

Quantitative Measurement of Advanced Manufacturing Technology Transfer from Foreign-Based Companies to Local Companies

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Abstract-The literature on foreign direct investment (FDI) has recently analyzed the nature of the firm's entry mode choice in a foreign market, particularly the choice between a joint venture and a wholly owned subsidiary. Most of these companies use Advanced Manufacturing Technologies (AMT) in manufacturing operations conducted in host country. Therefore this paper aims to measure the contribution of AMTs to a host country. A study of 1026 foreign-based companies was analyzed and results mainly categories under two analytical tool. The present research has used multiple regression (MR) models for determining the factors affecting to the usage of AMT, which are introduced by foreign-based companies. The result indicates some guide to the organization of advanced manufacturing technologies from foreign-based companies. Artificial Neural Networks (ANN) model also guided better than the MR model for prediction of AMT from which variables are better for the developing countries.

the factors influencing to usage of AMT by foreign-based companies in host country.

Advanced manufacturing technologies are an integral part of the production process. It is important to understand the factors that are associated with differences in technology use at the plant level. This paper examines the relationship between the use of AMT at the plant level and the characteristics of these plants. Information on AMT use is derived from a literature that investigates the use of 22 advanced manufacturing technologies. These 22 technologies can be divided in to 5 functional group-design and engineering, fabrication and assembly, automated material handling, communications and inspection, manufacturing information systems and integration and control of manufacturing system of the organization.

I. INTRODUCTION

Global competition continues to drive the adoption of new technologies. FDI is one of the ways to obtain a technology to the developing countries today. To date, the most researchers have recently been turning their attention to "technology transfer" and particularly the advanced manufacturing technology transfer. It seems that there is a major underlying influence that transfer of technology to host countries. The influence can be seen as transfer of technologies from foreign-based companies to local companies and from local companies to foreign-based companies. Therefore developing a developing countries have required, and, in most cases still requires, the setting up of foreign-based companies with local partners, particularly when the prime motive of technology transfer from one country to the another country. Although, since the mid-nineties the legislation of the various Countries have evolved in a more liberal way, entering into collaboration agreements with foreign-based companies. It is therefore important for researchers to understand what types of advanced Manufacturing technologies (AMT) contributed to the host country through their parent companies. The purpose of this study is to determine

The link between technology used by the companies and factors influencing to introduce the AMT from foreign-based companies to local companies are important to understand. This paper asks which plants are more likely to use one or more of AMT usage or adoption and the factors that are related to the decision to use of the AMT. Further investigation have concluded to determine the relationship between the use of AMT in companies and determinant factors of AMT.

The remainder of the paper is organized as follows. definition of AMT, literature review, research methodology of empirical model and empirical results and conclusion.

II. DEFINITIONS

Computer-based technologies have penetrated all parts of the production process. Computer-aided design and engineering is used in the early stages. Numerically controlled machines are part of the cutting and assembly process. Computers aid the communication and inspection process either by providing information through local area networks (LANs) or through computers on the factory floor. Computers are also basic to materials planning

systems. While computers have stimulated the development of individual components of the production process, they are central to those systems that bring the components together into one integrated whole. In this paper has been identified 22 advanced manufacturing technologies according to the Survey conducted by Canadian statistics in Canada. List of AMT representing a wide range of items grouped into the three categories computer hardware, computer software and plant and equipment.

In literature, suggest that foreign-owned firms make a significant contribution to technological progress and innovation in Canadian industry. And some researchers have mentioned that foreign investment allows the host or recipient country to benefit from the specialized competency of the firm. In particular, it facilitates the transfer of the technological assets and technical know-how [1].

AMT represents a wide variety of modern computer-based or numerical control-based systems devoted to the improvement of manufacturing operations. The relatively high cost of AMT and local firms does not have competency to install of AMT as much therefore, foreign-based companies collaboration is more important to host countries.

III. LITERATURE REVIEW

Foreign-based companies, joint ventures, transnational companies and Multi-national companies are mostly used form of International business, and have given a great deal of attention in the literature, particularly from five perspectives. The first viewpoint focused on the theoretical background of the transaction cost theory [2] or economic analysis [3]. From this point of view, foreign companies are seen as a means of coping with market imperfections or information asymmetry. The second viewpoint emphasized the role of foreign-based companies in the globalization of multinational firms [4]. The basic argument developed here is that foreign-based companies are a means to acquiring local capabilities in order to enter markets. The third stream dealt particularly with the evolution of foreign-based companies or joint-ventures, over time, from their inception their contribution to learning [5] or to their motives for termination [6] The fourth viewpoint looked at the specific issues related to the stability of international companies, whether in developing countries [7] or elsewhere [8]. In this body of literature there is an attempt to analyze the sources of successes and failures of the joint ventures. The final one is Technology transfer from their own countries to host countries. While the current literature emphasizes that learning in general, and technology transfer in particular, should be prominent goals within any foreign-based companies, there is still very

little systematic evidence of what technologies are transferred and how such transfers take place.

