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Is R&D A Measure of Manufacturing Performance? Answer from Labor Intensive Industries

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Abstract

This study attempts to address the impact of R&D on manufacturing performance of labor intensive industries. Convenience sampling method has been used to conduct this research. Two categories of industries such as R&D and Non R&D industries have been chosen to perform this study. Inputs–outputs data of manufacturing operations of sample industries have been analyzed by using standard statistical techniques in order to establish relationship between dependent and independent variables. A significantly positive correlation is found between R&D knowledge and manufacturing performance. The study concludes that the R&D expenditure which generates new knowledge on manufacturing process is important inputs to labor intensive manufacturing process which is positively associated with performance.

Key Word:

R & D knowledge, Manufacturing Process, Plant Efficiency, Performance

1.Introduction

The labor intensive manufacturing industries are generally defined as the industry where labor costs are more important than capital costs. More specifically, labor intensive means use of manpower in production process with little of technology. Labor intensive companies generally have greater earnings stability compare to the capital intensive ones, due to low capital intensity. It is evident that the remuneration package of this type of industry is much less compared to capital intensive one, but why? As stated by Shahidul and Anwar [1], lower working capacity of workforce, unfavorable working environment and poor R&D intensity and low process capability of manufacturing system are main causes of low productivity which leads industry towards poor performance. The meaning of performance of manufacturing industries can be stated in different ways but the most common aspects available in literatures is some indicator relating to productivity, outputs produced, revenue rearmed and share value of firms.

2. R&D on Manufacturing Process and Outputs

Production schedule, materials movement planning and process layout design are the important components of manufacturing system. Quality of these parameters is dependent on R & D activities of manufacturing enterprise. Eventually, R&D could improve process capability of manufacturing systems and contributes to reduce non value added inputs of manufacturing process. Dirk Czarnitzki and Niall [2] pointed out that R&D intensity in manufacturing industries is playing a vital role in increasing process capability which could lead to achieve higher outputs. Furthermore, they added, the accumulating R&D expenditure of a firm are often interpreted as its knowledge stock on manufacturing process. Gregory Tassey [3] found that at 8.6 percent positive changing in R & D intensity contributed to increase about 38 per cent output. Griliches [4] reports that at an elasticity of 0.07, a ten percent increase in R & D expenditure will bring 0.7 percent increase in output. However, the research found that the rate of return on R & D is significantly high and it is about 10 to 27 percent. Peter and Phil [5], in a study on Taiwanese integrated circuit industry found that R & D capability is positively correlated with manufacturing performance.

Bangladesh provides the example of success of use of low cost labor in export industries. The textile and garment sector has made remarkable contribution to the economy of this country. This sector is expanding at a rate of about 20 percent per year [6]. In 2007-2008, garment accounts for 81 percent of the total exports ($12 billion) of that country [7] . Presently, this sector is using labor intensive technologies and about 2.5 million workers are engaged in 4.500 registered industries. Regardless of labor productivity, the labor price of these industries is fixed about USD 0.3 per hour. Indeed, it looks Bangladesh garment is executing the policy of 'cuts cost regardless of manufacturing productivity'. However, low and unsustainable remuneration package has been creating crises in Bangladesh garments manufacturing sector [8].

Wage and productivity issue are searched well in developed and many developing countries but in Bangladesh perspective no study attempts have been made to address this issue. Though it is saying that Bangladesh garments are not much productive due to some manufacturing barriers but it is not tested to find out the reasons behind. To address this issue, this study aims to examine and estimate the impact of R&D on outputs and efficiency of production system to measure the manufacturing performance. The structure of this paper is such that the description of manufacturing operations is placed in section 3, research objectives are placed in section 4, section 5 is dedicated for describing research methodology, analysis and research findings are placed in section 6 and finally, section 7 is reserved for conclusions. Reference and Appendix are placed at the end of this paper.

3. Theory of Manufacturing Operations

When an attempt is made to estimate outputs; typically starts from a production function. The mathematical presentation of input-output model typically based on the Cobb-Douglas form[9]:

$$Q = f(K,L,R,Fp) \quad (1)$$

Where, $f(K,L,R,Fp)$- is the total factor of inputs. Equation 1 is known to be the input-output model and its schematic diagram is shown in Figure 1.

