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An Empirical Model to Measure Engineering Management Contribution to Output Growth of Machinery Manufacturing SMEs

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Abstract— **This study has developed a novel model to measure the output growth of machinery manufacturing SMEs; and the ultimate target is the developed model to be used for evaluating the performance of this sector. Based on the literature review findings on production growth theory, a mathematical model is developed and rebuilt through short term production. The rebuilt model is refined by incorporated engineering management as an input. The developed model is tested through 20 machinery manufacturing SMEs by using year's input-output data. The results revealed that engineering management contribution to output growth of 16 SMEs is significant at 95% connivance level (p-value <0.05). The test and validation results suggest that the developed model is useful to evaluate the engineering management contribution to output growth of machinery manufacturing SMEs. Therefore, this model is new in manufacturing domain that would add to be a new knowledge in manufacturing filed. In this aspect, this work is novel. This study proposes further study in this area which requires building a general model to devalue the engineering contribution to output growth of all types of manufacturing industries.**

Keywords: Growth Model; Manufacturing SMEs; Engineering Management; Input-Output; Output Growth

I. Introduction and Background

This paper aims to develop a model to evaluate the engineering management contribution to output growth of machinery manufacturing Small and Medium Manufacturing Enterprises (SMEs). The developed model is used to test and refine with input-output production data to evaluate the significance level of engineering management contribution to output growth. Output growth of machinery production depends on effective use of inputs. The important inputs to machinery production process are killed labour, capital for purchasing process machinery, raw materials for products and engineering management for production planning, quality control and R&D.

The optimization of input is vital for achieving a sustainable growth. It is evident that in major cases the relevant stakeholders are not paying full attention to reinforce production resources by optimizing skilled labour, capital, raw materials, engineering management capability. For improving product quality, and to achieve higher productivity in production, engineering management is a proven higher value added inputs for machinery manufacturing industry; and this management is a determinants of output growths machinery production.

The contribution of manufacturing industry to GDP is about 50 percent both in developed and developing countries. In this aspect process machinery and machinery manufacturing industries play a vital role. The machinery manufacturing SMEs are commonly categorized to be the component manufacturers for larger machinery manufacturing industries. Machinery manufacturing SMEs in developing countries are important socially and economically for a number of reasons including: creating job opportunity and smooth money flow through society.

SMEs account for a significant share of employment due its wide dispersion across rural areas.

It has the ability to employ a significant amount of the technical labours in local economies; (Tambunan, 2006).

Therefore are SMEs directly connected to poverty alleviation and important for rural economies. In this aspect, SMEs are critical to economic growth. Therefore, machinery manufacturing SMES has the power to contribute to economy growth (Olusola & Oluwaseun, 2013; Elaswad, et al., 2014).

However, in machinery manufacturing process, engineering management is a vital input, and to know about its contribution to outputs and output growth is important. Currently published literature shows that in the published journals and books no model is available to measure engineering management contribution to outputs and output growth of machinery manufacturing SMEs. Hence, it is important to build a model. This study attempts to fill this gap by building and testing growth model related to the labour, capital, raw materials, and engineering management.

This study has mainly five main sections: introduction and background is placed in section 1; the literature review and objectives are stated in section 2; theoretical framework and research methodology are described in section 3; research findings and conclusion are in section 4; following section, 5 which describes the conclusion.

II. Literature Review on Growth Theory

This section presents overview of the literature review findings and theoretical framework related to manufacturing SMEs and its growth. Findings suggest that there has been a lack of empirical research to evaluate output growth of manufacturing SMEs. Most of the performance measurement model of machinery manufacturing SMEs does not have model to evaluate the contribution of inputs to output growth. More particularly, no model is available to measure the engineering management contribution to output growth of production. In this regards, gaps are observed between

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existing performance measurement growth models and engineering management practices. The review work started to study academic research papers and textbooks on the conceptual model and manufacturing SMEs. Researchers studied over (15) papers and about (30) percent of these published before the year (2010); and about (70) percent papers published after (2010). Related titles which were taken into account during literature are presented and discussed here.

2.1 Capital in SMEs Business and Growth

Capital is an important input for manufacturing SMEs for achieving business sustainability and production growth. Capital refers to money used by SMEs to purchase machinery, buildings, and raw materials for maintaining production operations. A major constraint for manufacturing SMEs is limited access to formal financing system and business capitals (Ted, 2002). In general, the SMEs have two sources of fund: equity and debt. Equity refers to internal funds including owners' savings, accumulated profits, contribution from partners and private investments of friends (Haynes, 1999). To support production operation, business owners manage funds from convenient sources with respect to the business norms in the form of debt. However, literature suggests that funding size and SMEs growth are positively associated, and the large fund size contributed to speed up business growth as stated Bruce et al. (2012) and Barkman (1994). They also suggest, SMEs needs easy access to both formal and informal financial institutions to get necessary fund for maintaining its business operations; and lack of fund inputs may reduce business growth.

