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Bootstrapping profit change: An application to Spanish banks

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ABSTRACT

The aim of this study is to provide a tool which enables us to conduct statistical analysis in the context of changes in productivity and profit. We build on previous initiatives to decompose profit change into mutually exclusive and exhaustive sources. To do this we use distance functions, which are calculated empirically using linear programming techniques. However, we may not learn a great deal by solving these linear programs unless methods of statistical analysis are used to examine the properties of the relevant estimators. Our purpose is to provide a methodology based on bootstrap that allows us to conduct statistical inference for the profit change decomposition. Thus, it will be possible to answer questions such as whether variations in the profit change components, or the differences across firms, are statistically significant. We provide an application to Spanish commercial banks for the 2003/2004 period. Results suggest that profit change differentials between them are not always significant. Therefore, the validity of the conclusions which do not factor in the bootstrap may be jeopardized to varying degrees.

1. Introduction

In recent years there has been a growing interest in analyzing the productivity of firms that operate in different industries worldwide. Studies have dealt with this issue from a variety of angles and most of them have implicitly focused on the concept of total factor productivity (TFP), given the multiproduct nature of many firms in different industries—both on the input and output sides. According to the traditional definition of growth accounting, TFP changes are constituted by the differences between output growth rates and input growth rates [1]. This definition implicitly assumes that no inefficiency exists, requiring all production units to lie on the frontier. However, should inefficiency exist, TFP growth could be composed of both technical change (shifts in the frontier) and catching-up (changes in efficiency).

Some approaches ignore inefficiency, implicitly assuming that the observed output is Farrell [2] technically efficient. They may be labeled as "nonfrontier" (see Diewert [3,4], Morrison Paul and Diewert [5]), because of presupposing that all production units are on it. On the other hand, frontier models assume inefficiency may actually exist. Although the focus of some proposals has been parametric (see Førsund and Hjalmarsson [6], Nishimizu and Page [7]), most of them are nonparametric. The latter approach builds on the pioneer study by Caves et al. [8], who devised individual productivity indices and named them after Sten Malmquist. Later, the indices were refined by Färe et al. [9,10]. Malmquist productivity indices are calculated from distance functions which, according to Grosskopf [11], constitute a natural way to model the production frontier by taking into account both efficiency change and technical change.

In the specific case of financial institutions, on which our application is focused, some studies such as Berger and Mester [12] or Bauer et al. [13] estimate translog cost functions to construct indices of productivity change. Although their findings are interesting, they share the disadvantage of *a priori* specifying functional forms which, as suggested by some authors, may be problematic.[1] In contrast, other studies which examine productivity change in banking have used data envelopment analysis (DEA) and the Malmquist index. See, for instance, Wheelock and Wilson [17,18], among many others.

Despite the fact that the analysis of firms' productivity has mostly been carried out by economists, other disciplines such as operations research and management science, engineering or psychology have also dealt with the issue [19]. For instance,

[1] McAllister and McManus [14], Mitchell and Onvural [15], and Wheelock and Wilson [16] test and reject the translog specification of bank cost functions, and suggest semi-nonparametric and nonparametric methods for estimating bank costs [17].

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business literature [20,21] has proposed partial productivity measures which, given their incomplete nature, can vary in opposing directions. The advantage of using distance functions is that they can be linked unambiguously to profit [22]. Accordingly, some authors such as Banker et al. [23] or Banker [24] propose variants of a three-way decomposition in which profit change is decomposed into a price effect (including changes in resource prices paid and product prices received), a productivity effect (usually attributed exclusively to an improvement in technology) and an activity effect, capturing the effect of changes in the size and partly the scope of the business.

By merging the economics literature on productivity change and the business literature on profit change, Grifell-Tatjé and Lovell [22] (G-T&L hereafter) provide a methodology aimed at disentangling the links between firms' profits and their productivity. Specifically, they attempt to embed a productivity change decomposition similar to that developed in economics literature within the profit/productivity linkage developed in business literature [23–26]. In order to do this, they decompose the different sources of profit change with activity analysis techniques, highlighting the role of productivity change and its components, while considering other determinants of profit change simultaneously. Specifically, their analysis sheds light on four aspects of the link. First, profit change is decomposed into a price effect and a quantity effect. The quantity effect is further decomposed into a productivity effect and an activity effect, following some of the ideas in business literature. The ensuing stage decomposes the productivity effect into a technical change effect and an operating efficiency effect—whose relevance was stressed earlier—whereas the activity effect follows a threefold decomposition, namely, a product mix, a resource mix, and a scale effect.