In particular, the impact of the use by firms of different production technologies has not been devoted sufficient attention in the literature. On the one hand, it is rather obvious, and by now well recognized in the innovation literature that productivity differences also depend on adoption of advanced manufacturing technologies. On the other, there are sizable differences among technologies in the cost structure and the amount of the required investments that are likely to influence exit behavior. In addition, even though the ownership, country of origin, was recognized early as an important determinant of technology transfer, such issue has not been devoted sufficient attention in the literature. In accordance with the above reasoning, this paper analyzes the impact upon the likelihood of AMT use by plants of a different country of origin.

In this paper relates more variables usage of AMTs and how companies are determine the level of AMTs to host companies. The one of the findings is that increased technology has led to a decrease in plant size in the USA [11] it also observed a shift in average plant size distribution towards smaller average plant size. [12]

IV. RESEARCH METHODOLOGY

This main objective is to find out of determine the factors of usage of AMT among foreign-based companies in Sri Lanka. The use of AMT measured by the open-ended questionnaires and direct visits to the relevant plant.

The questionnaire consists of two sections. The first section refers to the company profile. The second section investigates the current usage of AMT in foreign-based companies in Sri Lanka. A questionnaire was developed-based on previous research and some modified questions relevant to the foreign-based companies in Sri Lanka. This process yielded to questionnaire that focused on Present usage of different types of AMT and number of AMT usage by the foreign-based companies. Questionnaires were directed to senior production managers in their respective plants.

Classification of firms is mainly based on the host country standard. The companies who having foreign-based relationship and using of AMTs were selected. As a whole those companies contributed approximately US \$ 5000 million of the total turnover of the overall economy. And more than 60% of them from develop country based mother companies.

In an attempt to reach a broad spectrum of company's usage of AMT's, a sample of 1468 companies was selected from Company registration

department and Board of Investment in host country. A total of 1026 usable completed questionnaires were received. The resultant response rate was 85%. This is particularly satisfactory number for business surveys. [13]

TABLE I
FOREGIN-BASED COMPANIES

Industry	Number of companies	Percentage
Manufacturing	388	37.81
Garments and Footwear	226	22.02
Bev.food, Tobacco	141	13.74
Chemicals, Pharmacy	150	14.64
Construction	122	11.79
Engineering		

A questionnaire survey was sent to 1468 production managers, in foreign-based companies in Sri Lanka. One thousand and twenty six questionnaires were returned of which is 85 %. The sample description reported in table I. The sample can be considered as significantly representative of the population of foreign-based companies functioning in Sri Lanka, although it represents a wide variety of industries and countries of origin on average, the companies had invested US \$ million 2748 and employed 300,000 people. Our sample is made up essentially of foreign-based companies who establish a company in host country (Sri Lanka) with their own or collaborated with local partners. The local partners are a mix of public companies, private companies and government. The questionnaire comprised 22 questions in which the respondents had to give an opinion on a statement

V. MEASUREMENTS

Information about the use of 22 AMT, at the establishment (plant) level, the survey asked from manufacturing companies to indicate their usage level and non-usage level among 22 separate list of AMT. For the purpose this paper, the 22 technologies are classified into 5 functional groups, corresponding to the point in the production process where each is used. The functional groups are design and engineering, fabrication and communications, manufacturing information systems and integrations and control.

TABLE II

USAGE OF AMT		
AMT Use	Number	Percentage
1-5	40	0.4
6-10	306	30.0
11-15	548	54.4
16-20	136	13.1
Above 21	32	3.1

TABLE III

ORIGIN OF COUNTRY		
Origin	Number	Percentage
Developing country	591	57.6
Developed country	435	42.4

TABLE IV
EMPLOYEES

Employees level	Number	Percentage
Less than 100	547	53.31
101-200	174	16.95
201-300	89	8.67
301-400	44	4.28
401-500	33	3.21
501-1000	139	13.58
Total	1026	100.00

TABLE V
MODE OF ENTRY

Ownership	Number	Percentage
Less than 50	320	31.2
50-50	273	26.6
60	294	28.6
100 Ownership	139	13.6
Total	1026	100.00

Table II, III IV and V represent the usage of AMT, country of origin, number of employees and mode of entry. The sample consists of 54 percent of AMT use between 11 and 15 and 30 percent between 6 and 10. The majority of manufacturing plants are small. 53 percent of them are employed less than 100 employees. According to this sample more developing country foreign-based companies (57 %) entered to the host country than the developed country foreign-based companies. Joint ventures were the most frequently used mode of entry, which shows 31 percent and majority takes second highest.

