

The Effect of Organizational Factors and IT on Productivity in Valve Manufacturing

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Abstract

We investigate the relationship between productivity of the business and the role of information technology (IT). Our case study is a valve manufacturing. We examine the effect of implementing new IT systems on improvements in employee skills, manufacturing process, quality of product, etc. We show that the implementation of new IT contribute to enhancement in business strategies, production efficiency by reducing the set-up time, and the skill and capabilities of the employees. This paper gives the importance of productivity, skills of an employee and role of Information technology in a manufacturing industry. It also describes the relationship between all the three factors and their individual roles in a valve manufacturing industry or company which helps in a great extent to be more effective, productive and to maintain the standards. Information technology also uses a lot of investments for machinery and technology which can be backed by the productivity strategies of the industry with the main support of the workers by honing their unique skills. Our study shows how this is performed and apply innovative business strategies, how effective it can be by shortening the technology installing periods, improves efficiency in production with the raising requirement in employee individual skillset in the valve manufacturing unit.

Key words: Organizational Factors, Information Technology, Productivity, Employee Skills, Efficiency, CNC Machines, Valve Manufacturing.

INTRODUCTION

The effect of information technology in the past few decades has been significant especially with the improvements in the information sharing systems (Bartel et al., 2007). Many researcher believe that the investment in new information technologies contribute to advances in business productivity (Dedrick et al., 2013; Tohidi et al., 2017). On the other hand, some analysts claim that it the workers skills that result in improvement in productivity. However, there have been few studies, which argue that there is a significant relationship between the productivity, employee skills, and information technology. It is argued that the implementation of new IT systems enhance the workers skills and consequently the efficiency of the production will be increased (Hawash and Lang, 2010; Ko et al., 2008; Chou and Shao, 2014). The role of IT in businesses, manufacturing, factories, agricultural environments and may other organizations has long been studied among the researchers (Lee et al., 2011; Dewan and Kraemer, 2000; Pierce et al., 2015). The role of IT is not only summarized in purchasing new computers and installation of new applications (Mithas et al., 2012). It can also explain the information sharing systems between the members of a business or even between the elements of a system (Stiroh, 2008). While, there are many different ways to improve the efficiency of a system including hiring more skillful workers, implementing quality improvement systems, adopting high quality facilities, the role of information technology cannot be underestimated (Agha, 2014; Chun et al., 2015).

Productivity is the basic measurement of a technology. To be precise productivity defines as the ratio of overall output quantities to overall input quantities (Namdari et al., 2017). The output and input quantities are differentiated between quantities like number of items and employees and currency terms like revenues and profits. Financial productivity measures give us currency figure evaluating the productivity on balance sheet or on ledger of the company. Non-financial productivity evaluates accounting strategies and valuation techniques. Life insurance industry study shows premium income per employee and total operating expenses to premium income are used as operating measures of productivity (Francalanci and Galal, 1998). Premium income per employee defines total income divided total number of employees and operating measures which means the operating cost efficiency ratio is calculated and how lower the ratio the better the industry. These are some measures how productivity is measured.

Traditional researches on productivity focused on plants and equipment. But IT is must to contradict capital into further sub categories of investments. IT investments includes both telecommunications and computers which includes software and hardware. Mostly IT investments considers the computer hardware and in some other cases the whole expenditure on them including their services (Dedrick et al., 2003). Total output growth is directly proportionate to growth in inputs and its quality and increase in productivity of inputs. Increase in inputs happens when labor productivity increases which is done by a phenomenon known as "capital deepening" which provides more capital to workers to increase their productivity. Now to increase the productivity inputs without adding any investments there is a phenomenon known as "multifactor productivity (MFP)" which means for a fixed quality of inputs an organization is receiving higher level outputs. In production process impact of improved IT allows employees increase in effective decision making. For example, AutoZone are store based automobile market where all types of automobile parts are sold. When you arrive at the front desk and ask them about a part of an engine they have a system software showing your car model and name of the part of the engine so that you can choose and order the part. These are very helpful to maintain and update the inventory. It's the same case with the valves. There are so many types of valves and their usage. Figure 1 is taken from the annual statistics page of Valve Manufacturers Association of America which shows the market forecast of valves used in different industries until the end of 2017.

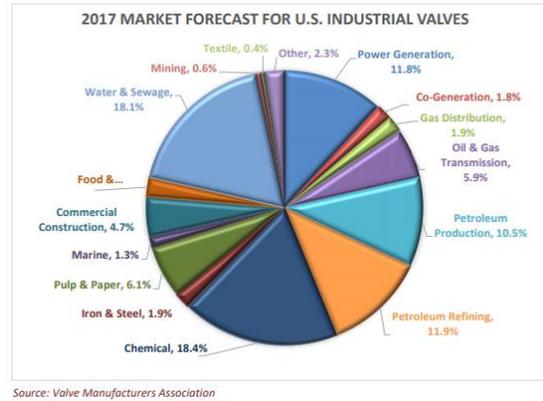


Fig. 1: 2017 Market Forecast for U.S. Industrial Valves.

