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SCALE PROBLEM IN CAPITAL MARKET RESEARCH

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ABSTRACT

This paper is a review and aims to present and interpret the results of previous research carried out in the context of reducing the problems associated with “scale effects” in capital market research. Evaluating the results of investigations in the field shows that deflating all the elements of the regression model using suitable deflator is the preferred approach of dealing with scale problem in research. However, there is no agreement among researchers on the best deflator and studies on scale effect sought to be continued.

Keywords: *scale, scale effect, deflator, size-based variables.*

INTRODUCTION

“Size” has been an interesting issue to capital market researchers. Some results of the estimations will change if the size of companies in the sample change, and without considering size effects, the results of the correlation models will not be correctly interpreted. Effects of “size” in capital market research is often called “scale effects” and the complex analytical problems which occurred due to the different size of the participants (in capital market research, companies) is called “scale problems” (Barth and Clinch 2009). Lo (2004) stated that “scale effects” could be considered both at the corporate level and at the level of the market. At the corporate level, “scale” simply refers to the size of companies. Larger companies have larger numbers. Therefore, the results (parameters) obtained about them would be larger. For market level research, “scale” means the shares value of the firms. Share values of some companies, regardless of their future cash flows are higher only because the number of their outstanding shares is less than other companies. To date, the literature of capital markets research has identified different types of “scale effects” and dealing with any of them is well identified. However, there are some difficulties in using these methods. Shen and Stark (2010) claimed that there is no agreement among researchers on the statistical definition of “scale effect”. This paper studies and analyzes the types of scale and the existing methods of dealing with them.

What Scale Effects Really Are?

“Scale effect problem” is a two-sided phenomenon and can be described through both economic and statistical explanations. For better understanding of the nature of “scale effect” on the capital market research, in the following example, we focus on the economic aspect of “scale effect”.

Many capital market researchers have used Ohlson (1995) model (or a modified form of that) to show the relationship between the market value of equity with the book value of equity and net income. These relationships are shown in equation 1.

$$MVE_{it} = \alpha_0 + \alpha_1 BVE_{it} + \alpha_3 Earns_{it} + \varepsilon_{it} \quad (1)$$

In this model, MVE is the market value of equity and assumed to be the function of the book value of equity (BVE), net income (earned) and

some unrecognized variables(ε). This model's basic assumption is that companies with higher market value (MVE) are companies that have higher capital and profitability. In other words, the model claims that the success of companies with better economic performance and higher profitability is demonstrated and consequently their higher capital value is brought about. The model aims to estimate its parameters and determines the level of these relationships with regards to this assumption. This model is regressed in cross-sectional or time series form. Both approaches of this model would open windows for the probabilities that the size of companies would deteriorate what the model is trying to assess. The result obtained, (either over time or between companies) may be a function of the differences in size of companies instead of differences between their economic successes. This makes interpretations incorrect because it is natural that firms with higher capital have more money and income. Furthermore, their higher market value could be completely different from their level of economic performance, which the model tries to test.

Barth and Clinch (2009) stated that scale effects may cause the error term, ε , to violate assumptions underlying the estimation of the Ohlson (1995) model in different ways, including the frequency with which the standard t-statistics reject the null hypothesis that and equal zero, the extent of coefficient estimation bias and efficiency, and the explanatory power of the regression.

Types of Scale Effects

Barth and Clinch (2009) introduced five types of scale effects that could result in inference problems when estimating the basic Ohlson (1995) model. They stated that each type resulted in a different functional form of how scale caused and violated the assumptions underlying the model and thus, created a different effect on inferences relating to estimation. The different types of "scale effects" are as follows:

- Multiplicative Scale Effects
- Additive Scale Effects
- Scale-varying Coefficients
- Survivorship Effects
- Scale-related Heteroscedasticity

Multiplicative Scale Effects

Barth and Kallapur (1996), Lo (2004), Brown, Lo and Lys (1999), Gu (2005), Barth and Clinch (2009) investigated this type of scale effect and stated that when all elements of a model (e.g., Ohlson's model) are a function of a size variable (such as the number of shares or the amount of capital), this kind of "scale effect" could be expected. This kind of "scale effect" is due to the differences in the amount of initial investment and it essentially allows the estimated coefficients to be biased. When this type of scale effect exists in survey data, the differences recognized between companies could simply be due to the fact that bigger companies have higher operating power than smaller ones. And they are not necessarily better than them.

