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AN EXPLORATORY FACTOR ANALYSIS OF FIRMS ENDOGENOUS GROWTH MEASURES

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Abstract

Purpose: This study attempts to standardize firm endogenous growth measures by performing exploratory factor analysis on nine firm endogenous growth measures (equity book value, equity market value, working capital, stock R&D investments, stock advertisement investment, stock capital asset investment, operating expenses, sales revenue, and the number of employees).

Methodology: Data was generated by pooling a panel dataset of 116 firms and13 years timespan data.

Main Findings: The result of the analysis reveals three underlying firm growth factors (namely firm financials, operations, and capabilities) representing the initial nine growth measures.

Implications/Applications: The results of this research can be used as the bases for further research in firm endogenous growth model analysis.

Keywords: *Firm growth measures, endogenous growth factors, financials, operations, capabilities.*

INTRODUCTION

The study of firm growth measures and growth models have long been an interesting debate in the literature of economics and business management. By investigating the firm growth measures and growth models researchers gain insights into the key drivers of firm performance and economic growth (Shepherd & Wiklund, 2009). An important aspect of the research on firm growth is firm strategy and innovation. Firm strategy, in essence, is about resource heterogeneity and positioning for sustainable competitive advantage and growth(Nonaka & Toyama, 2003). Innovation, on the other hand, generates the capabilities needed to fuel firm growth and help sustain the competitive advantage of the firm (Geroski & Machin, 1992; Teece, 2009; Shin & Seo, 2017). Although research in firm strategy (Barreto, 2010; HBR, 2011)and firm innovation (Eveleens, 2010; LOPES, Kissimoto, Salerno, Laurindo, & Carvalho, 2012)have had considerable advances over the past decades, theoretical development in firm growth research have faced considerable challenges due to the difficulties in identify suitable growth measures during firm growth studies and the variability of the growth measures used across different growth studies(McKelvie & Wiklund, 2010). As noted by (Juan V. Garcia-Manjon & Romero-Merino, 2011), some authors have suggested focusing on a single growth measure in firm growth studies while other authors recognize firm growth as a multidimensional phenomenon and have suggested the use of multiple growth measures in firm growth studies. The approach of unidimensional growth measure and multidimensional growth measures both have their pros and cons. For example, the unidimensional approach to growth studies may result in conclusions biased towards certain aspect of firm growth. A firm may show low growth in its annual equity book value but high growth in its number of employees with the possible implications that the firm revenue is being re-invested to recruit and train new employees to further expand its business. In this case, using firm equity book value as the only measures of firm growth will result in a biased conclusion that the firm is not growing (Cebeci, 2016). On the hand, the use of many growth measures may result in complex analysis and growth models that obscure meaningful growth patterns. The approach suggested by this paper is to start with a large set of growth measures but to reduce them to a smaller set of meaningful indicators or representative underlying factors using the method of exploratory factor analysis as a data reduction technique. The resulting reduced set of growth measures or growth factors can be used to construct tractable growth models which (1) a less complex as the number of variables involved in the model will be reduced small and (2) capture multiple dimensions of firm growth.

A number of growth measures have been used in previous studies of firm growth. For example, sales revenue, profitability, number of employees, and equity book value(Shepherd & Wiklund, 2009; Madani, 2017), R&D investments(Coad & Rao, 2010; Del Monte & Papagni, 2003; Juan V. Garcia-Manjon & Romero-Merino, 2011; Sundar & Harthi, 2015), market share, market value(Blundell, Griffith, & Van Reenen, 1999; Niesing, Merwe, & Potgieter, 2016), advertisement investment (Chauvin & Hirschey, 1993). In this study we start with the nine growth measures namely, sales revenue, number of employees, operating expenses, R&D investment, advertisement investment, capital investment, equity book value, equity market value, and working capital, and use exploratory factor analysis to reduce these nine measures to three theoretical constructs or growth factors which we subsequently named as operations, financials, and capabilities. Thus is in the construction of firm growth models, the three growth measures of operations, financials, and capabilities can be used rather than the original nine growth measures (Boonvut, 2017).

