it into output (we assume that this is on average the case to a sufficient degree). Other exogenous factors are not sufficiently under control of the individual. These are the conversion factors some of which are used in the second stage of our approach.

Income, adjusted (GBP)	Min	Max	Mean	SD
	.2	504,991.90	12,005.45	10,098.08
Well-Being (GHQ-12)	Min	Max	Mean	SD
	1	37	25.72	5.49
Health Status last 12 months	absolute	%	Mean	SD
			3.83	0.92
very poor	252	1.83		
poor	954	6.93		
fair	2,834	20.58		
good	6,578	47.76		
excellent	3,155	22.91		
Highest Academic Qualification	absolute	%	Mean	SD
			3.19	1.76
none of these	3,834	27.84		
cse	686	4.98		
o level	3,576	25.96		
a level	2,734	19.85		
hnd,hnc,teaching	962	6.98		
1st degree	1,569	11.39		
higher degree	412	2.99		

Table 1: Descriptive Statistics - Input & Output Indicators

Let us now discuss the proxies we choose to measure inputs, outputs and conversion factors. Table 1 gives an overview of the input income and our three outputs and the proxies we use to measure them. We are using the most 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 13,773 individuals. This includes all individuals of the BHPS that report a positive (however small) income (after transformation, see below). 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 11.86% of the data of the original sample (15,627 observations).

While the mean gross income of our sample in 2006 is 15,240.1 GBP (standard deviation of 17,056.65 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 income as it depends on the income of the household. We therefore added up the incomes of all household members and divided them by the number of household members. While this still neglects the insights drawn from the literature of equivalence scales (cf. Kuklys, 2005, ch.5), we feel that our indicator is thus less distorted than it were if we were just taking the reported income. Mean income per person of a household is according to our calculation 12,005.45 GBP (s.d. 10,098.08 GBP).

Concerning our first functioning achievement 'being happy' we have chosen the individual's assessment of mental well-being as a proxy. 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. 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 25.72 (s.d. 5.49). This proxy is widely used in the psychological literature (for more details on this indicator cf. e.g. Gardner and Oswald, 2001; Clark and Oswald, 2002).

To measure functioning achievement 'being healthy' we have chosen to use an individual's subjective assessment of health (during the last 12 months). This is ordinally scaled on a five point Likert scale, ranging from 'excellent' (five) to 'very poor' (one).[10] Mean health is 3.83 (s.d. 0.92). Note that 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 (cf. 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.

Achieved functioning 'being educated' is measured by an individual's highest level of education. Again, this measured ordinally, ranging from one ('none of these') to seven ('higher degree'), giving intermediate values to the middle education levels.[11] The summary statistics of our output variables are depicted in table 1. Note that all three output variables are correlated with our input measure of per-person income to varying degrees. Our indicator 'being happy' is correlated with income at $r = 0.0810$, income and health are correlated at $r = 0.1201$ and income and education at $r = 0.3039$ (all Spearman rank correlations). Measures of well-being are generally very low correlated with income in intra-country cross-sections (Bechtel, 2007).

The last category of variables concerns the conversion factors. As has been said, these are variables we include in the second stage of the analysis. We have decided to use gender, age as well as some dummies regarding job status and individual marriage status as a selection of some of the most important individual factor influencing achieved functioning. These factors and their descriptive statistics are summed up in table 2.

[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

Age		Min	Max	Mean	SD
		15	99	45.67	18.47
Gender		absolute	%		
	male	6,201	45.02		
	female	7,572	54.98		
Job Status		absolute	%		
	Self-employed	937	6.80		
	unemployed	431	3.13		
Marriage Status		absolute	%		
	married	7,186	52.17		
	separated, divorced, widowed	2,419	17.56		

Table 2: Descriptive Statistics - Control Variables

Of our sample, 54.98% (7,572 individuals) were female. Mean age is 45.67 years (s.d. 18.47) with maximum age at 99 years and mimimum age at 15 (younger individuals were not interviewed in the BHPS). We decided to include dummies for being married (52.17%) and for being widowed or separated or divorced (17.56%) as special relationship conversion factors, the former being a positive conversion factor, the latter a negative one. Regarding work status, we have included dummy variables for being self-employed and being unemployed. Of the sample 6.80% fell into the category self-employed and 3.13% were unemployed.

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 conversion factors. Note however a certain circularity inherent in Sen's framework because an individual's health could also influence the conversion of resources into achieved functioning (in general, parts of the output also influence the conversion and vice versa).

5.3 Findings and Discussion

The first impression on the results is that there exists a comparatively large number of individuals which transform their resources efficiently into functioning achievement: $3,218$ individuals are found to be efficient in their conversion. In relation to the $13,773$ valid observations, this is 23.36 percent. Of interest is also the mean of the inefficient observations which is about 1.33. This indicates two things: First there is quite a number of individuals showing inefficiency in Great Britain. 76.64 percent of the individuals in the sample are not able to transform their resources into functioning achievement as efficiently as the best 23.36 percent. Second, the mean of 1.33 shows that the average 'inefficient' individual achieves about 33% 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 $1,500$ randomly drawn individuals that have equal or less resources as the individual under observation.