2.2 Labour Contribution to Output Growth of Production Process

Education and experience of labour force are the important factors for manufacturing SMEs in growing phase. Cobb-Douglas production function (1928) demonstrates that no labour no outputs. According to Charoenrat et al. (2013) manufacturing SMEs in Thailand operate with high level of technical inefficiency. Such manufacturing SMEs are caught in a trap where production is heavily dependent upon labour input. Predominantly, in Thailand unskilled labour in production is considered low value-added activities. Furthermore, Charoenrat et al*.,* (2013) added that firms must know the best use of skilled labours for maintaining its smooth production. He added firm size could increase through greater access to skilled labours and upgrading labour skills through improvements in education and training programme. Baldwin and Lin (2001) acknowledged the need of improvement poor labour skills in order to meet organizational challenge. Literature suggests that labour productivity and manufacturing productivity are positively associated (Broadberry, et al., 2013; Singh, & Mohanty, 2012).) Therefore, skilled labour is a value added input for the growth of manufacturing SMEs.

2.3 Contribution of Raw Materials Output Growth

In machinery manufacturing plant raw materials utilization is playing a vital rule in the output growth as stated by Shahidul et al. (2013). He found that wastage of raw materials in production process and economic performance of manufacturing business are positively associated. Low level of raw materials inventory cost, and managing economic performance in raw material supply chain are the dominant factors of output growth. Raw materials utilization efficiency is an indicator of output growth.

2.4 Contribution of Engineering Management to Output Growth

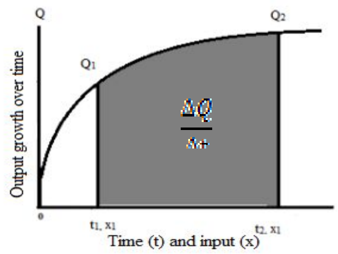
Engineering management is a higher value added inputs to machinery manufacturing process. Also the degree of skill of an engineer play a vital role in manufacturing SMEs growth. Engineering management is a combination of production management, operations management, and R&D. Production growth depends on efficient utilization of inputs, product quality, and productivity of production process. Production operations manager needs to get involve in R&D to identity non-value added inputs, production capacity gap (Shahidul et al., 2013). A major constraint of SMEs is engage a highly skilled operations and production engineer/manager in innovation activities for producing new products and processes to achieve sustainable growth of manufacturing SMEs (Charoenrat et al., 2012). However, all of them suggested that engineering manage is an essential input for machinery manufacturing SMEs to stay in growth path.

2.5 Outputs Growth Machinery Manufacturing SMEs

The output growth of machinery manufacturing SMEs depends on how efficiently inputs are being used in production process. It is reported that the degree of output growth is influenced by lower non value added index of physical inputs such as labour, capital, raw materials, and engineering management (Wernerfelt, 1984). According to Barney (1991) and Shahidul et al. (2013), the vital factors of output growth of firm are knowledge, skills, planning, and optimization of assets. Therefore, output growth of firms implied a development process where a firm maintain balanced growth in total performance inputs (Sun, 2004). Furthermore, technical efficiency and economic efficiency of production process are indicators of output growth. Higher degree of engineering management capability could greatly contribute to achieve a sustainable production growth. From the published literatures, mentioned above, it could be stated that output growth of machinery manufacturing SMEs depends on skill level of SMEs of managing labour, capital, raw materials and engineering resources.

2.6 Growth Model

The theoretical literature on growth models are traditionally focussed on economics and agriculture. The relationship between productivity and growth has also featured in a number of theoretical frameworks. The summary of growth model is managing and reallocates resources from less productive to more productive firms (Bottazzi, et al., 2008). The growth model used in the current study involve five inputs ;Labour skills, Capital investment in new technologies in production machineries, Quality of raw materials and Engineering management and its elements such as R&D capability. Production growth happens inputs growth positively affects output growth within the architecture of production function (Majumdar, 2004; Saari, 2011). Production function is expressed the relationship between the inputs used in production and the output. The production function gives a simple of inputs transformation process to outputs. The output growth production involves of two factors which are time and inputs. It is illustrated by Figure 1.