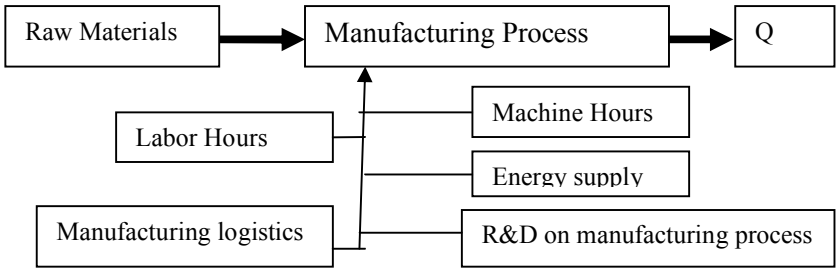

Figure -1: Manufacturing Operations model

Here, K-capital consists of cost of raw materials, energy and machine hours. L- Cost of labor hours directly associated with manufacturing process. R-expenditure of R&D directly associated with conducting research on manufacturing process. Fp- factor associated with production cost that consists of motivation cost of labor and other logistics. The input-output manufacturing operations can also be expressed in log form;

$$\text{Log } Q = \text{Log}P_m + \lambda t + \alpha \text{log} L + \beta \text{log} K + \gamma \text{log} R_p + \delta \text{log} F_p + \varepsilon \quad (2)$$

Where, Pm is manufacturing productivity, λ is technical change of industry in operating time t, α is the coefficient of Labor, β is the coefficient of capital used in manufacturing process, γ is coefficient R&D, δ is coefficient of Fp and ε is standard error terms. According to Equation (1) and Figure 1, it is reasonable to believe that any higher value added inputs such as higher degree of skills and R&D knowledge on manufacturing process has capability to create an impact on outputs. Eventually, the impact would be positive or negative but definitely it would reflect on outputs which will lead to have higher performance. Such type of knowledge input is mostly delicately used to reduce non value added input of manufacturing process and sized down the production cycle time. When these two components of manufacturing process are optimized, ultimately the outputs per unit time would be increased and the cost of inputs per unit of product would eventually be reduced. This relationship can also be visualized from the following equations;

$\Delta I = I_2 - I_1$, While $I_2 > I_1$ (3)

$\frac{\nabla(\ )}{\nabla} = \frac{}{} - \frac{}{}$,While; $\frac{(\ )}{} > \frac{(\ )}{}$ (4)

Where, ΔI refers the amount of inputs reduced due to use of R&D knowledge and known to be the non value added inputs. I_1 and I_2 refers as the total cost of inputs, Q1 and Q2 refers as the outputs of these two cases, ∇t refers as the reduction of manufacturing cycle time. And ΔI, $\frac{\nabla(\ )}{\nabla}$, ∇t are to be considered as impact of R&D.

Estimating outputs from the production function shown in equation 1 and Figure 1 is not a trivial task as because it could be biased by several factors associated with manufacturing systems. For instance, a firm could have better R&D management which would lead to have higher output. Then, there would be difference in performance and as a result, the estimated coefficient of R&D will be biased upwards.

4. Objectives of the Research

This study is designed to examine the impact of new manufacturing process knowledge which is usually generated due to R&D activities. More specifically, the target of this study is to examine the impact of innovative process knowledge on;

(a) Manufacturing Outputs, (b) Plant Efficiency

5.0 Research Methodology

5.1 Sampling Criteria

Convenience sampling method has been used to conduct this research. This sampling criterion is also as non-probability sampling technique. This method provides the opportunity for selecting those industries that are convenient to get access for collecting information. Two types of industries have been chosen such as R & D Industry and Non R & D Industry. R&D industry is defined as R & D knowledge on manufacturing process is used to utilize the potentials of skills of work forces and other manufacturing physical resources, such as installed capital machineries, in manufacturing process. Whereas, non R&D industry is budget for R&D activities is zero and designing the manufacturing system is based on traditional experience

5.2 Data and Methods

The manufacturing data in terms of inputs and the corresponding output have been gathered from audited document of the relevant sample industries. The data range and its quality level are shown in Table 1.

