

Stability and integrity tests in data envelopment analysis

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Abstract

Studies that apply data envelopment analysis often neglect testing the stability of the efficient frontier to data perturbations, and, to a lesser extent, the ability of efficiency scores to correctly discriminate between units on performance (integrity). Our primary motivation is to demonstrate methods that can help reduce the number of managerial decisions based on results that may be unreliable. To this end, we illustrate multiple tests of stability and integrity in an environment of fully units-invariant efficiency measurement. This application of tests of stability and integrity using a slacks-based measure of efficiency is the first in a peer-reviewed journal.

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1. Introduction

Ease-of-use and the intuitive appeal of data envelopment analysis (DEA) have lead to its quick adoption across a wide range of disciplines over the last 10–15 years. In turn, this has meant a proliferation of application papers where DEA results are often taken at face value. Thus, it is important to be able to test the stability of the efficient frontier, and integrity of scores to ensure managerial decisions are made with confidence. We hope that the stability and integrity tests illustrated in this paper will help reduce incidences of decisions made on test results that may be unreliable.

With the above motivation in mind, we demonstrate multiple tests of stability and integrity in a setting of fully units-invariant bank efficiency measurement. These tests are illustrated by investigating the productivity of foreign bank subsidiaries in Canada during the period 1996–2000 using the DEA model known as slacks-based measure (SBM) [1]. To the best of our knowledge, use of SBM in this manner is the first in a peer-reviewed journal at the time of writing.¹

Stability tests (listed in no particular order) include: (a) deleting variables and its impact on the efficient frontier membership; (b) the number of variables in relation to sample size and dimensionality; (c) deleting variables and its impact on rankings; (d) deleting units and its impact on efficient frontier membership; and (e) sensitivity scores.

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¹SBM's first application in a refereed publication can be traced to Morita et al. [2].

Tests of integrity include: (a) ability of scores to discriminate between organizations (here, banks) when compared to performance measured by unweighted output/input ratios; and (b) comparing rankings based on scores against those based on commonly used financial ratios.

The CCR (Charnes, Cooper and Rhodes [3]) and BCC (Banker, Charnes and Cooper [4]) models, while producing units-invariant (i.e. dimension-free) radial inefficiency estimates, do not generate units-invariant estimates of non-radial (slacks) inefficiency [5].² On the other hand, SBM can account for input and output slacks in the calculation of a decision making unit's (DMU) efficiency score (reported as scalar ρ), where slacks represent input excesses or output shortfalls after radial inefficiencies have been identified (see [1,6]).

Thus, in the presence of slacks, the SBM score will be less than the CCR score. We note that, while additive DEA models also measure slacks, they cannot produce a scalar measure of efficiency. Hence, we regard SBM as a more appropriate model unless one is certain that there are no significant slacks; or, there is no need to summarise efficiency evaluation in a single figure which facilitates ranking; or, variables have the same dimensions. The reader is referred to Cooper et al. [7] for a comprehensive technical exposition of DEA.

The focus of this paper remains that of illustrating multiple tests of stability and integrity, and, as such, our use of Canadian data is of secondary importance. Thus, instead of launching into a literature survey of Canadian banking, we here provide an introduction to the Canadian banking sector.

Canada is a large country with a small, multicultural population comprised of an aging baby boomer group and shrinking population in remote and rural communities. The concentrated banking system that serves this population consists of 14 domestic banks (six of which are majors), and 54 foreign banks, which include 32 foreign bank subsidiaries,³ 18 full service branches,⁴ and four lending branches⁵ (sourced from Office of the Superintendent of Financial Institutions, or OSFI, web site [8]). Foreign banks account for about 10% of the banking sector's assets in Canada, and are mainly involved in wholesale banking or niche financing.

Foreign banks, like their domestic counterparts, are regulated under the Bank Act, which currently has a 5-year sunset provision, and are authorised to accept deposits (subject to restrictions outlined in footnotes 3–5). Foreign banks have been able to set up Canadian subsidiaries since 1980, and have been allowed to establish branch banks (i.e. full service branches and lending branches) since 1999. The latter are allowed to carry on their commercial activities without establishing a Canadian subsidiary through incorporation. A branch can be maintained alongside an existing foreign bank subsidiary, or a subsidiary can be converted into a branch. Currently, a majority of the small number of subsidiaries under liquidation are re-emerging as branches, and a few banks, namely, Citibank, HSBC and UBS, are operating subsidiaries as well as branches.

The paper unfolds as follows. Section 2 outlines the choice of input and output variables for the productivity model, and the justification for model orientation. We begin Section 3 by identifying outliers in the data set, and then proceed to analyse the efficiency of banks; this is followed by our testing the stability of the efficient frontier and reliability of the resulting efficiency scores. Section 4 concludes the paper with a summary, managerial implications, and directions for future research.

2. Data and methodology

DEA has become a highly popular technique in bank efficiency analysis since its first application by Sherman and Gold [9]. Berger and Humphrey [10] provide an international survey of efficient frontier analysis of financial institution performance. Our illustrative pre-test sample consists of 27 Canadian foreign bank subsidiaries during the period 1996–2000. Bank financial statement data are available on the web site of the Office of the Superintendent of Financial Institutions [8] (from 1996 onwards); this source provided most of

²Radial efficiency measures how close a unit is to the efficient frontier on a straight line drawn through the origin, the unit under observation and the frontier. For example, when radial measurement is output oriented, that is, looking for possible output expansions calculated on the line through the origin, non-radial measurement searches for simultaneous possible input contractions located in a region of the production possibilities set where a straight line cannot be drawn to intersect the efficient frontier.

³Allowed to accept deposits and may enjoy Canada Deposit Insurance Corporation (CDIC) insurance.

⁴Not allowed to accept deposits of less than CDN\$150,000; the full-service branch is required to deposit in Canada minimum unencumbered assets of \$5 million before starting business.

⁵Not allowed to accept any deposits; the lending branch is required to deposit in Canada minimum unencumbered assets of \$100,000 before starting business.

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