Finger 1: Output Growth over Time

Over the time, labour, engineering, and R&D capability increase and contribute to increase output. This phenomenon can be presented by the following mathematical model:

$$\frac{\Delta Q}{\Delta t} = \frac{Q_2 - Q_1}{t_2 - t_1}$$
(1)

2.7 Growth Components

The growth rate of output that stated in Figure 1 and presented by equation (1) is a combined contribution effect of all inputs namely capital, labour, raw materials and engineering management. It implies that the contribution of each inputs a part of the ΔQ/Δt. The equation (1) is allowed to state that the contribution of an input to total growth is a ratio of the growth a components to total output growth. This logic could be presented by the following equation.

$$C(g) = \frac{\text{Idividual Input growth}}{\text{Total output grouth}} = \gamma \frac{g_i}{g_t}$$
(2)

Here, g_i is the individual input growth and γ is the efficiency component of an individual input and g_t is the total output growth of production process

2.8 Time Effect on Growth

The contribution is not static and changes occur with the passage of time. A professional body or a technical person tends to gain experience over time that enhance contribution capability. This type of skill growth is exponentially distributed as acknowledged by Idris, & Rahmah, (2007). Therefore, the increasing capability of contribution can be presented by the equation (3):

$$A(t) = A_0 e^{\theta t}$$
(3)

Here, θ = Time efficiency parameters of inputs of a production process is also known as a technological parameters (Admassie, & Matambalya, 2002; Idris, & Rahmah, 2007; Liik, et al., 2014; Canis, B. 2011). Equation 3 indicates that the contribution is time dependent.

2.9 Theory of Significant Level of Contribution to Output Growth

The output growth significancy can be measued in various ways. Commonly, at 0.05 significant and 95% confident level or at 0.1 significant and 90% confident leve are being used. The P-value is commononly used to evaluate the significancy level . The mathamtical model of significancy is shown in (4).

$$Z = \frac{(\overline{X} - x)}{\frac{\sigma}{\sqrt{n}}}$$

(4) Where; σ is the standard devotion of growth, n is the sample size and $x_{(i,\dots,n)}$ is the output growth of production and $\overline{X}$ is the average of output growth The meaning of p-value demonstrates in Figure 2.

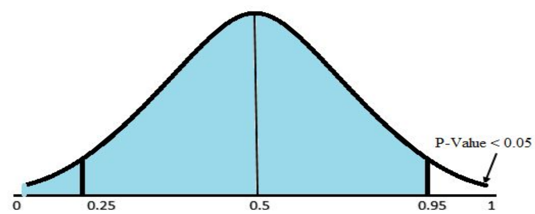


Figure. 2: Sginfcance Measuement Model

If signifiancy is measued at 95% level, then the P- value <0.05 or P-value >0.05. If appears P- value <0.05 then growth is significant. If appears P-vaule >0.05, then growth is not significant.

2.10 Research Problem Statement

The findings of literature review on production growth reported in section 2.2 to 2.8. Results indicate that empirical models for measuring the engineering management contribution to output growth are not available in published materials. In aspect of this revealed fact the question is, **"what is the shape of empirical model for evaluation significant level of engineering management contribution to output growth?"** This study is undertaken to address this issue and would be looking for answer of this question.

2.11 Objectives of the Study

The broad objective of this study is to evaluate the contribution of engineering management to the performance of machinery manufacturing SMEs. To achieve this research goal, objective has been divided into three parts.

I. To develop a model to evaluate engineering management contribution to output growth of machinery manufacturing SMEs.
II. To test the develop model at machinery manufacturing SMEs.
III. To validate developed model by evaluating the significance level of engineering management contribution to output growth of machinery manufacturing SMEs.

2.12 Scope of This Study

An empirical model has built by the aid of short term production function. The developed model has tested at 20 manufacturing SMEs by using 5 years input-output data to judge its fitness. The developed model has validated by using Statistical tool of significance. Statistical Package of Social Sciences (SPSS) software was used for analyzing data for measuring degree of significance. In this aspect, it is considered that if the contribution appears within 95% significant level then model is fit to use for evaluating contribution of engineering management to outputs.

2.13 Novelty of the Study

To evaluate engineering management contribution of to output growth of machinery manufacturing SMEs is also not available in published materials. This indicates that a gap exits in the machinery manufacturing SMEs domain and this study aims to fill up this gap. Hence, the novelty of this study is to develop an output growth model to evaluate engineering management contribution to manufacturing SMEs growth. Definitely, this study would add new information to knowledge stock of manufacturing SMEs. In this aspect this study is a novel work.

