International Journal of Management and Sustainability
2018 Vol. 7, No. 1, pp. 63-71
ISSN(e): 2306-0662
ISSN(p): 2306-9856
DOI: 10.18488/journal.11.2018.71.63.71

SOME THOUGHTS ON OPERATIONALIZING THE CONCEPT OF SUFFICIENCY IN EFFICIENCY ANALYSIS

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Article History
Received: 9 April 2018
Revised: 2 May 2018
Accepted: 8 May 2018
Published: 14 May 2018

Keywords
Data Envelopment Analysis
EATWOS
EATWIOS
Efficiency
Productivity
Sufficiency
Sustainability

ABSTRACT

The concept of sufficiency is rarely acknowledged in mainstream business economics and has not been addressed so far in the literature on efficiency analysis. In this paper, satisficing levels as known from the Efficiency Analysis Technique With Output Satisficing (EATWOS) and from its extension Efficiency Analysis Technique With Input and Output Satisficing (EATWIOS) are suggested to operationalize sufficiency in efficiency analysis. Moreover, a simple data transformation approach is proposed in order to use satisficing levels in other efficiency analysis techniques, particularly in the widely used Data Envelopment Analysis (DEA).

Contribution/Originality: This paper contributes to the literature on efficiency analysis and to the literature on sustainable development. Its primary contribution is to operationalize sufficiency in efficiency analysis by utilizing the concept of satisficing levels.

1. INTRODUCTION

The concept of sufficiency introduced by Frankfurt (1987) into the field of practical philosophy has been discussed by several philosophers (e.g. (Glannon, 1995; Rosenberg, 1995; Crisp, 2003; Benbaji, 2006; Axelsen and Nielsen, 2015)). Philosophical scholars have dealt with the principle that all humans should have enough (money, opportunities, resources, utility or welfare) and with distributive justice (e.g. (Frankfurt, 1987; Axelsen and Nielsen, 2015)). After some early contributions (Daly, 1977; Durning, 1991) more recently sufficiency has been considered widely in the literature on sustainable development and especially in the ecologically oriented literature (e.g. (Mauch *et al.*, 2001; Dyllick and Hockerts, 2002; Princen, 2003;2005; Alcott, 2008; Mont and Plepys, 2008; Hilty *et al.*, 2011; Schäpke and Rauschmayer, 2014; Allievi *et al.*, 2015; Spengler, 2016)). In this context, sufficiency is regularly concerned with modifying patterns of consumption (Mauch *et al.*, 2001; Griese *et al.*, 2015; Moser *et al.*, 2015). It is proposed that individuals should restrain their consumption (Princen, 2003;2005) and focus on what is essential to well-being (Mauch *et al.*, 2001). Thus, it is aimed at limiting or even reducing consumption (Schäpke and Rauschmayer, 2014; Griese *et al.*, 2015). Though sufficiency refers primarily to individual consumers, Figge *et* *al.* (2014) advocate sufficiency as a strategy for companies, since decision makers may pursue not only economic objectives, but environmental and social objectives as well.

Daly (1993) has already stated: "It will be very difficult to define sufficiency and build the concept into economic theory and practice" (p. 361). However, sufficiency is still rarely acknowledged in mainstream business economics, although it is often contrasted with the concept of efficiency in the literature on sustainable development and many scholars are claiming to apply both concepts together (e.g. (Mauch *et al.*, 2001; Mont and Plepys, 2008; Hilty *et al.*, 2011; Schäpke and Rauschmayer, 2014)). Allievi *et al.* (2015) have made a first step in this direction by calculating two simple indicators to measure efficiency and sufficiency, respectively, of 10 different regions of the world. But, sufficiency has not been addressed so far in the literature on efficiency analysis.

However, it is out of the scope of this paper to deal with distributive justice or with changing patterns of consumption. Instead, the present paper offers some thoughts on incorporating sufficiency into efficiency analysis and thus seeks to make a small step forward to introduce sufficiency into the field of business economics.

