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Technology-based total factor productivity and benchmarking: New proposals and an application ☆

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ABSTRACT

The present study fills a gap between the benchmarking literature and multi-output based efficiency and productivity studies by proposing a benchmarking framework to analyze total factor productivity (*TFP*). Different specifications of the Hicks–Moorsteen *TFP* index are tailored for specific benchmarking perspectives: (1) static, (2) fixed base and unit, and (3) dynamic *TFP* change. These approaches assume fixed units and/or base technologies as benchmarks. In contrast to most technology-based productivity indices, the standard Hicks–Moorsteen index always leads to feasible results. Through these specifications, managers can assess different facets of the firm's strategic choices in comparison with firm-specific relevant benchmarks and thus have a broad background for decision making. An empirical application for the Spanish banking industry between 1998 and 2006 illustrates the managerial implications of the proposed framework.

1. Introduction

Literature on benchmarking focuses on the selection of a unit of strategic value against which performance is compared [1]. Another series of academic studies analyze the efficiency and productivity of firms with multiple inputs and outputs. So far there seems little or no link between these two streams of research. In this paper we propose to bridge this gap by defining novel total factor productivity (*TFP*) benchmarking methods. These are devised to include cross-sectional and inter-temporal perspectives not only concerning unit to unit benchmarking, but also efficiency frontier benchmarking. These various perspectives are introduced stepwise starting with static indices, continuing with fixed base and unit, and ending with dynamic benchmarking. This provides managers of any industry with a new set of *TFP* benchmarking indices for decision making.

Both benchmarking and *TFP* analysis represent key tools in business economics. For instance, Balk [2] points to two main actions a manager constantly carries out: the monitoring activity (i.e., assessing how the firm is doing over time) and the benchmarking activity (i.e., comparing firm performance with respect to its main competitors). Although both activities aim at enhancing performance, monitoring is internally oriented while benchmarking has an external focus.

Benchmarking is defined as the search and emulation of the industry's best practices and it thus is an objective setting procedure [1]. Through benchmarking, a firm can deduce whether it has a best or worst practice. Thus, it can aim at maintaining superiority or at closing the gap to its competitors [1]. Therefore, benchmarking appeals most to firms with similar strategic orientations or facing comparable problems and opportunities [3,4].

Empirical applications suggest different methods for monitoring or benchmarking activities. In managerial studies of performance, the simplest method is the use of output-input ratios or any other kind of ratios for that matter (see [5,6]). Managers care about profitability and implicitly about productivity: "the most encompassing measure of productivity change, *TFP* change, is nothing but the "real" component of profitability change. Put otherwise, if there is no effect of prices then productivity change would coincide with profitability change" ([2]: 6).

The above *TFP* measures are easily adaptable to benchmarking purposes. One can simply divide the firm's *TFP* change (or performance) ratio to the one of a chosen competitor. However, in multiple inputs and outputs technologies various problems emerge related to the use of ratios for benchmarking. When comparing two firms, different partial productivity ratios (built by dividing different outputs by some inputs) can point to different results. The management literature suggests a way to remedy this problem.

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Specifically, in the presence of prices, multiple outputs and inputs productivity indices are proposed by the American Productivity Center (*APC*) method [7].

Turning attention to efficiency and productivity analysis, this literature uses frontier methods with economic underpinning in production theory to handle multiple inputs yielding multiple outputs. These non-parametric techniques have known an important upsurge and are probably best known under the label Data Envelopment Analysis (*DEA*) (see [8,9]). *DEA* methods compute the degree of inefficiency separating a certain Decision Making Unit (*DMU*) from the efficiency frontier. In this case, the comparison is done against the whole analyzed sample, not against some specific strategic competitor as in benchmarking. Thus, in *DEA* benchmarks are the efficient units on the frontier against which the other *DMUs* are projected using some efficiency measure (see [8,9]). Therefore, it is highly unlikely that a single benchmark is found for all units evaluated in the sample.

In inter-temporal analyses, the efficiency and productivity literature captures the potentially shifting efficiency frontier usually through index numbers. The Malmquist productivity index is probably the best known measure that has been extensively used in past research.[1] However, there are some pitfalls to the use of Malmquist indices. First, it is not always a *TFP* index: while the *TFP* properties are maintained under constant returns to scale, shortcomings appear in the presence of variable returns to scale (*VRS*) which mostly represents the true technology [13]. Second, there is the possibility of having infeasible results.[2] For example, Glass and McKillop [15] find infeasibilities for up to 7% of the analyzed UK building societies.[3] This issue could have an important impact on benchmarking analysis, since managers wish to obtain firm level results that may not always be available.[4]

As a result, there are two main issues with the Malmquist index that need to be resolved: *TFP* interpretation and infeasibilities. To address these problems, one can turn to Bjurek's [19] proposal for a Hicks–Moorsteen *TFP* (*HMTFP*) index (see also [20]: footnote 18). The *HMTFP* index is defined as a ratio of an aggregate output quantity over an aggregate input quantity index. More precisely it measures the change in output quantities in the output direction and the change in input quantities in the input direction, instead of exclusively adopting an input- or output-orientation as Malmquist indices usually do. The *TFP* characteristics of the *HMTFP* index solve the limitations of the traditional Malmquist productivity index in the presence of *VRS*. Furthermore, this *HMTFP* index is well-defined under general assumptions of variable returns to scale and strong disposability.[5] However, in spite of its attractive properties, the *HMTFP* has been scarcely empirically applied.[6]