III. Methodology

This study aims to develop a model to evaluate engineering management contribution to output growth of machinery manufacturing SMEs. The model is built from short term production function and Cobb Douglas production theory. The model has tested at twenty (20) machinery manufacturing SME by using 5 years input output data. The input data has edited by using SPSS software in order to improve data quality. Following section presents the description of variables used in the current study.

3.1 Characteristics of Variables Used

3.1.1Dependent Variable:

The Output and output growth of machinery manufacturing SMEs are dependent variable.

3.1.2 Explanatory Variables:

I. Capital- the amount of money used for purchasing machinery and equipment for manufacturing SMEs.

II. Labour- the amount of money that is being spent for labour for conducting manufacturing process operations.

III. Raw Materials- The total cost of raw materials that are being used in production process.

IV. Engineering management- the total cost that are being used to manage engineering staff for planning, scheduling and R&D for smooth production operation of manufacturing SMEs.

3.2 Model building and testing Procedure

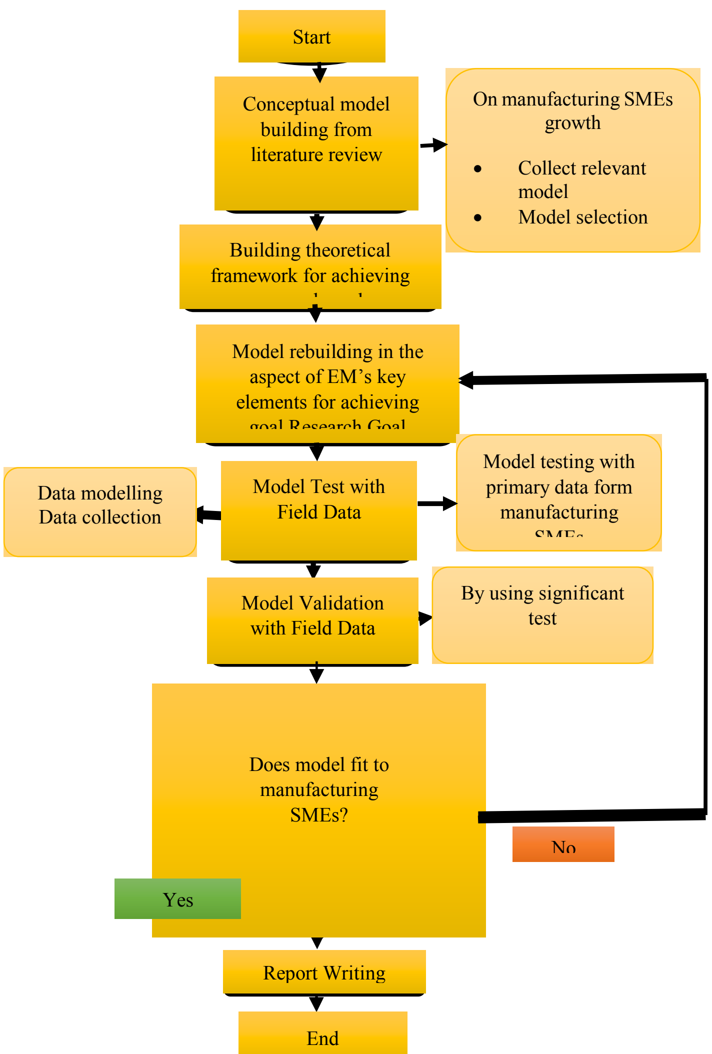


Figure 3: Flow Diagram of Model Building and Testing

3.3 Model Validation Procedure

The developed model was validated by using Statistical tool of significance. Statistical Package of Social Sciences (SPSS) software was used for analyzing data for measuring degree of significance. In this aspect, it is considered that if the contribution appears within 95% significant level then model is fit to use for evaluating contribution of engineering management to outputs.

4.0 Model Building, Testing and Validation

This section is developed to meet the requirement of research objectives. This section has three parts. Section 4.1 is designed to fulfil the requirement of objective number one that stated in 2.11. (i). Section 4.2 is organized to test the develop model to fulfil the requirement of objective number two that stated in 2.11. (ii). Section 4.3 is organized to validate the developed model to fulfil the requirement of objective number three that stated in 2.11.(iii).

4.1 Model Building to Evaluate Engineering Management Contribution

This section is designed to develop model to evaluate engineering management contribution to output growth of machinery manufacturing SMEs which is known as objective number one that stated in 2.11.(i).