Companies started additive manufacturing now a day such as 3D designs which are mostly prototype and have each individual component and sub components. 3D valves design can be made in software like ProE and MATLAB and analyze its factors and physical attributes in Ansys software which help in reduction of costs and time.

Workers in a manufacturing industry are divided as managers, professionals and clericals all of them has their own workspace and responsibilities. To reach the standard of new IT enhanced systems and to work with them employees should be highly skilled and well educated. As an organization it is their responsibility to train the workers with the IT systems and help them to update very often. There is a growth in white collar work force because of Information technology as half of the employees use computers in their jobs and there is a demand for clerical employees (Brynjolfsson and Yang, 1996). Sometimes there is a decrease in productivity which is not because of IT but it is a response to transform the economy.

Application of all these factors in valve industry: A valve is a metal piece which connects pipes which control the flow of liquids and gases. Valves are also used as service product where valves used in air conditioner, valves used in sink, valves built for ship or submarine. Above pie diagram gives the wide variety of valves for different purposes in different industries. The manufacturing of valve is a made of machines from designing to assembling. Initially a valve is designed in a software using the same measurements and then by taking a section of raw material valve is subjected to undergo several processes from machine to machine like cutting, finishing, threading and boring holes. Then they are manufactured and assembled to the control devices.

Four decades earlier valve manufacturing unit was highly sophisticated with highly skilled workers using manual machine tools but today we use Computer Numerically Controlled (CNC) machines. These CNC machines were introduced in 1970s where they were controlled punched paper tapes which were automated off line by computer programmers and given to system inputs by tape reader. But today after much advancement in IT sector and technologies computing power is directly programmed into new CNC machine controllers. Due to the computing power is programmed directly only experts can change and improve in the valve production. CNC controller is the heart of the CNC machine which gives output to the machine the point of contact to cut, depth, angle, radius, how uniform to cut and so on. There are several functions that they can perform. By 2003 CNC used new model which has fusion control which reduces the set-up time and time spent programming the CNC. Further now they even reduced the run time process due to more advancements in science and technology. Managers report that due to the increasing in the advancement in CNC machine employers can operate program easily using simple software interfaces. Now they can perform multiple variety of tasks on a single part of raw material. There is another technology advancement in valve manufacturing unit is "three-dimensional computer aided design (3D CAD)" which helps in giving the exact specifications and exact design to show customers which reduces time and most importantly manufacturing costs.

In this study, we examine the impact of information technology on quality of products, the workers skills and capabilities, and productivity of the plant. We use present a mathematical model of implementing information technology in business environments and explain the parameters and variables in details. Then we provide a case study as well as a numerical example, which has a real world application and attempt to solve the model following the limitations and assumptions. Furthermore, we present the findings and results, which may be beneficial for business practitioners as well as the researchers who are interested in this subject. Lastly, we summarize the paper and present the highlights of this study as conclusions.

Literature Review:

Daily growth of technology gave us to access the depths of Information technology (IT). Not only in any manufacturing unit IT is essential in any industry which helps in minimizing work and giving more output. Initially in a manufacturing sector there was an increase of IT from 1.6% in 1970 to 10.6% in 1988 (Weill, 1992). We know right now we are using technology as much as any year so by now its probably even more. Usually there is no evidence that we get expected returns from IT investments because of the huge leverage on the enterprise and new research tools which are questioned to be effective. When you speculate on some of the most successful organizations or industries, it is found out that they are have a huge impact in data interpretation and analyzing the risk and cost of the firm effectively by using the same research tools. Returns are not only depending on IT investment alone they also depend on business strategy and productivity of the company. For implementing the business strategy, we need skilled workers. Weill (1992) concluded that there is no evidence of the relationship between firm performance and IT investment from limited findings of different units of analysis and performance, limited theory base and reliance on cross sectional method. A Life insurance industry study states that when there is an increase in IT investments there is a need of heavy managerial skills so by decentralization in workers composition we can increase the productivity (Francalanci and Gala, 1998). Technology was the only factor used in prediction of productivity but there are other variables in productivity which influence on overall output of the firm. The relationship between Information technology and productivity has been referred to as the technological imperative and contrasted against the organizational imperative (Markus and Robey, 1988). Organizational imperative need to combine variables like human, organizational and technological to remain in the competition of successful companies. Thus, performance of the company initiates from management variables rather than technological variables. The organizational imperative advises the choice of variables which shows IT's impact on productivity which gives us supreme strategies to lead an industry.