The three growth factors of operations, financials, and capabilities represent three fundamental dimensions of firm endogenous growth. We refer to these factors as endogenous growth factors since they are generated from growth measures of firm internal activities. In this study, we do not include exogenous factors such as GDP and economic total

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workforce which represent to some extent the market conditions in which the firms are operating and uniformly effects all firm in the market.

The remaining section of this paper is organized as follows: methodology, data and variables, analysis and results, discussion, and conclusions.

METHODOLOGY

In an attempt to formalize firm growth measures and develop theoretical constructs of firm underlying growth measures and state variables, we start by looking into the existing literature for previous measures of firm growths. We identified six growth measures (sales revenue, number of employees, equity book value, equity market value, R&D investments, and advertisement investment) frequently used in firms growth studies. Using this six growth measures and the following three additional growth measures (operating expenses, capital investment, and working capital), we collected annual data from the financial reports of firms via COMPUTAT database and build a balanced panel data set of 116 firms with data available from 2000 to 2012. After performing data transformation procedures on the collected data, we pooled the panel data and test the data for adequacy for exploratory factor analysis to determine whether exploratory factor analysis can be applied to the dataset. With a pass on the adequacy test, we perform factor analysis on the sample data and reveal three underlying theoretical constructs behind the nine measures of firm growth.

DATA AND VARIABLES

The sample consists of COMPUSTAT database firms with complete financial reports from the year 2000 to 2012. Complete in the sense that annual data are reported for all nine variables throughout all the years from 2000 to 2012. This resulted in a balanced panel dataset of 116 firms matching these criteria. We use a balanced panel dataset to avoid breaks when calculating the stock of R&D investments, stock of advertisement investments, and stock of capital asset investments. This calculation uses the perpetual inventory method which aggregates discounted year to year investments (Hall & Mairesse, 1995). Given the time periods from 2000 to 20012and the 116 firms in the sample, the total number of observations in the balanced panel dataset is 1508. The distribution of the firms in sample across industrial sectors is shown in Table 1 below using the global industry classification code system (GICS).

Table 1: Summary of Firms Distribution Across Sectors

GICS	Sector	Number Firms	Number of periods	Number of Observations
10	Energy	0	13	0
15	Materials	4	13	44
20	Industrials	6	13	66
25	Consumers Discretionary	17	13	187
30	Consumer Staples	11	13	121
35	Health Care	17	13	187
40	Financials	0	13	0
45	Information Technology	61	13	671
50	Telecommunication Services	0	13	0
55	Utilities	0	13	0
		N=116	T=13	N*T=1508

For each period in the 13 years period used in this study, data is collected for each firm in the sample on nine growth measures. A summary of the nine growth measures is shown in Table 2.

Table 2: Firms Growth Measures

Variable	Full Name
sales_t	Sale revenue
xopr_t	Operating expenses
emp_t	Number of employees
bval_t	Equity book value
mval_t	Equity market value
$wcap_t$	Working capital
sxrd_t	Stock of R&D investment
sxcap_t	Stock of capital asset investment
sxad_t	Stock of advertisement investment

The measures sales revenue, operating expenses, number of employees, equity book value, equity market value, and working capital are direct measures from the annual financial reports of the firms in our sample. However, the measures stock of R&D investment, stock of capital assets investment, and stock of advertisement investment are not directly available in the firm financial reports. These are respectively calculated using R&D investment, capital asset investment,

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and advertisement investment which are directly available on the firm financial reports. These three indirect measures are further described as follows:

Stock of R&D Investment ($\mathbf{sxrd}_t$)