The target of this study is developed model from a production function where labour, capital, raw materials, and engineering management are being used. The input-output model can be used to measure the output growth of manufacturing process. The output growth of an industrial production depends on dynamic behaviour of inputs. The output growth measurement model can be developed from short term production function as established earlier by (Shahidul & Shazali, 2011; Elaswad, et al., 2014). Short term production model is shown in equation (5).

$$\mathrm{Log}(Q) = \log(A) + \alpha\log(K) + \lambda\log(R) + \beta\log(L) + \gamma\log(M) \quad (5)$$

Here; $Q(t)$=Average output of production over time t. K= capital of machinery and production operations. R = Raw materials used. L= number of labour on the manufacturing process. A= transformation factor from inputs to outputs, M= engineering management needs to manage production. The conceptual model of outputs growth model with above mentioned inputs is shown in Figure 4.

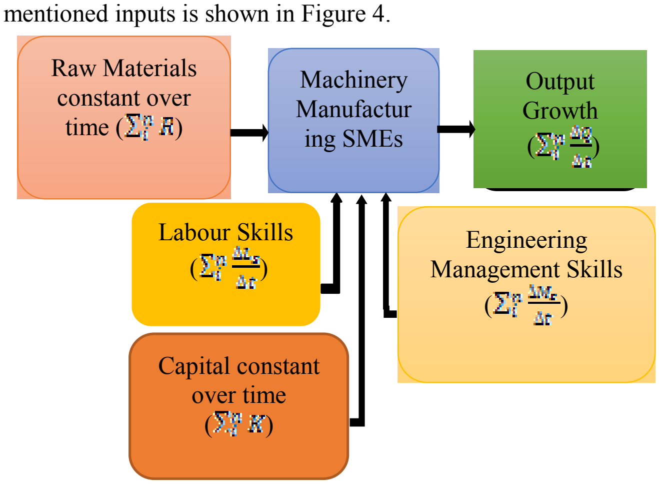


Figure 4: Conceptual Growth Model

Based on Figure 4, the mathematical model is to measure output growth of machinery manufacturing SMEs which can be presented by (6):

$$g(Q) = \alpha_1 g(K) + \beta_1 g(L) + \lambda_1 g(R) + \gamma_1 g(EM) \quad (6)$$

Where, g(Q) is total output growth and combined of contribution of growth rate of labor [g(L)], capital [g(K)], raw materials [g(R)] and engineering managements [g (EM)].The $\alpha_1, \beta_1, \lambda_1$ and γ_1 are the factor efficiency parameters inputs of capital, labour, raw materials and engineering management. This growth is due to skills growth engineering staff, labour, and management of over time. The theory of contribution to output growth that state in section 2.7 in equation (2) and equation (6) are allowed us to state that the engineering management contribution to total growth is a ratio of engineering management growth to total output growth. This logic could be presented by the following equation (7).

$$C(EM) = \frac{\text{Engineering management growth}}{\text{Total output growth}} = \gamma 1 \frac{g(EM)}{g(Q)} \quad (7)$$

The growth of output is not static and changes occur with the experience of labour and management involved in production process. A professional body or a technical person tends to gain experience over time which is used to enhance the contribution capability. This type of skill growth is known as the exponential distribution (Idris, & Rahmah, 2007). Therefore, the increasing capability of contribution can be presented by the equation (8):

$$A(t) = A_0 e^{\theta t} \quad (8)$$

Here, θ = Time efficiency parameters of inputs of a production process is also known as technological parameters (Idris, & Rahmah, 2007; Admassie, & Matambalya, 2002; Liik, et al., 2014; Canis, B. 2011). Equation 8 indicates that the contribution is time dependent. If the equations 7 and 8 are combined in results, the time dependent contribution model gets a new shape which can be presented by the equation (9):

$$C(EM) = \gamma 1(t) \frac{g(EM)}{g(Q)} e^{\theta t} \quad (9)$$

Equation (9) indicates that the value of $C\ (EM)$ depends on the elasticity of outputs $[\gamma\ (t)]$ and time efficiency parameter of skill $[\theta t]$. Equation (9) is the model which could be used to evaluate the contribution of engineering management to total output growth. Thus, objective number one of this study that stated in section 2.11. (i) is achieved.

Parameters	**α_1**	**β_1**	**λ_1**	**γ_1**	**R^2**	**DW**
Mode esimate	**0.076**	**0.761**	**0.73**	**0.77**	**0.992**	**2.309**

4.2 Model Testing

This section is designed to test developed model for evaluating engineering management contribution to output growth of machinery manufacturing SMEs which to be known as objective number two stated in 2.11.(ii). In first part of this section is organized to validate data and to estimate the effect size of input to output growth.

For model testing we used input-output time-series data of twenty (20) manufacturing SMEs of the year 2009-2014. We analysed collected data by using SPSS software. The findings are reported in Table 1 and details analysis is attached in Appendix A1.