The empirical evidence in this area is flawed and inconsistent. However, Brown, Lo and Lys (1999) declared that this kind of scale effect could deteriorate inferences from R^2 . Gu (2005) rejected the results of Brown et al., (1999) and announced that these inferences resulted from levels and returns models differing in the economic relations they represent, rather than from scale effects (Barth and Clinch, 2009).

Landsman and Magliolo (1988), Hand and Landsman (2005) studied this kind of scale effect. Multiplicative Scale Effect is due to later increase in a company's capital by reasons other than performance. When firms pay dividends at different rates or issue new stocks, their size and estimated parameters will be different from others while their economic performance may be significantly indifferent. This is called Multiplicative Scale Effect and causes deterioration of regression results. Bart and Kallapur (1996) argued that this case occurred because firms have had some finance decisions unrelated to their returns. In other words, companies that have large capital injection are different from those that have become large due to successful operation. From a statistical perspective, when this scale exist estimation of Ohlson model will be contaminated by the dollar-for-dollar association between equity market value and equity book value associated with that new equity issue.

Scale-varying Coefficients

Lee (1999), Lo and Lys (2000); and Easton and Sommers (2003) suggested these scale effect. In general, if the regression coefficients vary

with changes in the participants' size, this scale effect occurs. In this case, scale (size) is correlated with response (independent) variables, and large firms' coefficients (which often are higher) could be created just because these firms have the ability to operate in more matured or predictable places, not because of their better performance.

Survivorship Effects

This "scale effect" is related to the firms which are in the sample. In general, sample firms should be selected randomly. But usually companies with zero or negative information (e.g. negative capital or zero market value) are removed from the sample. The possibilities of eliminating large firms are lower than that of small firms because the former have a larger initial data. The consequence is that the sample will contain a large percentage of large companies. This can cause problems in the error component of the model and challenge the interpretation of the results. Barth and Clinch (2009) introduced this "scale effect".

Scale-related Heteroscedasticity

One assumption underlying regression models is that variances of residuals are stable. When this assumption is not established, heteroscedasticity arises. In this case, change in the firms' size change the stability of error variances. Christie (1987), Landsman and Magliolo (1988), Barth and Kallapur (1996), Easton and Sommers (2003), and Barth and Clinch (2009) have examined this scale effect. Easton and Sommers (2003) stated that in the case of large firms, change in coefficients and error variances have greater effect on the regression elements. Barth and Clinch (2009) argued that if the surveyed companies have equal coefficients but have different size and have experienced different economic shocks, this kind of scale effect can exist. Heteroscedasticity can reduce estimation efficiency and can affect the regression R^2 . Also, because of the standard method for calculating coefficient standard errors and thus, t-statistics assumes homoscedasticity, the calculated standard errors and resulting inferences can be incorrect.

Dealing with the Effects of Scale in Capital Market Research

Accounting researchers have had many concerns about the scale effects and several accounting researchers have studied the approaches of reducing them. However, reducing the “scale effect” in the first instance requires identifying the types of “scale effect” and then determining the point where the identified “scale effect” can corrupt the soundness of interpretations.