This 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 close to the mean. While we observe a long 'tail' of efficiency scores larger than 1.8 these represent only about 3 percent of the individuals in the sample. Hence, the degree of inefficiency here is rather small.

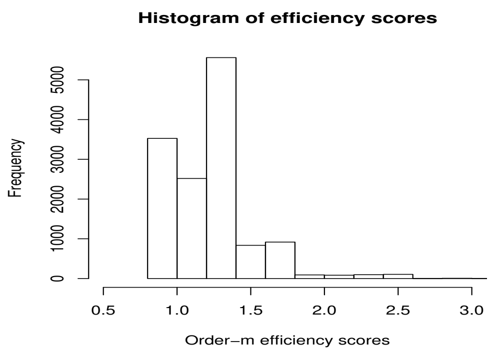

Figure 1: Histogram of Efficiency Scores

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 number of other factors not included into the analysis. As pointed out before, we employ an ordinary-least-square regression to evaluate the effect of five factors that are most commonly said 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.

Coefficients:	Estimate	Std. Error	t value	Pr(>|t|)	Sig.
(Intercept)	1.1397390	0.0069531	163.919	< 2e-16	***
age	0.0027927	0.0001655	16.873	< 2e-16	***
d_male	-0.0438853	0.0049534	-8.860	< 2e-16	***
d_selfempl.	-0.0624656	0.0097234	-6.424	1.37e-10	***
d_unemployed	0.1109389	0.0140097	7.919	2.58e-15	***
d_married	-0.0171725	0.0065846	-2.608	0.00912	**
d_sepdivwid	0.0456222	0.0088151	5.175	2.31e-07	***
Signif. codes: 0 (***) 0.001 (**) 0.01 (*) 0.05 (.) 0.1 ( ) 1					
Residual standard error: 0.283 on 13766 degrees of freedom					
Multiple R-Squared: 0.05554, Adjusted R-squared: 0.05513					
F-statistic: 134.9 on 6 and 13766 DF, p-value: < 2.2e-16					

Table 3: Second-stage Regression Results

Table 3 shows the second-stage regression results for age, sex (d_male), being self-employment (d_selfempl.), being unemployment (d_unemployed), being married (d_married), and being separated, divorced or widowed (d_sepdivwid).[12] The 'd_' indicates the variable being constructed as a dummy with the value 1 for 'yes' and 0 for 'no'.

With the exception of marriage status, we find a highly significant relationship with the order-m efficiency scores for all variables. In detail, we find that being female, young, self-

[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.

employed, not being unemployed, and not being separated, divorced or widowed increases the conversion efficiency.

These findings support several well-known results from the literature. 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 from two individuals with the same resources, the one being self-employed is more efficient in the conversion of his resources into achieved functioning.

Similarly straightforward is the case of the positive coefficient for d_sepdivwid. The negative experiences of being separated, divorced, or widowed is likely to be an obstacle in the conversion of the given commodities into achieved functioning.

In the literature, one can find also that elder people score lower in the achievement of absolute functionings (Chiappero Martinetti, 2000). Our results add that being older also means being less efficient in the conversion of resources into functionings achievement.

A last (and perhaps more puzzling) result regards gender. While it is usually reported that female individuals score lower in functionings achievements (Sen, 1985a; Chiappero Martinetti, 2000), we find that being female nevertheless increases the efficiency in transforming one's resources into this achievement. One could argue that while women are still disadvantaged as regards absolute levels of functionings achievement, they have learned to more efficiently convert their resources into functioning achievement. Given lower absolute functioning achievement, this explanation seems more likely than arguing that women face less institutional barriers that hamper their conversion of resources into achieved functioning. This example is an instance that 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 evaluating the results.

Note also the correlation between the variables, see table 4. For example, not surprisingly d_married and d_sepdivwid are strongly negatively correlated ($r = -0.482^{***}$). Similarly age and married status are positively correlated. Hence, the low significance of d_married in the regression is likely a result of parts of its influence being accounted for by these two variables.

	d_male	age	d_selfempl	d_unemployed	d_married
age	-0.010				
d_selfempl	0.150^{***}	-0.007			
d_unemployed	0.034	-0.116^{***}	-0.049^{***}		
d_married	0.055^{***}	0.287^{***}	0.063^{***}	-0.103^{***}	
d_sepdivwid	-0.128^{***}	0.333^{***}	-0.029	0.001	-0.482^{***}

Table 4: Pearson Correlation of Control Variables

Summarizing, we find that the analysis confirms and complements some findings in the literature on absolute functionings achievement. Moreover, the analysis adds to a better understanding of the relation between individuals' resource endowment and their achieved functionings. We find that the conversion efficiency is positively affected by being female, young, self-employed, not unemployed and not being separated, divorced or widowed (our findings for being married were not significant). With the second-stage regression we have shown that the obtained efficiency scores are related to the existence of obstacles, e.g. institutional setups, that influence individuals' abilities to achieve valuable functionings given their resources.