Table 1: Criteria of Sample industries

	Manufacturing Variables	Industrial category A, B and C
1	No of sample industries	30 from each category
2	R&D expenditure level in percent (CR&D)	$0.5 \leq CR\&D \geq 1$ of input cost
3	Surveyed data level(*Manufacturing data of operations)*	*30days/month *8 hours/day
4	No of labor per production line(labormix *)	100
5	Labor mix in production line	Unskilled-40%, Semi skilled 35%, Skilled 25%
6	Production capacity(design) per line	500-550 unit/8hrs
7	Experience of sample industries	5-8 years
8	Capability of manufacturing supervisor	*Minimum college graduate working Experience 4 years
9	Process capability index of manufacturing	Range of process capability index $0.8 < C_p \leq 1.1$
10	Price level and market	Price with in 3 % standard deviation. 100 % Export to USA market
11	Product type	Shirt 14 to 17 inch
12	Data quality level	Statistically 95% Confidence level

Labor mix

- *Unskilled- Primary School graduate, 6 months in probation and has minimum 3 years working experience*
- *Semi Skilled- High school graduate, minimum 6 months in probation and minimum 3 years working experience*
- *Skilled -High school graduate, minimum 6 months in vocational school, 6 months in probation and has minimum 3 years working experience*

5.3 R&D on manufacturing process

The Parameters of R&D activities of the sample industries are ; i. Process study on findings the non value added inputs of the manufacturing process, ii. Production planning and scheduling, iii. Time and Motion Study of inputs flow through process, iv. Statistical quality control of inputs and outputs, v. Study on process layout to optimize working space

5.4 Research Variables

The input-output model as shown in Equation (1) and Figure 1 is the basis of selecting independent and dependent variables of this research.

a. Independent variables

Expenditure on R&D for improving manufacturing process is to be known as the independent variable. The meaning of R&D activities on manufacturing process is describe in 5.3

b. **Dependant variable**

Output and plant efficiency are the dependent variables of this study. The variation in outputs and plant efficiency due to apply of R&D knowledge of manufacturing process is considering as the measure of impact of independent variables.

5.5 The measuring tools of dependent variables

Q(outputs**) =** ——————————————— (5)

η**(**Plant efficiency**)=** ——————————————————— (6)

6.0 Dada Analysis

Input-Output model, as shown in Equation-1 and Figure-1, has been used to establish relationship between dependent and independent variables. For finding the results and in-depth analysis of different variables, statistical techniques of correlation and regression have been used. The summary of statistical analysis of all variables is shown in Table 3 and Table 4.

6.1 Correlation of Dependent and Independent Variables

Table 3: Correlation of independent and dependent variables

Dependent Variables	Independent variable	Correlation
Q^a(Output/labor-hour)	Expenditure on R&D	0.80^c
η^b (Plant efficiency)	Expenditure on R&D	0.85^c

Based on equation (5), b-Based on equation (6), c-Correlation is significant at 0.01 level (two tailed)

Table 4: Outputs of R& D and non R&D manufacturing industries

Dependent variables	Independent Variables				
	Non R & D[a] Industries	R&D Industries			
	At $C_{R\&D}=0$ Q(unit/hr)	at $C_{R\&D}\leq 0.5$ Q(unit/hr)	at $0.5C_{R\&D} \leq 0.75$ Q(unit/hr)	at $0.75C_{R\&D} \leq 1.0$ Q(unit/hr)	at $C_{R\&D} \geq 1$ Q(unit/hr)
Output/labor-hours	68.4	80.82	82.1	83.2	83.4
Growth of outputs	-	18.9%	28.4%	28.6%	28.7%
Plant efficiency (%)[d]	72.5	80.2	81.9	83.1	83.2
Growth in plant efficiency	-	2.6%	6%	10%	9.80%

a-Expenditure on R&D is zero($C_{R\&D}=0$, i.e very much insignificant,) b-Expenditure on R&D is significant (0. $5\leq C_{R\&D}\geq 1.0$) c-output in unit of products, d- Plant efficiency = utilization of capacity to installation capacity of plant process machineries
Note:***The data of inputs- outputs of operating period is January 1, 2008 to December 31, 2008. Data used in analysis are within 2 standard deviations(95%)***

6.2 Research Findings

According to Table 4, the output per labor hour (Q) is increased with the expenditure of R&D. However, it is found that the outputs of R&D manufacturing industries are higher than non R&D industries. Whereas, the Table 4 has shown that the growth rate in outputs at higher R&D level is almost steady and the marginal change tends to zero.