Figure 2 explains how both technological variables and organizational variables effects on total performance. Information technology and workers' skills plays a pivot role in managerial performance of the industry and their combined result can show an increase in productivity. To affect the productivity every firm should design a worker's composition and their workstyle. Mainly in any organization there are managers, professionals and clericals. Each of them has their own work and responsibilities. There should be special training and seminars for the workers to develop their skills. In the IT system we expose to high information processing capacity which is more swift, frequent and less analytical decision making. Managers has the responsibility to take some important decisions as IT also helps them in their decision-making skills and analyzing the problem it reduce the time and work of the employee. Just as in managers IT also influences professionals by complementing them and extend their work and in some companies "Deskilling effect" takes place which results in reduction of professionals by machines or technology. But regarding clericals there is an increase in their number due to arrival of Information technology as the organization need more people to operate the computers and technological tools which are user friendly and easily accessible without the help of professionals. There is a huge effect on workers due to IT which is why there is every responsible to improve their skills to attain increase in productivity. This paper focuses on the effects on new IT in valve manufacturing industry by considering the factors like improvement in production process, innovative product design, worker's skills and work organization. The

diverse measures are more defined than expenditures on computing equipment or usage of computers by employees and IT enhanced capital equipment in a valve manufacturing unit. These factors have a huge effect in valve industry. Firstly, introduction of new IT systems there will be some changes in production and financial strategies of valve makers as the production will be long production in lesser batches. Secondly, due to the new research tools and production process there will be a reduction in functioning time, inspection time, run time and most importantly setup time. Finally, there will be increase in human resources and taking steps to maximize their technical skills. Thus, modification by the new IT results in greater personalization of products and services in a firm, documenting product process techniques of new IT based technologies, expecting maximum efficiencies and new strategic practices in a valve industry.

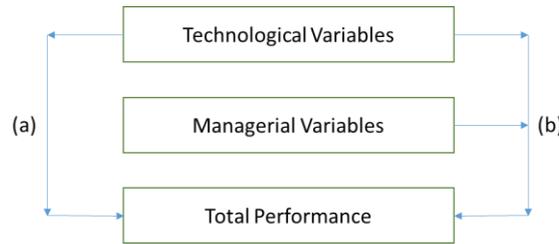


Fig. 2: Relationship between Technological Imperative (a) and Organizational Imperative (b) Including Technological and Managerial Variables as well as Total Performance.

Methodology:

We took data from some of the small to medium sized valve manufacturing units. Valve industry has many customers 18.1% of sales from water and sewage to textile 0.4% as you can see in the above pie diagram (Valve Manufactures Association). Thus, its use is diverse, and it doesn't affect by any sector as it has customers in almost every sector. Population of certain valve manufacturing firms has taken which has an average sale of \$73 million. A hypothesis test is performed between our sample and population which shows no significant difference which have a z score of 0.72 comparing to the z criteria of 1.96 for an alpha of 0.05. There are two types of variables quantitative and perceptual. Quantitative items are like total sales of total investment and Perceptual data is taken from the selected three components of IT investment: Transactional, strategic and informational. IT investment is measured by the ratio of IT expenditure with the total annual sales. Variables can be fitted to regression models and solved so that to estimate the coefficients for all the variables.

Based on this simple model some hypotheses are tested:

Hypothesis 1: There is innovative product design and increase in productivity with the help of new IT.

Hypothesis 2: Due to the introduction of IT we need new human resources and their skills.

Hypothesis 3: As there is a drop in the costs of IT machines, there is an increase in the implementation of IT machines like CNC machines, 3D CAD software and so on.

There is much increase in setup time, run time and Inspection time which are quicker and with the use of new softwares like CAD and all we can always expect some innovative product. So, Hypothesis 1 is true. As we know from the HRM that to work effectively with ease we need to have new workers and hone their skills eventually. As in case study we use decrease in number of CNC machines used to manufacture a given final product as a direct indication of the new ones. A decrease in the number of machines used to yield the plant's final product reflects the purchase and use of newer, more CNC machines. By this all the other hypotheses are true.

Valve Manufacturing and Information Technology:

Valve industry, has been of great academic interest since it has real world applications especially in the modern age of manufacturing. In more details, a valve a piece of metal, which is, connected to the pipes in order to clear the rotation of the liquids as well as the movement on gasses. The entry split body of Trunnion Ball valve us depicted in Figure 3.



Fig. 3: The entry split body of Trunnion Ball valve.

A few decades ago, the mechanists with high level of capabilities initiated the valve industry (Lei and Hsu, 2003). The valve industry is automated with the IT-related equipment. This important equipment is Computer Numerically Controlled Machines (CNC), which employs computer codes to generate command to produce a product (Timar et al., 2005). Since the foundation of CNC machines, many analysts have investigated the details and process of these machines (Olwal et al., 2008). A HASS Five-Axis CNC machine is illustrated in Figure 4.