Table 1: Model Estimate of 20 Machinery Manufacturing SMEs

The value of effect size (R^2) is 0.992 which indicates that 99.2 percent inputs has used in outputs. The DW statistics 2.3 indicates that auto correlation is within acceptable limit. The estimated value of output growth rate of labor labour, capital, raw materials and engineering management are α_1=0.761, β_1=0.076, λ_1=0.73 and γ_1 = 0.77 respectively.

The engineering management contribution to output growth model is presented by equation (9) and time effect on growth model is presented by equation (6). The detail analysis of both equations is attached at Appendix A2 and Appendix A3. The growth model (6) has estimated to determine the total output growth which attached at Appendix 3. The estimated values of engineering management contributions to output growth are listed in Table 1 at column 2.

Table 2: Estimate Engineering Management Contribution to Output Growth

Sample SMEs	Contribution Engineering Management to Growth Cg(EM)	Significant level of Contribution Engineering Management to output Growth P-Value
SMEs1	0.845518	0.0002*
SMEs2	-0.20729	0.0002*
SMEs3	0.644466	0.0002*
SMEs4	0.77646	0.0003*
SMEs5	0.821505	0.0003*
SMEs6	0.928104	0.0047
SMEs7	0.646091	0.0003*
SMEs8	0.825002	0.0003*
SMEs9	1.109122	0.0838
SMEs10	0.850343	0.0005*

SMEs11	1.161679	0.1539
SMEs12	0.986056	0.0017
SMEs13	0.95022	0.0084
SMEs14	1.965442	0.0853
SMEs15	0.644485	0.0002*
SMes16	1.132904	0.1131
SMEs17	0.363919	0.0002*
SMEs18	0.858888	0.0008
SMEs19	0.659555	0.0003*
SMEs20	12.44725	0.0003*
Average	**1.420486**	

*One tail test at 95% confidence level

The final shape of engineering management contribution to output growth model is shown in Equation (10).

$$Cg(EM) = 0.77 \frac{G(EM)}{G(Q)} e^{\theta t} \quad (10)$$

The factors [$0.77\, G\, (EM)$] indicates the engineering management contribution to outputs growth. Table 2 indicates that 12 SMEs out of twenty is significant. Equation (10) indicates that the value of $g\,(M)$ depends on $[\gamma 1\ (t)]$ and time efficiency parameter $[\theta t]$. Equation (10) represent a model that could be used to evaluate engineering management contribution to output growth. Thus, objective number two of this study that stated in section 2.11. (ii) is achieved.

4.3 Model Validation

This section is designed to validate developed model for evaluating engineering management contribution to output growth of machinery manufacturing SMEs which is known as objective number three stated in 2.11.(iii). Model validation is conducted at twenty (20) machinery manufacturing SMEs by using equation (4) stated in section 2.9. Detail analysis of validation is listed in Appendix 4 and Appendix 5. The Significance Test of SMEs 1 is depicted in Figure result of other 19 test are shown in Appendix 6. The estimated value of degree of significance is reported in Table 2 at Column three (3) in section 4.2.

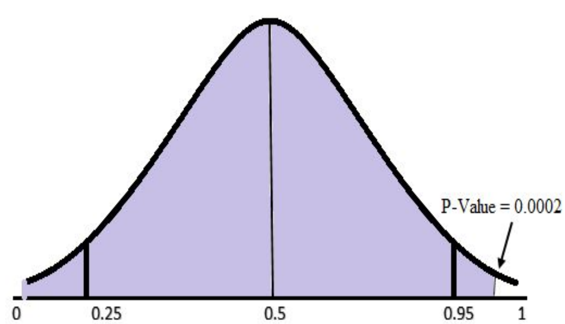


Figure 5: Degree of Significant of Engineering Management Contribution

The significance test is conducted at 95 percent confidence level. The p-value of contribution to growth is found to be 0.0002 which is less than 0.05. The location of p-value is outside 0.95. This finding demonstrates that engineering management contribution (as input) to output growth is significant. The total output growth factor of SMEs 1 is found to be 16.63 that stated in Appendix 4.

These findings indicate that about 95% of engineering management resources has been used in production process that contributed significantly to achieve total output growth 16.63%. The significance test of 20 SMEs are listed in Table 2 and column 3; that demonstrate engineering management contribution of 12 SMEs out of 20 SMES is significant. These findings state that the developed model is quite fit to evaluate engineering management the contribution to output growth of machinery manufacturing SMEs. Thus, objective three of this study that stated in section 2.11.(iii) is achieved.