VI. AN EMPIRICAL MODEL

The empirical estimates in this paper use the one dependent variable to investigate the determinants of the of AMT usage. Multiple linear regressions are used to measure the determinants of AMT usage by plant. This variable counts how many AMTs use by plant out of 22 AMTs. When measuring of AMT used by plant, a multiple linear regression technique and artificial neural network model also used.

The explanatory variables are, employment size, area of establishment, experience (plant age), and initial investment.

Scale is also an important variable to measure the AMT usage and determines factors. Larger plants are more complex and perform a wider range of activities, from design and engineering to fabrication. To measure plant scale, Size is separated in to those with less than 100 employees, those with between 100 and 500 employees, and those with more than 500 employees.

Area of establishment is divided in to two parts. One is if a manufacturing plant located in Board of investment (BOI) area or, outside the area. Therefore, a explanatory variable is included that equals one if a manufacturing plant located in BOI area and zero

otherwise. Initial investment is the amount that companies invested from the beginning of the business.

Experience of the plant is included to test whether maturity or usefulness is more closely associated with technology use. The date of installation of the plant is essential for the measurement of experience of the plant. Age represents experience of the plant.

AMT used by foreign-based companies vary from their mode of entry. Therefore dependant variables represent developed country foreign-based companies with their four types mode of entry and same as developing country. The final model indicates country of origin and mode of entry both as total contribution of AMT to host country.

Total effect firm variability's with explicit consideration of origin of country.

$$\sum_{i=1}^8 y_i = \sum_{i=1}^8 \left(\beta_{0i} + \sum_{j=1}^4 \beta_{ij} x_{ij} \right) \quad (1)$$

$$\sum_{i=1}^8 y_i = \sum \beta_{0i} + i = \sum_{i=1}^8 \sum_{j=1}^4 \beta_{ij} x_{ij} \quad (2)$$

Considering the transfer of AMT with a classification of origin of country and mode of entry.

$$T = \sum_{i=1}^4 y_i \quad (3)$$

With consider the effect of country of origin alone with mode of entry.

$$T = \sum_{i=1}^4 y_i + \sum_{i=5}^8 y_i \quad (4)$$

Total contribution can be formulated as follows:

$$T = \sum_{k=1}^2 T_k \quad (5)$$

T is the total contribution of AMT from different mode of entries with different origin of countries. Coefficients are estimated using multiple regression techniques. β_0 is constant value for 8 models and β_{ij} x_{ij} are represent coefficients of explanatory variables in different mode of entries and different country of origin.

A. Neural Network Modeling

Neural net works models derive the name from their origin in the study of natural neural systems, where layered neurons are interlinked to form an information processing network. The applicability of neural network models, however, extends to any problems of pattern recognition, prediction, or

classification. [14] From the point of view of statistics or econometrics, neural networks model are a particular class of nonlinear input-output models.

In most neural models, the system is equipped with a learning method, which decides the values of connecting weights. The connection weights are the most important factors in the input and output processes of the neurons. Information generated by the NN is determined by those weights.

The number of the nodes forming the NN hidden complexity and their connections is decided by the trial and error, according to several specification parameters decided by the research until the best fit reached. The set of NN parameters includes the following:

TABLE VI
MODEL TOPOLOGY

Type of output	Continuous
Transfer function	Sigmoid
Network connectivity	Fully connected
Learning algorithm	Momentum (0.5)
Learning rate coefficient	Input (0.10)
Hidden layers	One
Number of Inputs	Four
Output layer	One
Threshold	0.0001

VII. RESULTS

Using the Statistical Package for the Social Sciences (SPSS), several analytical trials were conducted on the sample data set. Results of the analysis have shown that high coefficient of determination values of all models. To determine how well the model fitted the data, analysis of variance and the associated F test were conducted to test the null hypothesis $\beta_{1i}=\beta_{2i}=\beta_{3i}=\beta_{4i}=0$ where i represents the model number ranges from 1 to 8. As F value is grater than the critical value and the observed significance level is 0.000, the null hypothesis could be rejected and conclusion drawn that a linear relationship exists between the dependent variable and the independent variables in the equations 1 to 5.

Experience is significant in all models except model 3, it means, usage of AMT totally depend on experience or age of the plant Other than the experience, area of establishment also have significant impact to the models except model4 and 7. Employees and Initial Investment are not more influence to the overall models but individual models are concerned, there is significant impact to the AMT usage by each company.