2. EFFICIENCY

Productivity – defined as ratio of the quantity of one output type (e.g. sales revenue) to the quantity of one input type (e.g. number of workers) – is frequently used as measure of efficiency (e.g. (Cooper *et al.*, 2007; Fried *et al.*, 2008; Cook and Seiford, 2009)). But often it is required to consider the quantities of multiple output types (or shortly referred to as outputs) and the quantities of multiple input types (or shortly referred to as inputs), when measuring the efficiency of so-called Decision Making Units (DMUs) (Charnes *et al.*, 1978) such as branch banks, hospitals, hotels, retail chain stores, sports teams or university departments. Then, each DMU i is represented by J output quantities $y_{i,j} \geq 0$ (with $j = 1, \ldots, J$) and K input quantities $x_{i,k} \geq 0$ (with $k = 1, \ldots, K$), while it is often assumed that each DMU considered has at least on positive output quantity and at least one positive input quantity (e.g. (Seiford and Thrall, 1990; Cooper *et al.*, 2011)). Moreover, importance weights v_j and w_k are required for outputs and inputs respectively, because the outputs as well as the inputs are being regularly measured in different dimensions. A fraction with output quantities multiplied by the respective output importance weights in the numerator and input quantities multiplied by the respective input importance weights in the denominator is defined as measure of efficiency:

$$\frac{\sum_{j=1}^{J} v_j * y_{i,j}}{\sum_{k=1}^{K} w_k * x_{i,k}}$$

Efficiency measures of this type form the basis of many efficiency analysis techniques like Data Envelopment Analysis (DEA) (Charnes *et al.*, 1978; Cooper *et al.*, 2006;2007; Zhu, 2016) and Efficiency Analysis Technique With Output Satisficing (EATWOS) (e.g. Peters and Zelewski (2006)) as well as its extension Efficiency Analysis Technique With Input and Output Satisficing (EATWIOS) (e.g. Peters *et al.* (2012)). Especially, DEA has been extensively employed to analyze the efficiency of DMUs and is widely accepted in the field of business economics (e.g. (De Castro and Frazzon, 2017; Emrouznejad and Yang, 2018)). Furthermore, several DEA models have been developed to measure eco-efficiency (e.g. (Kuosmanen and Kortelainen, 2005; Sanjuan *et al.*, 2011; Lahouel, 2016)).

3. SUFFICIENCY AND SATISFICING

Spengler (2016) stresses that Frankfurt (1987) has considered two kinds of sufficiency. On the one hand, sufficiency is interpreted as a maximum level (or more precisely an upper level) that is desirable to attain, while quantities above this level are undesirable (Frankfurt, 1987; Spengler, 2016). On the other hand, sufficiency is understood as a minimum level (or more precisely a lower level) that should be attained, while it is not compulsory that higher quantities are not desirable (Frankfurt, 1987; Spengler, 2016).

The understanding of sufficiency as a level that is desirable to attain corresponds to the concept of satisficing. Firstly, there may be a linguistic proximity, since some scholars claim that satisficing is a combination of the words "satisfy" or "satisfying" and "suffice" (e.g. (Manktelow, 2012; Iannone, 2016)) while Simon who introduced the concept of satisficing (Simon, 1956;1972;1990;1997) asserts that satisficing is a "Scottish word" (Simon, 1972). Secondly, satisficing has been taken up extensively in the field of Multi Criteria Decision Making (MCDM), in particular in Goal Programming (e.g. (Zionts, 1992; Rehman and Romero, 1993; Schniederjans, 1995; Munoz *et al.*, 2018)). In MCDM, satisficing is often understood as setting target levels or aspiration levels for objectives, goals or criteria (e.g. (Zionts, 1992; Wang and Zionts, 2008)). Princen (2005) who is one of the mayor proponents of sufficiency within the ecological context states that his "use of sufficiency could not be more contrary" (p. 18) to Simon's notion of satisficing. He refers to statements by Simon concerning the limited wits of decision makers as well as concerning their decision-making behavior (Simon, 1997; Princen, 2005). However, the aforementioned understanding of satisficing from the field of MCDM is compatible to sufficiency, since objectives, goals or criteria are deliberately selected and target levels or aspiration levels are consciously set.