Table 4 shows that the plant efficiency is increased with the expenditure of R&D. Indeed, the efficiency of plants of R&D manufacturing industries is higher compare to non R&D. Table 4 has also indicated that the growth rate of plant efficiency at higher R&D level (CR&D≥0.75) is not significant.

Table 3 reveals that the correlation coefficient of outputs and expenditure on R&D is 0.80. It can also be seen from Table 3 that the correlation coefficient of plant efficiency and expenditure on R&D is 0.85. Table 4 shows that the growth rate in outputs is about 18.9, 28.4, 28.6 and 28.9 percent higher compare to non R&D industries (CR&D=0). Additionally, the growth rate in plant efficiency is 7.7, 12.9, 14.62 and 14.7 percent higher compare to non R&D industries (CR&D=0).

6.3 Result and Discussion

A positive and significant relationship is found between outputs and R&D activities of labor intensive manufacturing industries. The correlation coefficient 0.8 indicates that the R&D activities on manufacturing process, an important component of manufacturing system, have an positive effect on outputs. It can also be seen from table no 4 that the outputs of all level of R&D are higher compare to non R&D industries ($C_{R\&D}=0$). Thus higher growth rate indicates that new knowledge on manufacturing process, the proxy of R&D expenditure, contributes to increase outputs of the surveyed plant. In other words, R&D contributes to reduce non value added inputs which has created a positive effect on outputs. Indeed, the knowledge on statistical process control attributes to increase the product quality which leads to reduce the rework of outputs. Additionally, the knowledge on production planning, optimization of process layout contributes greatly to reduce process cycle time. However, the combined effect of all improved process variables eventually contributes to reduce processing time which increases the production rate. Thus, it can be argued that R&D activity on manufacturing process is positively associated with the outputs. This finding is comparable with other international studies such as, Griliches(1980) study reports that a ten percent increase in R&D that would bring about 27 percent higher return. In a recent study, Gregory Tassey (2009) found that at 8.6 percent positive changing in R & D intensity had contributed to increase about 38 percent output.

A positive correlation is found between R&D on manufacturing process and plant efficiency. In table no 3, it is found that the correlation coefficient between R&D and plant efficiency is 0.85, it means that plant efficiency has a strong association with manufacturing process knowledge. However, Table 4 reveals that the plant efficiency of R&D manufacturing industries is higher compare to non R&D industries. This finding demonstrates that innovative manufacturing process has potential to contribute for increasing plant efficiency of labor intensive industries. In other words, R&D on Time and Mention study contributes to increase the utilization of installed plant capacity by

reducing the production cycle time. Additionally, production planning and scheduling has also greatly effected on utilization of plant capacity by using spare capacity of manufacturing resources. This finding is inline with other studies. In early stage, Donal J.(1973) was working on capacity utilization of firm operating in Less Developed countries. His finding reports that R&D on input-out process is an influential factor which could contributes to utilize the capacity of firm. In later stage, Buddhaded and Chiranjib (1993) while they were working on Indian manufacturing industries found that new technology, as the outputs of R&D, contributes to increase the plant efficiency and productivity. In a recent study, Michele Cincera et al.(2007) found that R&D relating to processing of inputs, is a important factors for achieving higher efficiency.

Thus, the innovative manufacturing process knowledge, which is generated by R&D activities, has greatly affected on the output and plant efficiency of labor intensive manufacturing industries which leads to have higher performances.

7.0 Conclusions

The labor intensive industries such as garments must have budget to conduct R & D for improving manufacturing process for enhancing manufacturing performances. The findings of this study would be the basis to formulate the strategy in designing R & D activities on manufacturing process for identifying and optimizing the inputs of process variables. The R&D effort could play a vital role in reducing non value added inputs and sizing down the production cycle time. On the basis of this research it can be concluded that expenditure to execute R & D activities to generate new knowledge on manufacturing process is essentially important for labor intensive industries and it could be a decision making indicator for policy makers. Thus, the R&D expenditure is a good measure of manufacturing performance of labor intensive industries. The return of this investment would greatly contribute to increase outputs and plant efficiency leading to higher manufacturing performance.

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