G-T&L methodology builds on solving different linear programming problems that modify and extend the DEA technique,[2] which is intensively used by economics and business literature to analyze business performance as well as macroeconomic performance (see, for instance, Färe et al. [10], Lozano-Vivas and Pastor [28]).[3] However, since their methodology is based on DEA, it is also subject to its disadvantages. For example, sensitivity to outliers, curse of dimensionality (see, in a different setting, Xu [31], Warfield [32], Staley and Warfield [33]) and the fact that noisy data are not allowed. But above all, statistical inference can be difficult. This latter disadvantage requires a detailed comment given that there is always the tendency to think of an estimation as the final stage of inference. As stated by Simar and Wilson [34,35], if we do not give importance to the underlying statistical model (that is, the process which has generated the data and the sampling scheme used to draw them), we could erroneously convolute the underlying true distance functions and their estimates. Some contributions, nevertheless, attempt to minimize all these disadvantages. In particular, Simar and Wilson [34–37] propose a bootstrap methodology in order to conduct statistical inference in the context of nonparametric frontier models which entails all the features mentioned above.

Our purpose in this paper is to extend the profit change decomposition suggested by G-T&L by giving a statistical interpretation to its different components, via a similar bootstrap procedure to that proposed by Simar and Wilson [34]. Bootstrapping [38] is based on the idea of resampling from an original sample of data so as to create replicated data sets from which we can make inferences on the required quantities of interest. We will therefore be able to determine whether the discrepancies found in the firms in our sample, and for the different components of profit change, are statistically significant or not. Accordingly, results will have a variety of angles since they will be subject to both "vertical" and "horizontal" examination, that is to say, not only across firms but also across the different components of profit change. Although our methods hinge on DEA, they can easily be extended to its nonconvex (FDH) counterpart.

We have applied our methodology to the context of the Spanish banking system,[4] which has witnessed remarkable changes over the last two decades due to deregulation (i.e. regulatory harmonization with banks of other European Union countries) and technological change. The industry is made up of three types of firms: namely, private commercial banks, savings banks and credit cooperatives, yet their importance in terms of the share in total industry assets is unequal. As of 2005, their share of total industry assets were roughly 50%, 45% and 5%, respectively.[5] Given that they all now face the same regulatory environment, operational differences have virtually faded away, and the only remaining differences relate to firms' ownership type (see Crespí et al. [40], Kumbhakar et al. [41]).

These differences might be important for our specific setting since they determine how profits are allocated and therefore might influence the intensity with which firms pursue profits. Whereas private commercial banks allocate most of their profits to their shareholders, savings banks cannot do so and must either retain their earnings or invest them in social and cultural programs, which account for roughly 25% of their net annual profits. Indeed, since they have no formal owners there is no market for the corporate control of savings banks, and some authors even label them as "not-for-profit" organizations [40], or "commercial nonprofit organizations" [42]. Although we do not entirely share these views, we do consider that savings banks might have an incentive to seek profits less intensively than private commercial banks do, due to their *a priori* weaker corporate control mechanisms.

Based on the above rationale, our analysis will be confined to those firms pursuing profits with more intensity, i.e. private commercial banks. Although some recent deregulatory initiatives—such as the removal of restrictions on the geographic expansion of savings banks—triggered an unprecedented growth in this type of firms to the detriment of commercial banks, their quota of total industry assets is still quite remarkable. Thus our study attempts to decompose the profit change between two particular years (2003 and 2004) for each bank in our sample into several sources, incorporating a statistically based vision of the magnitudes being estimated. This statistical approach is the main contribution of our paper.

The rest of the article is organized as follows. Section 2 summarizes the proposals of G-T&L, in order to provide a seamless link to our methodology, which is presented in Section 3. Section 4 provides full details of the empirical application, both on data (Section 4.1 and 4.2) and results (Section 4.3). Section 5 presents the concluding remarks.

[2] Although it could easily be extended to its nonconvex variant, the so-called free disposable hull (FDH) (see Tulkens [27]).

[3] However, in the case of economics, many applications also consider econometric techniques. For an interesting review of both types of techniques applied to banking, see Berger and Humphrey [29] or, more recently, Weill [30]. There are also some new proposals being developed. See the special issue of the *Journal of Econometrics*, volume 126, number 2, year 2005.

[4] For applications with a more global perspective see, for instance, Xu [39].

[5] Since the share of the latter group of firms is comparatively minor, the discussion will be based on the other two types of firms.