4. SUFFICIENCY AND SATISFICING IN EFFICIENCY ANALYSIS

The concept of satisficing has been integrated in two efficiency analysis techniques (e.g. (Cooper *et al.*, 1996; Peters and Zelewski, 2006)). Firstly, the DEA technique has been advanced. Beyond the deterministic DEA models stochastic so-called satisficing DEA models have been developed, in which aspiration levels for efficiency measures can be set (e.g. (Cooper *et al.*, 1996;2006;2007; Charles and Kumar, 2014)). From a sufficiency standpoint, this approach can be problematic, since the aspiration levels are applied to the "globally defined" efficiency measures and the approach does not offer the opportunity to set "local" aspiration levels for individual inputs or outputs. Therefore, this approach is not considered further in the present paper. Secondly, in EATWOS and EATWIOS so-called satisficing levels can be set – like target levels or aspiration levels in some MCDM techniques – for outputs only or both for inputs and outputs, respectively (Peters and Zelewski, 2006; Peters *et al.*, 2012). If an output satisficing level is set, this implies that an output quantity, that is equal to this satisficing level, is being rated as equally good as an output quantity that is higher than the satisficing level (e.g. Peters and Zelewski (2006)). However, if an input satisficing level is set, this means that an input quantity, that is equal to this satisficing level, is being rated as equally good as an input quantity that is lower than the satisficing level (e.g. Peters *et al.* (2012)).

Output satisficing levels are suitable to incorporate sufficiency in efficiency analysis, since an output satisficing level can be set, when a certain quantity of an output is considered to be enough. In this way, both the notion of a minimum level or lower level as well as the notion of maximum level or upper level are taken into account. If an output quantity is below the satisficing level for this output, that means neither the lower level nor the upper level is attained, then the efficiency score of the respective DMU is negatively affected. Output quantities above the satisficing level do not have a positive effect on efficiency scores so that there is no incentive to exceed output satisficing levels. Furthermore, there is no incentive to employ higher input quantities in order to achieve output quantities above the respective output satisficing level. The application of output satisficing levels may even lead to situations where DMUs employ lower input quantities so that the objective of reducing consumption can be achieved. For example, output satisficing levels can be set to avoid an overuse of natural resources like wood. However, it could be problematic, that a DMU producing one or more outputs in quantities equal to the respective output satisficing levels with a specific level of input quantities, although it would be possible to produce the same output quantities from lower input quantities. In such a case, EATWOS can be applied without and with consideration of satisficing levels to identify efficiency improvement potentials by comparing the two resulting efficiency rank orders (Peters and Zelewski, 2006).

The application of input satisficing levels prima facie contradicts the notion of sufficiency, since the incentive to reduce input quantities below an input satisficing level is removed. Thus, the application of input satisficing levels counteracts the objective of reducing consumption. However, input satisficing levels can prove to be advantageous for reducing the work pressure negatively perceived by employees (Peters and Zelewski, 2016a;2016b). So, in some cases, a certain extent of input quantity reduction can be regarded as sufficient or enough. Therefore, it has to be questioned whether the concept of sufficiency should be extended.

However, sufficiency can be operationalized in efficiency analysis by applying (output) satisficing levels as elucidated above. So, a simple approach is to use EATWOS or EATWIOS, since these efficiency analysis techniques have been designed to consider satisficing levels. It is, moreover, desirable to use satisficing levels in other efficiency analysis techniques, particularly in the widely used DEA technique. Then, it would also be possible to examine whether different efficiency analysis techniques lead to similar results under consideration of satisficing levels. So far, there are only few studies available that compared EATWOS to other efficiency analysis techniques without consideration of satisficing levels (Özbek, 2015a;2015b).

An easy way to consider satisficing levels in efficiency analysis is to manipulate the DMU data. Output (input) quantities above (below) the respective output (input) satisficing level must be set to the output (input) satisficing level. This data transformation can be done manually or with simple formulas in spreadsheet software programs. Alternatively, if operations research or optimization software programs like Lingo from Lindo Systems Inc. are utilized and the number of DMUs to be ranked is large, then the two constraint sets described below can be applied to manipulate or adjust the DMU data.

The constraint set for output satisficing consisting of the constraints $(1a)$, $(1b)$, (2), (3) and (4) is adapted from EATWOS (e.g. Peters and Zelewski (2006)) whereby constraint (4) is slightly modified compared to that used in EATWOS. At first, it has to be decided for which of the J outputs a satisficing level $SL_j > 0$ should be set. Then, the output satisficing levels SL_j need to be specified, so that the constraint set for output satisficing can be applied for all outputs with a satisficing level. The values of the logical variables $z_{1,i,j}$ and $z_{2,i,j}$ are restricted by the constraints $(1a)$, $(1b)$, (2) and (3). Constraint (4) determines the adjusted output quantity $y_{i,j}^{SL}$ under consideration of the output satisficing level SL_j.