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 controls (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 in the 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. Beside the information discussed in this section, it is of course desirable to understand our analysis only as a first step in identifying these unknown constraints. This however has to be accomplished in a qualitative analysis which could be used to single out different possible constraints. These could then be included in a second analysis of the type conducted in this paper and the analyst could thus assess whether inclusion of the factor identified would lead to a more favorable distribution of conversion efficiency scores (by which we mean higher numbers of efficient individuals and/or lower means of the inefficient individuals). We consider such an analysis to be the next step in future research in this direction. Another direction to extend this line of research would consist in building a more comprehensive basket of basic functionings and choose more carefully (than in this exemplification) the proxies for the measurement exercise. And as has been alluded to, cross-country comparisons as well as the dynamic development of conversion efficiency also provide interesting research possibilities. In the case of cross-country comparisons, 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.

6 Conclusion

In the capability literature, studies on the empirical measurement in the functionings space are abundant and a few studies even measure capability to function. We have argued that the absolute measurement of functioning achievement (and capability to function) should be complemented by a measure more familiar to most economists, namely the efficiency with which individual resources are transformed into achieved functioning. We have called this measure 'conversion efficiency'. We have used a nonparametric efficiency procedure and constructed such a measure for a basket of basic functioning achievement (comprising of the functionings 'being happy', 'being healthy' and 'being educated'), 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 in capability space. Based on the idea that inefficiencies are undesirable also in capability based welfare assessments, we argue that a measure of 'conversion efficiency' reflects diverse welfare-reducing institutional constraints on the individuals. We have found out that in our sample around 23% of the individuals can be considered efficient while the mean of the inefficient individuals reaches one third less functioning achievement with a similar income as the efficient individuals. Moreover, the analysis adds to a better understanding of the relation between individuals' resource endowment and achieved functionings. We found out that the conversion efficiency is positively affected by being female, young, not unemployed, self-employed and not being separated, divorced or widowed. A next step would be to extend the analysis over different countries or intertemporally.

References

Anand, P. and Hees, M. v. (2006). Capabilities And Achievements: An Empirical Study. *Journal of Socio-Economics*, 35:268–284.

Banker, R. D. and Morey, R. C. (1986). Efficiency Analysis for Exogenously Fixed Inputs and Outputs. *Operations Research*, 34(4):513–521.

Bechtel, T. G. (2007). The Pursuit of Happiness. *Survey Research Methods*, 1(2):109–120.

Beguin, C. and Simar, L. (2004). Analysis of the Expenses Linked to Hospital Stays: How to Detect Outliers. *Health Care Management Science*, 7:89–96.

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/.

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.

Cazals, C., Florens, J.-P., and Simar, L. (2002). Nonparametric Frontier Estimation: A Robust Approach. *Journal of Econometrics*, 106(1):1–25.

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.

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.

Cooper, W. W., Seiford, L. M., and Zhu, J. (2004). Data Envelopment Analysis: History, Models and Interpretations. In *Handbook on Data Envelopment Analysis*. Kluwer Academic Publishers, Boston.

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

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.

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. (2001). Does Money Buy Happiness? A Longitudinal Study Using Data on Windfalls. Discussion Paper.

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.

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. (2000). *Women And Human Development*. Cambridge University Press, Cambridge.

Ravallion, M. (2005). On Measuring Aggregate "Social Efficiency". *Economic Development and Cultural Change*, 53(2):273–292.

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

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

Sen, A. (1985b). Well-Being, Agency and Freedom: The Dewey Lectures 1984. *The Journal of Philosophy*, 82(4):169–221.

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

Sen, A. (1993). Capability and Well-Being. In Nussbaum, M. and Sen, A., editors, *The Quality of Life*, pages 30–53. Clarendon Press, Oxford.

Simar, L. (2003). Detecting Outliers in Frontier Models: A Simple Approach. *Journal of Productivity Analysis*, 20:391–424.

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.

Sugden, R. (1993). Welfare, Resources, and Capabilities: A Review of Inequality Reexamined by Amartya Sen. *Journal of Economic Literature*, 31(4):1947–1962.

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.

Wheelock, D. C. and Wilson, P. W. (2003). Robust Nonparametric Estimation of Efficiency and Technical Change in U.S. Commercial Banking. *The Federal Reserve Bank of St. Louis Working Paper Series*, 37A:1–34.

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.