Here, the technology of a firm is assumed to be internally developed by the firm through the process of R&D and not an endowment as a result of externalities. Even in the cases where the firm acquires technologies initially nurtured externally, such acquisitions are assumed to be followed by internal R&D to assist in further development, assimilation, and application of the technology to the context of the acquiring firm. Due to the uncertainty associated with R&D and technological innovation, the expected output of an R&D investment is difficult to quantify a prior. However, assuming R&D investment as the input to the firm technological innovation process and given the cumulative learning process involved in innovation, the output of firm technological innovation process can be assumed to be correlated with the stock of R&D investment and calculated using the perpetual inventory method **(Hall & Mairesse, 1995).**The rationale here is that firms use knowledge gain from previous R&D or innovation activities in their present innovation activities so that the output of current technological innovation activities depends on current R&D investment as well as past R&D investment. The perpetual inventory method formula is defined as follows:

$$\text{sxrd}_t = (1-\delta)\text{sxrd}_{t-1} + \text{xrd}_t \quad (1)$$

where δ is the depreciation rate of R&D capital stock,δ is assumed to be 15%, however, the actual choice of depreciation rate makes little difference for the estimation **(Hall, 2007).** Estimation of equation (1) requires that the initial R&D stock sxrd_0 be estimated. In this study we assumed sxrd_0 to equal the xrd_{2000}, the first period in our study. Also, this choice of sxrd_0 does makes very little difference in the calculations as sxrd_0 turn to be less and less important as the stock of R&D is discounted with time.

Stock of Capital Assets Investment ($\mathbf{sxcap}_t$)

The rational here is that when firms are making the investment into physical asset or another form of capital assets, they are doing so after careful consideration of how those assets will help them increase their operating efficiency. For example, the purchasing of new machinery, computers, and buildings are done in order to improve the process of producing and distributing a firm's products and services. Thus capital assets investment goes into increasing the production and distribution capabilities of the firm (Arrow, 1962). Also these investments are associated with certain changes taking place within the firm such as re-organization and redeployment of resources to make effective use of the new assets, or implementation of new processes supported by the newly acquired assets. During each occurrence of re-organization within the firm, the firm makes use of knowledge gain from previous organizational changes and also gain new knowledge from current implementations. Overtime, the firm's abilities to manage its production and distribution process increases so that the knowledge gain year on year follows a similar pattern like the knowledge gain from pure technological research and development. As such, we adopt the same procedures for calculating stock R&D investment to the calculation of stock of capital assets investment. This implies calculation of stock of capital assets investment also follows the perpetual inventory method.

Stock of Advertisement Investment ($\mathbf{sxad}_t$)

Advertisement investments are considered not only to affect the sales of firm products and services in the year for which the advertisement was made but to have a long term effect on the development of the firm's brand identity and communication of its value proposition to its customers. Also, Firms turn to learn from previous advertising experiences which marketing strategies and activities seem to be more effective for their products and services and knowledge gain from previous marketing activities in their future business activities such as the research and development of new markets. Overtime, as the firm learns and adjusts its marketing activities, the perception and position of the firm in its customers' mind are enhanced. The net effect is that the ability of the firm to market and sell its products and services increases overtime so that advertisement investment has a long term effect on the firms business capabilities as the R&D investment has on the technological capabilities. Thus the effect of advertisement investment follows a similar pattern as the effect of R&D investment, as such the stock of advertisement investment is calculated using the perpetual inventory method as the stock of R&D investment.

To avoid issues caused by differences in measurement units across variables and firm size effects, we normalize all measurements by dividing each time series by its value for the year 2000 (chosen arbitrarily as the pivotal year). For example, each measurement in the time series for annual sales from 2000 to 2012 (sales_t) is divided by the annual sales for the year 2000 to obtain the normalized time series.

$$s\_\text{sales}_t = \frac{sales_t}{sales_{2000}} \quad (2)$$

To smoothen the time series as wells as facilitates calculation of elasticity on these measures, we further transformed each normalized measurement by taking the natural logarithm of the measurement. Using the annual sales series as an example, the natural logarithm is given as follows;

$$\ln\_s\_\text{sales}_t = \ln(s\_\text{sales}_t) \quad (3)$$

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In order to eliminate firm-specific effect in the measurements, the difference of the measurements is used instead of their level values. Using the annual sales time series as an example, the difference series is given by:

$$d\_\ln\ \_s\_\text{sales}_t = \ln\_s\_\text{sales}_t - \ln\_s\_\text{sales}_{t-1} (4)$$

Unlike the levels of the measurements which are non-stationary time series, the difference of the measurements are shown to be stationary using panel unit test as illustrated in appendix B of this paper. By eliminating firm-specific effects, the panel data can be safely pooled and use in exploratory factor analysis. However, to perform exploratory factor analysis we first test for the adequacy of exploratory factors on the pool panel data.

