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Modeling risk concerns and returns preferences in performance appraisal: An application to global equity markets

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ABSTRACT

A technique used to assess relative performance in a multiple input–output framework is data envelopment analysis (DEA). In basic DEA models, an entity may show its best performance by selecting input and output factor weights different from those selected by the other entities in the sample. Hence, when using basic DEA models, divergence of weighting schemes across the assessed entities cannot be ruled out. Weighting imbalance is another issue encountered in the application of basic DEA models. The assignment of an extremely low or zero weight to an input or an output factor implies that it is disregarded in performance appraisal. We appraise equity market performance using the Assurance Region Global (ARG)–DEA model where weighting divergence may be eliminated while controlling weighting imbalance. We show that risk concerns and returns preferences can be modeled in the ARG–DEA model through the bounds on the virtual input and virtual output ratios. Different combinations of risk concerns and returns preferences assess equity market performance under different risk-adjusted return scenarios and thereby allow sensitivity analysis of performance.

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1. Introduction

The traditional investment performance measures are built on the notion that high risk is associated with greater demand for high return. For example, the Sharpe ratio measures performance by computing excess return per unit of total risk and the Treynor ratio measures performance by computing excess return per unit of systematic risk. In both cases, a higher ratio implies relatively better performance. In regression based appraisal methods, abnormal return is considered as a performance measure. An example of such a measure is Jensen's alpha. What is common in the ratio measures is that they are constructed under the risk-adjusted return framework with one output factor (excess return) and one input factor (risk). Another technique that is becoming increasingly popular in performance appraisal is the frontier technique known as data envelopment analysis (DEA). DEA has become a popular performance appraisal tool for a number of reasons. First, it is a non-parametric technique and therefore it is not required to pre-specify a functional form for the efficient frontier. Second, DEA can accommodate multiple input and multiple output factors and therefore can assess performance in a multi-dimensional risk-adjusted return framework. Third, DEA identifies role models for inefficient performers and the inefficient performers may emulate the best practices of their role models for performance improvement.

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The vast number of DEA applications in the banking and finance sector is testament to its acceptance as a credible performance appraisal technique. Paradi and Zhu (2013) refer to 275 DEA applications in the banking sector in the period from 1985 to 2011. Yang (2006) uses a DEA model to evaluate the overall performance of Canadian life and health insurance companies. Cummins and Zi (1998) apply DEA to assess the performance of US life insurance companies and Gregoriou et al. (2005) apply DEA to evaluate the performance of hedge fund classifications. A large number of studies apply DEA to assess mutual fund performance. See for example, Murthi et al. (1997),McMullen and Strong (1998), Choi and Murthi (2001), Malhotra et al. (2007) and Premachandra et al. (2012). Studies of equity market performance appraisal using DEA include Meric and Meric (2001), Bainbridge and Galagedera (2009) and Galagedera (2012).

In the DEA methodology, each input and output factor is weighted subject to the restriction that the ratio of the sum of the weighted outputs to the sum of the weighted inputs is less than 1. The objective of basic DEA models is to show the performance of an entity in the best possible manner by freely assigning weights (variables in the DEA model) to the input and output factors of the assessed entity. The freedom to choose the weights favorably to the entity being assessed is highlighted as an advantage of appraising performance using DEA. However, to show the entity being assessed in the most favorable manner to it the DEA solution procedure may assign an extremely low weight or even zero weight to some inputs and/or outputs. The assignment of an extremely low or zero weight to an input or an output factor implies that it is ignored in performance appraisal.

A DEA based performance measure that deals with potential input–output weight imbalance is cross-efficiency. When computing cross-efficiency, the performance of each equity market is assessed with the weights assigned to the inputs and outputs of each of the other equity markets in the sample separately. An alternative measure of performance is the arithmetic average of the cross-efficiencies computed for that market. An application of cross-efficiency in equity market performance appraisal is available in Galagedera (2013). Sexton et al. (1986) argue that averaging cross-efficiency is problematic because the weights may not be unique. They determine the weights for the equity market being assessed by maximizing its performance and minimizing the other equity markets' cross-efficiencies. Sexton et al. (1986) refer to their formulation as aggressive formulation. Doyle and Green (1994) suggest another formulation referred to as the benevolent formulation. In the benevolent formulation, the weights are determined by maximizing the performance of the equity market being assessed and at the same time maximizing the other equity markets' cross-efficiencies. More choices of weighting schemes are available in Liang et al. (2008), Wang and Chin (2010), Lam and Bai, (2011) and Ruiz and Sirvent (2012). Ideally, we would like all equity markets to have the same weighting scheme so that we may assess the performance of all equity markets under the same multi-dimensional risk-adjusted return scenario.

The model we use to appraise equity market performance is the assurance region global (ARG)–DEA model (hereafter, referred to as the ARG model) used in Allen et al. (1997). In the ARG model, we can control input–output weighting divergence by imposing bounds on the virtual input and virtual output ratios.[1] When assessing performance under a multi-dimensional risk-adjusted return framework, we show that risk concerns and returns preferences may be modeled through the bounds imposed on the virtual input (risk) and virtual output (return) ratios. The assignment of the same set of bounds on the virtual input and output ratios of all equity markets is in line with having a similar weighting scheme for all equity markets. Different sets of bounds reflect different combinations of risk concerns and returns preferences. Hence, in the ARG model we may not only assess equity market performance under the same multi-dimensional risk-adjusted return scenario, we may also assess equity market performance under different risk-adjusted return scenarios with each scenario reflecting a specific combination of risk concerns and returns preferences

Previous studies of equity market performance appraisal using DEA generally use systematic risk, downside risk and total risk as the input factors and average return as the output factor. We do the same. The selected input factors reflect investment risk under three different standpoints. To demonstrate the proposed performance appraisal procedure, we specify different combinations of these three risk factors to reflect four risk propositions. The risk propositions that we consider are; the main concern is downside risk (risk proposition 1 labeled as RiskP1), the main concern is systematic risk (risk proposition 2 labeled as RiskP2), the main concern is total risk (risk proposition 3 labeled as RiskP3) and all three risk measures are of similar concern (risk proposition 4 labeled as RiskP4). When specifying RiskP1–RiskP3 we ensure that the two risk measures not considered as the main concern are not ignored in performance appraisal.

In our empirical investigation we assess the performance of 44 equity markets (23 developed and 21 emerging) each year from 2003 to 2013 using an input oriented variable returns-to-scale ARG model under the four risk proposition (RiskP1–RiskP4) adjusted return scenarios. When systematic risk is the risk factor of most concern, we find that the ARG model assesses equity market average performance lower than when downside risk and total risk is the main concern. The input oriented variable returns-to-scale basic DEA model where weight imbalance is not controlled assesses the equity market average performance higher than the ARG model regardless of the risk proposition used in the ARG model. From 2004 to 2011, we find that the direction of year to year change in average performance estimated under different assessment scenarios is not consistent. However, after 2011, all risk propositions adjusted return scenarios reveal that equity market performance improves steadily on average. Variation in performance is observed at the individual equity market level as well. We observe considerable variation in the rankings based on the efficiency scores obtained in the basic DEA model and

[1] Virtual input for each input (output) is obtained by multiplying the observed input (output) value by its corresponding optimal weight obtained in the solution to the DEA model. The level of the virtual inputs and virtual outputs indicates what underlies the efficiency score computed in the DEA model (Thanassoulis, 2001).

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