Although dealing with the types of “scale effects” which theoretically are well defined and specified, however, because the type(s) of scale effect that exist in the data are unclear, these theoretical solutions are not practically applicable. Barth and Clinch (2009) showed that scales effect identification method could not correctly detect and determine the type (or types) of scale effect in the data. Their survey of well-known methods of identifying the existence and diagnosing the type(s) of “scale effect” could not identify the existence of scale effect especially when there were some kinds of scale in the data. Hence, researchers have considered alternative approaches to reduce the “scale effects” in capital market research. These alternative approaches are based on the principle that either size differences available between data (sample firms) should be eliminated and all the data be made identical or size as control variables should be imported in the regression model and a numerical value be given to that. Hence, some researchers suggest deflating all regression variables by a size-based deflator (first approach). Earnings management models such as the Jones model (1991) or some real earning management models are good examples of this type of encounter with the “scale effect”. In these models, in order to obtain more reliable results, all the variables of the regressions’ equation are divided by total assets of the companies at the beginning of the year. Equation 2 is a modified Jones (1991) model and Equation 3 is a real earning management model that is used to separate normal and abnormal parts of production costs. In both of these models, is the total assets of the companies at the beginning of the year t , which is used as deflator, and the final models are size-neutral.

$$\frac{TAC_{jt}}{A_{j(t-1)}} = \beta_1 \left[\frac{1}{A_{j(t-1)}} \right] + \beta_2 \left[\frac{\Delta sales_{jt} - \Delta REC_{jt}}{A_{j(t-1)}} \right] + \beta_3 \left[\frac{PPE_{jt}}{A_{j(t-1)}} \right] + \varepsilon_{jt} \quad (2)$$

$$\frac{prod_{jt}}{A_{j(t-1)}} = \alpha_1 \left[\frac{1}{A_{j(t-1)}} \right] + \alpha_2 \left[\frac{sales_{jt}}{A_{j(t-1)}} \right] + \alpha_3 \left[\frac{\Delta sales_{jt}}{A_{j(t-1)}} \right] + \alpha_4 \left[\frac{\Delta sales_{j(t-1)}}{A_{j(t-1)}} \right] + \varepsilon_{jt} \quad (3)$$

In these models TAC_{jt} denotes total accruals, are the changes in net sales dollars, is gross property, plant, and equipment and is the production costs. Each equation is for firm j in year t .

On the other hand, some researchers have advocated and proposed a second solution. They argue that using size-related variable(s) as a control variable(s) in regression models does not cause the effects of omitted variable to deteriorate the estimation results. Both of these approaches are acceptable and have been used in many capital market-based studies. But the question is, which approach is preferable? Or more exactly, which is better able to reduce adverse scale effects? In response, although it seems that researchers tend to use deflating method rather than size-based variable(s) as a control variable(s), the results are not compatible. For example, while Barth and Kallapur (1996) preferred inclusion of size as control method, Lo (2004) and Barth and Clinch (2009) rejected this idea and declared that the deflating method can better control scale problems. In this regard, another technical difficulty is that of choosing suitable size-based variable(s). In both approaches, this is an important subject, but in the deflation approach it is more important. In the next part, we will be discussing this topic in more detail.

Choosing Scale-related Variable

Both approaches are indirect approaches which try to alleviate scale problems by using scale-related variables. This kind of treatment needs great precision in choosing the variable(s) that is (are) intended to be used. In the deflation approaches, it is more important because in these types of models we are manipulating the raw data and making new data set. This new data set should make better inferences possible but choosing the wrong deflator might cause excessive adverse effects on the analyses.

There are two important questions about scale-related variables. First what are the common scale-related variables in capital market research? Among the common scale related variables, which is (are) the superior one (ones). The various variables that have been used as deflators include: 1. Total assets, 2. Sales, 3. Book value, 4. Stock price at the beginning of period, 5. Price of shares at the end of the period, 6. Number of outstanding shares; and 7. Number of employees, etc. Professional literature has emphasized the deflator scenario more. Christie (1987) and Wu and Xu (2008) emphasized the importance of choosing suitable deflators and

stated that choosing improper deflators could cause incorrect inferences of regression. Unfortunately, due to the variety of purposes and the variety of capital market research designs, there are some disagreements among researchers about which variables are superior. In practice, researchers have depended on their designs’ goals and methodologies to select a size-related variable as a deflator. By the way, some researchers have tried (basically using simulation method and experimental data), to determine the prior deflator. In Table 1, we summarize some of these findings on suggestions about the superior deflator.