$$\left(\frac{SL_j - y_{i.j}}{SL_j}\right) + z_{1.i.j} \leq 1 \qquad \forall i = 1, \dots, I \qquad (1a)$$

$$\left(\frac{SL_j - y_{i.j}}{SL_j}\right) * z_{2.i.j} \geq 0 \qquad \forall i = 1, \dots, I \qquad (1b)$$

$$z_{1.i.j}, z_{2.i.j} \in \{0; 1\} \qquad \forall i = 1, \dots, I \qquad (2)$$

$$z_{1.i.j} + z_{2.i.j} = 1 \qquad \forall i = 1, \dots, I \qquad (3)$$

$$y_{i.j}^{SL} = y_{i.j} * z_{2.i.j} + SL_j * z_{1.i.j} \qquad \forall i = 1, \dots, I \qquad (4)$$

If an output quantity $y_{i.j}$ is lower than the respective output satisficing level SL_j, then the adjusted output quantity $y_{i.j}^{SL}$ is equal to $y_{i.j}$. But, if an output quantity $y_{i.j}$ is equal to or higher than the respective output satisficing level SL_j, then the adjusted output quantity $y_{i.j}^{SL}$ is equal to the output satisficing level SL_j.

The constraint set for input satisficing consisting of the constraints $(1a')$, $(1b')$, $(2')$, $(3')$, $(4')$, $(5')$ and $(6')$ is adapted from EATWIOS (e.g. Peters *et al.* (2012)). Analogously to the constraint set for output satisficing constraint $(4')$ is slightly adjusted. The input satisficing levels $SL_k > 0$ need to be specified for the chosen inputs. The constraints $(1a')$, $(1b')$, $(2')$ and $(3')$ restrict the values of the logical variables $q_{1.i.k}$ and $q_{2.i.k}$. Constraint $(4')$ determines the adjusted input quantity $x_{i.k}^{SL}$ under consideration of the input satisficing level SL_k. The positivity constraint $(5')$ has been added in order to prevent a division by zero, while constraint $(6')$ is required, since constraint $(1a')$ would not be satisfiable, when the input satisficing level SL_k in the denominator is smaller than the numerator (e.g. Peters *et al.* (2012)).

$$\left(\frac{(x_{i.k} - SL_k):x_{i.k}}{SL_k}\right) + q_{1.i.k} \leq 1 \qquad \forall i = 1, \dots, I \qquad (1a')$$

$$\left(\frac{(x_{i.k} - SL_k):x_{i.k}}{SL_k}\right) * q_{2.i.k} \geq 0 \qquad \forall i = 1, \dots, I \qquad (1b')$$

$$q_{1.i.k}, q_{2.i.k} \in \{0; 1\} \qquad \forall i = 1, \dots, I \qquad (2')$$

$$q_{1.i.k} + q_{2.i.k} = 1 \qquad \forall i = 1, \dots, I \qquad (3')$$

$$x_{i.k}^{SL} = x_{i.k} * q_{2.i.k} + SL_k * q_{1.i.k} \qquad \forall i = 1, \dots, I \qquad (4')$$

$$x_{i.k} > 0 \qquad \forall i = 1, \dots, I \qquad (5')$$

$$SL_k \geq \frac{x_{i.k}}{x_{i.k} + 1} \qquad \forall i = 1, \dots, I \qquad (6')$$

If an input quantity $x_{i.k}$ is higher than the respective input satisficing level SL_k, then the adjusted input quantity $x_{i.k}^{SL}$ is equal to $x_{i.k}$. But, if an input quantity $x_{i.k}$ is lower than or equal to the respective input satisficing level SL_k, then the adjusted input quantity $x_{i.k}^{SL}$ is equal to the input satisficing level SL_k.

5. CONCLUDING REMARKS

In this paper, an initial step has been taken to incorporate and operationalize sufficiency in efficiency analysis. Satisficing levels known from EATWOS and EATWIOS have been used for this purpose. The idea of input satisficing levels raises the question of extending the concept of sufficiency. However, due to the ecological connotation of sufficiency it has been mentioned that the application of satisficing levels can pose risks from an ecological viewpoint (Peters and Zelewski, 2016a;2016b).

Future research should be directed towards the development of further approaches to incorporate sufficiency in efficiency analysis. Moreover, it should be investigated how sufficiency can be incorporated in other fields of business economics. To ensure the applicability of new approaches to corporate business practices, calculational ("quantitative") rather than solely verbal ("qualitative") approaches should be developed.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
Contributors/Acknowledgement: Both authors contributed equally to the conception and design of the study.

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