Table VII, VIII and IX represent the coefficient values of each model and its significance level fewer

than 5 percent confidence level. Table VII and VIII show that the corresponding R^2 value of each model which represents the percentage of the variance in each dependent variable explained by the particular independent variable in the model.

TABLE VII
REGRESSION RESULTS FOR DEVELOPED COUNTRY

Variables	Model1	Model2	Model3	Model4
Constant	1.964 *	2.52*	10.0*	3.7 *
Experience	.559 *	.539 *	.149	.935 *
Initial Investment	8.47	4.10	3.73*	2.718
Employees	1.64	-2.68	4.13 *	2.49
Area	2.45 *	1.79 *	.789 *	.185
R Square	.943	.885	.822	.991
F value	333.15 *	157.1 *	121.2 *	3246*

Significance, $p < 0.05$ *

TABLE VIII
REGRESSION RESULTS FOR DEVELOPING COUNTRY

Variables	Model 5	Model 6	Model 7	Model 8
Constant	4.01 *	1.16 *	4.12 *	3.216 *
Experience	.558*	.519 *	.996*	.617 *
Initial Investment	-166.08	2.730	9.57	-8.78 *
Employees	1.41 *	9.44 *	-1.47	5.86
Area	2.57	2.54 *	.118	2.26*
R Square	.608	.861	.985	.746
F value	29.98 *	263.81 *	2576.8*	135.3*

Significance, $p < 0.05$ *

TABLE IX
PATTERN OF VARIABLES OF BOTH SITUATIONS

Variables	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8
Initial Investment			*					*
Employees			*		*	*		
Area	*	*	*			*		*
Experience	*	*		*	*	*	*	*

* Significance

A. Results of the ANN model

Performance of the ANN model was measure using training and target RMS error. Target RMS error is higher than the training error. It can be concluded that the ANN model has worked with good predictive power. Further analysis using ANN model reinforced that higher explaining ability of dependent variable than regression prediction ability.

B. Comparison of MLR and ANN Model

It was found that both Multiple Linear Regression and Artificial Neural Networks using the Back propagation gave accurate models. However the back propagation function seemed to provide slightly better results. Table XI presents the averaged sum of squares of errors for the different Models studied.

TABLE X
AVERAGE SUM OF SQUARE

ASSE	Train	Test
Model 1 (MLR)	2.549	3.16
Model 4 (MLR)	2.543	4.676
Model 6 (MLR)	2.005	13.4
Model 7 (MLR)	1.645	0.865
Model 1 (ANN)	2.802	3.768
Model 4 (ANN)	3.162	2.761
Model 6 (ANN)	2.319	4.564
Model 7 (ANN)	3.318	2.659

TABLE XI
COMPAERISION OF REGRESSION

Models	MLP Regression R Square	ANN Regression R Square
Model 1	.943	.996
Model 2	.885	.993
Model 3	.822	.990
Model 4	.991	.998
Model 5	.608	.984
Model 6	.861	.952
Model 7	.985	.993
Model 8	.746	.986

However the combined use of both modeling techniques can complement each other. In this instance although the ANN Models can be used for prediction the regression model and ANN provides better results than regression.

The output of the neural network model demonstrated forecasting efficiency by making comparisons with regression data. In this research, the forecasting efficiency of a neural network prevailed over multiply regression. Table XI shows the feasibility of incorporating a neural network-forecasting model into the estimation of AMT usage by foreign-based companies in developing countries. Forecasting is a major requirement of planning [14] Practitioners and policy makers may confidently apply neural networks, as an alternative to the traditional time-series and economic forecasting models, for their planning activities.

XII. CONCLUSIONS

The analysis of AMT usage by companies revealed that there is significant relationship between dependent variable and independent variables. It has found that developed country foreign-based

companies invest more AMT than developing country and both foreign investors use joint venture strategy to spread the technology. On the part of the host country, joint ventures provide an efficient mechanism for technology transfer from foreign-based companies to local companies. By forming joint ventures with foreign investing firms to local companies have more accesses to AMT and learn new management skills.

The findings of this study have confirmed much of what have been found in previous studies of AMT usage. In particular, the findings point to strong relationship between AMT use and other variables mainly to area of establishment, employees, level of experience and Initial Investment in a developing country. Further this model reveals that AMT can do more for the development of the country.

Another interesting finding was the comparative analysis between Regression and ANN models. Using identical predictor variables one can conclude that both models perform well, although the performance of the ANN model is much better than the regression model.

A future research possibility is to include more dependent variables to determine the usage of AMT by foreign-based companies in host country. Another potential area for future research would be to perform the usage of AMT forecast, using a neural network, for other countries. It would be worthwhile to investigate whether a neural network can maintain such a high accuracy to forecast AMT usage in other countries.

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