ANALYSIS AND RESULTS

We perform exploratory factor analysis using the method of principle component analysis **(Joliffe & Morgan, 1992)** to reveal lower dimensions of theoretical factors from our original nine dimensions of growth measures. We use the first difference of the measures rather than the levels and pool the data from the 116 firms in our sample to generate a pool panel data set. For each firm in the sample for the following time series variables.

Table 3: Variables Correlation Matrix

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(vii)	(ix)
d_ln_s_wcap (i)	1								
d_ln_s_bval (ii)	0.508	1							
d_ln_s_mcap (iii)	0.313	0.426	1						
d_ln_s_sale (iv)	0.226	0.416	0.296	1					
d_ln_s_xopr (v)	0.165	0.367	0.1462	0.88	1				
d_ln_s_emp (vi)	0.047	0.325	0.1578	0.56	0.607	1			
d_ln_s_sxrd(vii)	0.069	0.187	0.0047	0.301	0.37	0.285	1		
d_ln_s_sxcap (vii)	0.054	0.172	0.0006	0.325	0.393	0.281	0.53	1	
d_ln_s_sxad (ix)	0.085	0.167	0.025	0.285	0.354	0.252	0.492	0.407	1

Table 4: Bartlett and KMO Tests

Bartlett test of sphericity	
H0: variables are not intercorrelated	
Chi-square =	4726.332
Degrees of freedom =	36
p-value =	0.0000
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	
KMO value =	0.742

As shown in Table 4 above, our sample passes the test for adequacy for exploratory factor analysis (Bartlett test p-value equal to zero and KMO tests KMO value greater than zero), implying the sample is suitable for exploratory factor analysis.

The basic goal of exploratory factor analysis is to describe a set of m random variables in terms of a smaller number of unobserved k constructs (k<m) which are determined by interpreting the coefficients (known as the loading) in the factor model. The exploratory factor model can be expressed as

$$X_i = l_{i1}F_1 + l_{i2}F_2 + \cdots + l_{ik}F_k + u_i \quad (5)$$

Where X_i is the variable i $(i = 1, 2, \ldots, m)$, $F_1, F_2, \ldots, F_k$ are the unobserved underlying common constructs (factors), and u_i is a unique factor or error variation. Thus the variance of each variable is split into a component that is common to all the variables represented by the loadings on the common factors and a component that is unique to the variable represented by the unique factor. Using an orthogonal rotation method such as VARIMAX and a factor extraction method such as the principle-component factors (PCF), variables with similar common variances as indicated by their factor loading can be grouped together under one factor. In this way, variables that are actually measuring a single underlying activity are grouped together.

In our analysis of the nine firm growth measures using VARIMAX rotation, PCF, and a 0.4 cut off value for factor grouping, we found that sales revenue, operating expenses, and the number of employees load together under a single factor. We name this factor "OPERATIONS". Stock of R&D investment, stock advertisement investment, and stock

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capital assets investment load together under a single factor and we name this second-factor "CAPABILITIES". Firm working capital, equity book value, and equity market value load together and we name this third-factor "FINANCIALS".

Table 5: Exploratory Factor Analysis Results

Factor analysis/correlation			Number of observations = 1276	
Method: principal-component factors			Retained factors = 3	
Rotation: orthogonal varimax (Kaiser off)			Number of parameters = 24	
Factor	Variance	Difference	Proportion	Cumulative
OPERATIONS	2.52262	0.57377	0.2803	0.2803
CAPABILITIES	1.94885	0.14601	0.2165	0.4968
FINANCIALS	1.80283		0.2003	0.6971
LR test: independent vs. saturated: chi2(36) = 4781.63 Prob>chi2 = 0.0000				
Rotated factor loadings (pattern matrix) and unique variances				
Variable	OPERATIONS	CAPABILITIES	FINANCIALS	Uniqueness
d_ln_s_sale	0.8782			0.1529
d_ln_s_xopr	0.8869			0.1350
d_ln_s_emp	0.8165			0.3169
d_ln_s_sxrd		0.8175		0.2903
d_ln_s_sxcap		0.7501		0.3692
d_ln_s_sxad		0.7512		0.3970
d_ln_s_wcap			0.8293	0.3022
d_ln_s_bval			0.7563	0.3043
d_ln_s_mcap			0.6858	0.4579
blanks represent abs(loading)<.4				