4.4 Scenario Analysis of Research Findings

Model building to evaluate engineering management contribution to output growth, model testing and validation are the scope of work of this study.

Based on the methodology of model building stated in section 3.2 and theory of growth model stated in section 2.6, 2.7, 2.8 and in equation (2), the model for evaluating engineering management contribution to output growth is built. The final shape of targeted model is presented by equation (10) which is shown.

$$Cg(EM) = 0.77 \frac{G(EM)}{G(Q)} e^{\theta t} \quad (10)$$

Thus, research objective to be known as one state in section 2.11.(i) is achieved.

Model testing is conducted based on the method stated in sections 2.12 and 3.2. The test results are reported in section 4.2 and Table 2. The validation of the developed model is conducted based of the procedure stated in section 3.3 and reported in section 4.3 and in Table 2. Findings suggest that developed model is to be found quite fit to explain the engineering management contribution to output growth. Thus, research objective to be known as two and three stated in section 2.11. (ii), and 2.11. (iii), are achieved.

Conclusion and Summary of Study

The aim of this study was to build and test a model to evaluate engineering management contribution to outgrowth of machinery manufacturing SMEs. The developed model is tested at 20 SMEs by using input-out data of the years 2009-2013. The model is validated at 95% confidence level at 20 SMEs. The test and validation results revealed that engineering management contribution to output growth of 12

SMEs is significant at 95% connivance level (p-value <0.05). The test and validation results suggest that the developed model is useful to evaluate the engineering management contribution to output growth of machinery manufacturing SMEs. Thus, research goal is to develop model, testing, and validation that stated in section 2.11 is achieved.
Definitely, this model is new in manufacturing domain, and that would add to be a new knowledge in manufacturing filed. In this aspect, this work is novel; so this study concludes that further study in this tropic is essential to build a general model to devalue the engineering contribution to output growth of all types of manufacturing industries.

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Appendixes

Appendix A1
SPSS Output

Model Summary

Model	R	R	Adjusted R	Std. Error	Change Statistics	Durbin-Watson

		Square	Square	of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	
1	.996[a]	.992	.992	.02709	.992	2425.751	4	75	.000	2.309
a. Predictors: (Constant), GM, GR, GK, GL										
b. Dependent Variable: GQ										

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	.000	.003		-.038	.970	-.006	.006		
	GL	.761	.051	.704	14.944	.000	.660	.862	.046	21.728
	GK	.076	.008	.120	9.808	.000	.061	.092	.681	1.468
	GR	.073	.003	.312	28.212	.000	.068	.079	.834	1.199
	GM	.077	.044	.083	1.760	.082	-.010	.164	.046	21.708
a. Dependent Variable: GQ										

AppendixA2

Estimate growth model on SMEs1

$G\ (Q) = 0.076G(K) + 0.761G(L) + 0.73G(R) + 0.77G(M),$

$G\ (Q)$= 0.761*(0.063258094) +0.076*(-0.151515581) + 0.73*(0.078189629) +0.77 * (0.094302068),

$G\ (Q)$=0.166315247. The results are listed in Table1

Table1: Estimate inputs- outputs growth model

Industry	Avβ*Gr(L)	Av α*Gr(K)	Av λ*Gr(R)	Av γ*Gr(M)	Av G(Q)
SMEs1	0.04814	-0.0115	0.05708	0.07261	0.16632
SMEs2	0.07738	0.00179	0.09672	0.08746	0.26334
SMEs3	0.05423	0.00486	0.06686	0.07003	0.196
SMEs4	0.02502	0.00553	0.00103	0.02505	0.05663
SMEs5	0.19643	0.02142	0.16663	0.19043	0.57491
SMEs6	0.02114	0.0002	0.03408	0.01103	0.06645
SMEs7	-0.0067	-0.005	0.03451	-0.0032	0.01962
SMEs8	0.02108	0.00125	0.03157	0.02969	0.0836
SMEs9	0.19643	0.01691	0.20039	0.24006	0.65381
SMEs10	0.01663	0.00537	-0.0139	0.01453	0.02265
SMEs11	-0.0067	0.00181	-0.0173	0.01679	-0.0054
SMEs12	0.01816	0.00241	0.02182	0.02957	0.07196
SMEs13	0.01913	0.00352	0.00687	0.02686	0.05637
SMEs14	0.07738	0.00847	0.06653	0.08693	0.23931
SMEs15	0.02108	0.00058	0.03639	0.02502	0.08306
SMEs16	0.04814	0.00927	0.0111	0.06953	0.13805
SMEs17	0.02108	0.00566	0.00151	-0.0059	0.02232
SMEs18	0.02108	-0.0143	0.14992	0.03118	0.18785
SMEs19	0.01913	0.00632	0.00181	0.01739	0.04465
SMEs20	0.02108	0.08427	2.03105	0.04673	2.18313
Average	**0.04546**	**0.00744**	**0.14923**	**0.05409**	**0.25623**