Various benchmarking applications have been developed in the non-parametric efficiency and productivity analysis framework by isolating reference frontiers or *DMUs*. In the non-*TFP* context, Berg et al. [25] adapt the Malmquist productivity index to have a base year frontier as a benchmark frontier, and measure productivity growth or regress relative to this fixed basis. Similarly Berg et al. [26] adapt the Malmquist productivity index to make comparisons across countries with respect to a fixed basis (i.e., a single country) for a given year. Also, single benchmark *TFP* analyses have been undertaken by Zaim et al. [27], Färe et al. [28] and Zaim [29]. Manipulating a Hicks–Moorsteen index, their proposals include both cross-sectional and inter-temporal analyses by mixing a single *DMU* and *TFP* benchmarking. Zaim et al. [27] use a five years sample of OECD countries to analyze the well-being of individuals in each country as compared to a benchmark country. Similarly environmental performance is measured against a benchmark *DMU* in Färe et al. [28] and Zaim [29]. While the former study looks upon OECD countries at cross-sectional level, the latter analyzes US states from both cross-sectional and inter-temporal perspectives.

A small existing literature thus proposes efficiency frontier comparisons using productivity indices combined with some form of unit to unit benchmarking. But, while consensus is reached regarding the usefulness of benchmarking, less agreement exists with respect to the choice of benchmarks. In a strategic analysis setting, the interest of a firm may be to know its relative performance to a certain specific competitor, instead of comparing itself to a frontier potentially composed of all firms in the sector. The benchmark could differ for each firm, even though it could remain the same over a certain time period. In addition, awareness of *TFP* positioning is useful in both static and dynamic environments. Efficiency coefficients (static) and *TFP* indices (dynamic) relative to a given benchmark are equally relevant and could represent the basis of strategic decision making. For instance, in the case of similar strategic configurations, firms constitute strategic groups and may choose their benchmark within their relevant cluster. In this case, the benchmark unit can be the leader of the strategic group or any other unit, say the local competitor, regardless of its performance.

To develop a systematic framework to analyze these issues, this study proposes a *TFP* benchmarking framework by adapting Bjurek's [19] *HMTFP* index for benchmarking purposes. The introduced *HMTFP* indices for benchmarking include the features of the traditional *HMTFP* together with some of the properties of the indices in Berg et al. [25,26], Zaim et al. [27], Färe et al. [28], and Zaim [29]. Various specifications of the *HMTFP* index measure distances (and catching-up effects) between analyzed *DMUs* and their selected benchmarks: these indices offer *TFP* interpretations with respect to static, fixed base or changing efficiency frontiers.

The empirical application considers the Spanish banking sector over the period 1998–2006, a post-deregulation growth phase. The sector experienced consistent growth following the disappearance of regulatory constrains and due to the competition between private and savings banks. In productivity and efficiency terms, the sector has been looked at from a multitude of perspectives.[7]

[1] See the general survey of Färe et al. [10], the survey on the banking sector in Fethi and Pasiouras [11], or applications/decompositions as the one of Wheelock and Wilson [12].

[2] The literature sometimes gives the impression that imposing constant returns to scale eliminates the issue of infeasibility. However, Briec and Kerstens [14] demonstrate that constant returns to scale are a necessary, but not a sufficient condition to guarantee that the Malmquist index is well-defined.

[3] Yörük and Zaim [16] report infeasible computations that reach 10% of their sample of OECD countries. Also, for the Spanish insurance industry Cummins and Rubio-Misas [17] mention that infeasibilities are present (without indicating the exact amount).

[4] To solve the problem of infeasibilities, Kao [18] propose a common-weights global Malmquist productivity index: apart from the common weights (i.e., the same frontier facet for every *DMU*), this amounts to creating a common frontier for all *DMUs* in all time periods.

[5] Briec and Kerstens [21] demonstrate that the Hicks–Moorsteen productivity index satisfies the determinateness property under mild conditions. According to Bjurek ([19]: 310) the feasibility of this index is attributable to the property that "all input efficiency measures included meet the condition that the period of the technology is equal to the period of the observed output quantities" and "all output efficiency measures included meet the condition that the period of the technology is equal to the period of the observed input quantities".

[6] Bjurek et al. [22] is the first empirical application of the Hicks–Moorsteen index. To the best of our knowledge, there are only two more empirical applications/decompositions of the Hicks–Moorsteen index: one is developed in a parametric context by Nemoto and Goto [23], another is proposed in O'Donnell [24].

[7] E.g., Grifell-Tatjé and Lovell [30,31], Lozano-Vivas [32], Kumbhakar and Lozano-Vivas [33], Más-Ruíz et al. [34]; Tortosa-Ausina et al. [35], or Illueca et al. [36].