DISCUSSIONS

The analysis in the previous sections reveals three endogenously growth factors or measures of firm growth. We name the factor containing Stock of R&D investment as capabilities, the factor containing sales revenue as operations, and the factor containing equity book value as financials. Figure 1 below visually summarizes the results of our analysis.

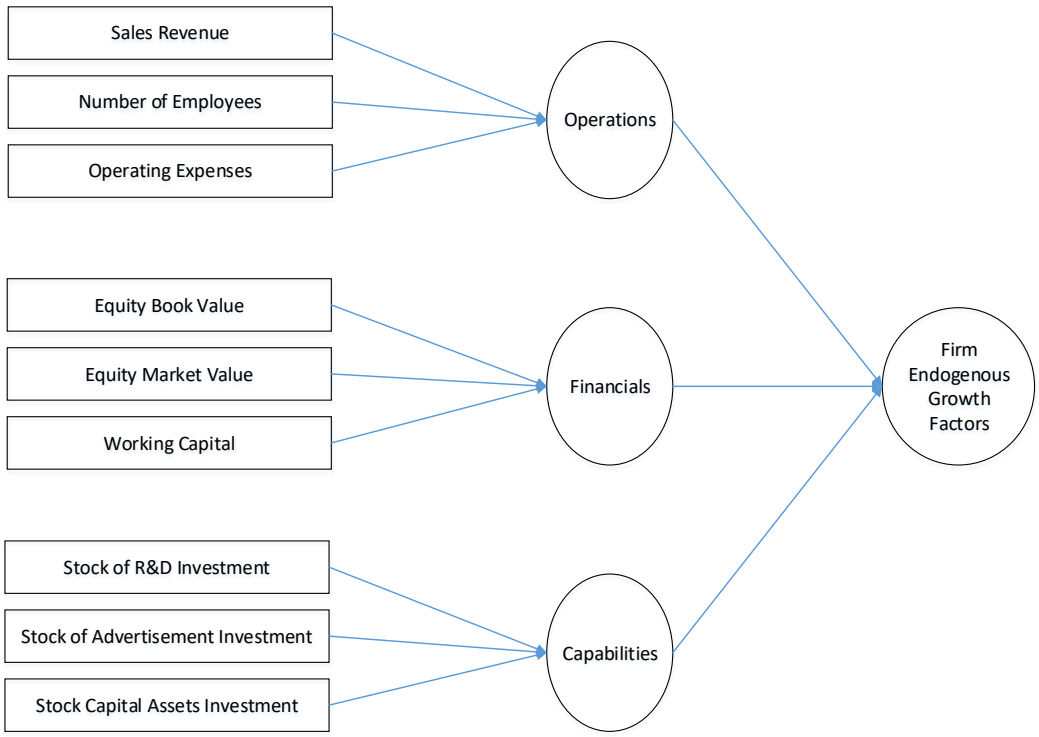

Figure 1: Firm Endogenous Growth Measures

Although the choice of names of these theoretical factors is arbitrary, we discuss below the rationale behind our choice of names.

Capabilities

The rationale behind this naming is that changes in Stock of R&D investment correlate well with the intensity of firm R&D activities which is the basis for firm innovations and capabilities development activities. Thus changes in Stock of R&D investment is seen as a primary indicator of the intensity of the firm capability development activities. Other measures that correlate highly with Stock of R&D investment, as indicated by the method of exploratory factor analysis as measuring the same construct as changes in stock of R&D investment, will thus appear as measures of changes in firm capabilities. Not surprisingly, this turns out to be stock of advertisement investment and stock of capital assets investment.