Appendix A3

Estimate the Contribution of Engineering Management Growth Model

$C(M) = \gamma \frac{g(m')}{g(Q)}\ e^{\theta t}$, $A(t) = A_0\ e^{\theta t}$

$\frac{A_{2015}}{A_{2009}} = e^{\theta t}, Ln\left(\frac{A_{2015}}{A_{2009}}\right) = -0.071828,$

Than $\theta = \frac{(0.009071)}{4} = 0.00226775, e\hat{}0.00226775 = 1.011203,$

$Cg\ (M) = 0.77 * (1.791742) * (1.011203)$

The total average, $Cg\ (M) \approx$ 1.420486

The results are listed in Table below;

Estimate Engineering Management Growth Model

Industry	γ	θ	Av-e^θ	gm/gQ	Cg(M)
SMEs1	0.77	0.010407	1.011756	1.085317	0.845518
SMEs2	0.77	0.015605	1.017228	-0.26465	-0.20729
SMEs3	0.77	0.010785	1.01281	0.826382	0.644466
SMEs4	0.77	-0.00846	0.995287	1.013165	0.77646
SMEs5	0.77	0.0365	1.042369	1.023524	0.821505
SMEs6	0.77	-0.00043	1.001186	1.203903	0.928104
SMEs7	0.77	-0.00797	0.993609	0.844476	0.646091
SMEs8	0.77	0.003511	1.004501	1.06663	0.825002
SMEs9	0.77	0.036737	1.042837	1.38125	1.109122
SMEs10	0.77	-1.9E-05	1.00121	1.103007	0.850343
SMEs11	0.77	-0.00777	0.993895	1.517941	1.161679
SMEs12	0.77	0.00255	1.00356	1.276049	0.986056
SMEs13	0.77	0.000158	1.001608	1.232071	0.95022
SMEs14	0.77	0.017568	1.019267	2.504272	1.965442
SMEs15	0.77	0.003669	1.004593	0.833167	0.644485
SMEs16	0.77	0.009813	1.011259	1.454922	1.132904
SMEs17	0.77	0.00292	1.003768	0.470848	0.363919
SMEs18	0.77	0.003709	1.004664	1.110261	0.858888
SMEs19	0.77	0.000178	1.001912	0.854931	0.659555
SMEs20	0.77	0.051975	1.056734	15.29738	12.44725
Average	**0.77**	**0.009071**	**1.011203**	**1.791742**	**1.420486**

Appendix A4

The model estimates the actual growth

Industry	Model Estimate	Actual growth

	(%)	(%)
SMEs1	16.63	16.3
SMEs2	26.33	13.5
SMEs3	19.6	12
SMEs4	5.66	5.6
SMEs5	5.71	7.6
SMEs6	6.64	9.3
SMEs7	19.62	8.1
SMEs8	8.36	7.6
SMEs9	.6.53	6.6
SMEs10	2.26	5.3
SMEs11	5.41	4.1
SMEs12	7.19	5.2
SMEs13	5.63	7.2
SMEs14	23.91	6.7
SMEs15	8.30	6.1
SMEs16	13.80	6.0
SMEs17	2.23	7.1
SMEs18	18.78	5.8
SMEs19	4.46	7.2
SMEs20	2.13	5.8
Average	**10.66**	7.65

Appendix A5

Estimate P-value for measuring output growth SMEs1 by Using Z-test: $Z = \frac{(\overline{X} - x)}{\frac{\sigma}{\sqrt{n}}}$ for

Standard deviation: $\sigma = \sqrt{1/n\ (x_i - \mu)^2}$

Where; σ is the standard devotion of Cg (M) in SMEs, N is the sample size of SMEs and x_i is the average Cg (M) to twenty SMEs within operating time 2009-2013; μ is the total average of Cg(M); $\bar{X}$ is the total average of Cg(M)

$\sigma - \sqrt{1/20\ (8.34338\ )^2}$ = 0.389098

Then $Z = \frac{\sqrt{20} * ((\bar{X} - x))}{0.10596348} = \frac{0.402100641}{0.10596348}$ = 6.401185, the value from the Z-table is given below.

P-vale =1- P, 1- 0.9998 = 0.0002.

Appendix A6
Significant level growth test SMEs