Table 1: Results on Suggestions About Deflator Priority

Authors	Suggested deflator
Christie (1987)	Opening market value
Easton (1998)	Closing book value
Brown, Lo and Lys (1999)	Opening market value
Lo and Lys (2000)	Opening market value
Easton and Sommers (2003)	Market capitalization
Akbar and Stark (2003)	No meaningful differences between variables in UK
Barth and Clinch (2005)	Number of outstanding stocks
Barth and Clinch (2009)	No meaningful differences between variables although share price and at lower level unadjusted market value better recognized scale effect available in the data
Shen and Stark (2010)	No meaningful differences between variables in UK

One important point about researchers that try to find the best deflator is that these researchers often rely on the simulation of Ohlson (1995) regression model. Some like Barth and Clinch (2009) simulated basic Ohlson model and some like Easton and Sommers (2003) used an adjusted form of Ohlson (1995) model. The point here is that there is not enough empirical evidence in supporting that the results from the simulation of Ohlson (1995) model can be used in other capital market research models. Due to this point and also due to the conflicting results from different studies on the superior deflators (see Table 1) and theoretical problems of some of these research (e.g. see theoretical drawbacks Wu and Xu (2008) inserted to the study of Easton and Sommers (2003)), Wu and Xu (2008) proposed a 5-step approach for selecting the best deflators in any kind of capital market

research. They argued; assuming that the type of “scale effect” in the data and its prevalence is unknown, deleting the adverse effect of scales is hard and the best deflator is a deflator that minimizes the adverse effects of scale. The different steps of Wu and Xu (2008) approaches are as follows:

1. Choose a working model which best reflects our understanding of the sample data and also meets our inference objectives of the study;
2. Create a pool of candidate models based on the working model, including those which can be justified either statistically or economically;
3. Divide all sampled firms into groups based on a chosen firm-size measure;
4. Evaluate each candidate model by computing the values of A_k and R_k for all size groups; and
5. Select the best model from the pool by comparing A_k and R_k among all candidate models.

SUMMARY AND CONCLUSION

This paper addressed the issue of “scale effect” on capital market research. “Scale effect” refers to the problems of the different size of companies in various capital market studies. The lack of uniformity in size and value of companies is one of the main participants of capital market research which challenged interpretations and reliability of regression results. In theory, five different types of scale effects are presented and the approach (approaches) in dealing with each of them in the correlations research are discussed in detail. But due to the lack of sufficient reliability on detection methods of identifying types of scales and because of simplicity, researchers prefer to rely on alternative approaches to minimize adverse effects of scale. They primarily rely on two main approaches. First is deflating all the elements of regression using a variable representing “size” and the second is adding a size-related variable(s) into the control variables list. While the priority of the deflating method is advocated by more researchers but there is no

consensus among them and what is more important is that the question of what is the best deflator (size-related variables) is not clearly answered. In this regard two interesting notes exist. First, the methods used to determine the best deflator are mainly based on simulation and simulation is based on many assumptions. It is possible that differences in these assumptions could undermine the reliability of the research results and perhaps the main reason for the differences offered by researchers is by hiding behind this fact. Second, assuming that a method would be able to identify the superior deflator (or even superior approach), it is necessary to verify the results in different countries scientifically to be able to use the famous capital market-based model such as profit management model in different countries. In this regard, Wu and Xu (2008) five-step approach for choosing the most efficient deflator by using a kind of systematic test for its purposes can be a valuable tool in reducing the adverse effects of scales.

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