Firm capabilities represent the core value proposition of the firm. It is built on the technological, business, and management knowledge accumulated by the firm over time. Growth in firm capabilities happens through the process of innovation during which the firm generates new capabilities or enhance existing capabilities in form of products, services, and processes. Thus the pattern of growth in firm capabilities follows the perpetual inventory pattern used to calculate the stock of R&D, stock advertisement, and stock of capital assets.

Operations

The operations of the firms act as the medium or activities through which the firm converts its capabilities to cash by producing, selling, and delivering its capabilities to its customers in mass quantities. Hence we name the factor that relates to production and sales of firm products and services as Operations.

Financials

Firm financials represents a measure of the growth of firm financial value attributed over time. In this study we use firm equity book value, equity market value and working capital as possible proxy measures of firm financial growth.

CONCLUSION

In this paper, we analyzed nine measures of firm growth and revealed that these nine growth measures are driven by the three underlying growth factors consisting of firm operations, financials, and capabilities. We propose these three theoretical growth factors are a measure of firm's endogenous growth. The three endogenous growth factors or measures developed in this research can be used for example to build firm growth models where firm financials is a function of firm operations and firm capabilities. Researchers can choose to build and analyze firm growth models using the original nine growth measures or to build simpler models using the theoretical three growth measures. Thus results of this research can serve as the bases of future research in firm endogenous growth analysis.

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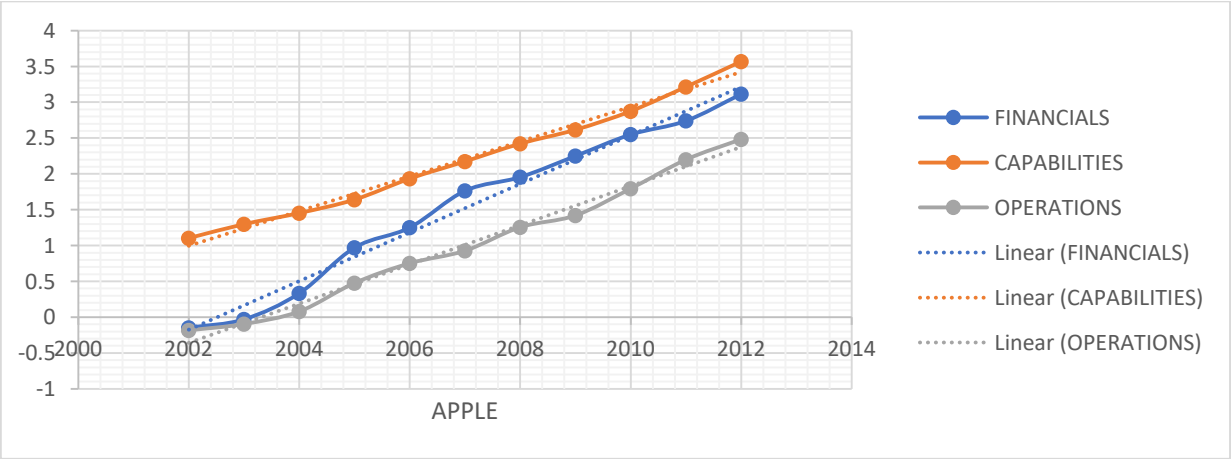
APPENDIX A: SAMPLE GROWTH GRAPHS

Below is a plot of changes in APPLE's and MICROSOFT's financials, capabilities, and operations from 2002 to 20012. The vertical axis scale represents changes using year 2000 values as the base values. Thus the changes are relative to values in the year 2000, the starting year. The horizontal axis represents timeline. Financials, capabilities, and operations are calculated by averaging of their factor loading. For example, operations are calculating by averaging the normalized values of operating expense, number of employees, and sales revenue.
During this period, APPLE Inc. has experienced steady growth with its operations, capabilities, and financials all increasing. Microsoft experienced stable growth in its capabilities and operations, however, it financials show a drop in 2008 (financial crises period) and a bounce in 2010.



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