The role of information technology in CNC machines can be modeled as follows:

$$\pi = N_{cu}B_{cu} [P_{cu} - (\text{unit cost})_{cu}] + N_{co}B_{co} [P_{co} - (\text{unit cost})_{co}] - P_{IT}IT \tag{1}$$

$$(\text{unit cost})_{cu} = (w+r) (S_{cu} / B_{cu} + R_{cu} + I_{cu}) - M_{cu} - D_{cu} / B_{cu} \tag{2}$$

$$(\text{unit cost})_{co} = (w+r) (S_{co} / B_{co} + R_{co} + I_{co}) - M_{co} \tag{3}$$

where S_{co} or S_{cu} are the setup times, R_{co} or R_{cu} are the runtimes, I_{co} or I_{cu} are the inspection times, M_{co} or M_{cu} are the materials costs, and D_{cu} is the design and sales times.

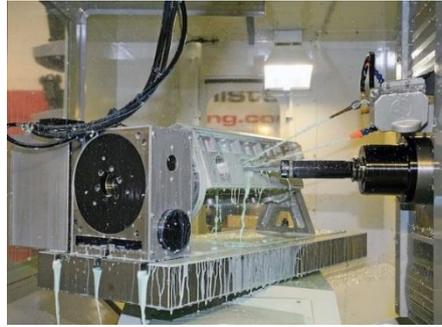


Fig. 4: A HASS Five-Axis CNC machine.

Therefore, profit can be modeled as follows:

$$\pi = N_{cu}B_{cu} [P_{cu} - (w+r)(S_{cu}/B_{cu} + R_{cu} + I_{cu}) - M_{cu} - D_{cu}/B_{cu}] + N_{co}B_{co} [P_{co} - (w+r)(S_{co}/B_{co} + R_{co} + I_{co}) - M_{co}] - P_{IT}IT \quad (4)$$

co commodity product

cu customized product

S_j hours to setup machine to run a batch of product; $j = co, cu$

R_j hours to run each piece of product; $j = co, cu$

I_j hours to inspect each piece of product; $j = co, cu$

D_{cu} cost of product design and product promotion (only customized products have these costs)

B_j average batch size (number produced per scheduled batch) $j = co, cu$

N_j number of batches of product j ; $j = co, cu$

M_j materials costs per unit; $j = co, cu$

P_j average price of product j ; $j = co, cu$

w wage rate

r maintenance cost of capital

P_{IT} price of new IT-imbedded machines times the quantity of IT-embedded machines

Equation (1) indicates that the profit is a function of revenues subtracted from the production costs, costs of materials, and cost related to the CNC machines. Equation (2) and Equation (3) determine the unit price of commodity products and customized products, respectively. Equation (4) is used for calculating the total profit.

Numerical Example and Results:

In this section, we present a numerical example a manufacturing, which uses CNC machines to produce valves. The number of CNC machines, which are used in this manufacturing plant, is presented in Panel A of Table 1. The setup time, run time, inspection time and the total time in an eight-hour working shift, before and after implementing CNC machines and improving the information technology, are determined and the average of each time are presented in Panel B of Table 1. In addition, three levels of percent catalog as well as the batch size are shown in Panel C of Table 1.

Table 1: The results of the numerical example of a manufacturing before and after implementing the CNC machines and improving the information technology

| Panel A | | |
|--|------------------------|-----------------------|
| The quantity of CNC machines used in the manufacturing plant | 6 | |
| Panel B | | |
| Time | Before implementing IT | After implementing IT |
| Setup time | 12.95 Minutes | 8.65 Minutes |
| Run time | 10.05 Minutes | 7.15 Minutes |
| Inspection time | 6.32 Minutes | 2.35 Minutes |
| Total time | 29.32 Minutes | 18.15 Minutes |
| Panel C | | |
| Percent catalog | Before implementing IT | After implementing IT |
| Level 1 | N=66 | N=57 |
| Level 2 | N=95 | N=83 |
| Level 3 | N=125 | N=112 |
| Batch Size | 140 | 110 |

Conclusion:

The main contribution of this study is to show that the improvements in information technology by implementation of CNC machines results in significant enhancement in productivity and the efficiency of the business. We use a case study of the valve manufacturing and presented numerical results after

implementing the CNC machines. It is found that the total production time including the setup time, run time, and inspection time are reduced after the information technology has been improved. There are significant differences between the time before and after the implementation of CNC machines. It can be concluded that information technology plays an important role in today's industry and it is significant to invest in IT systems among different methods to improve the productivity.

This paper gives us the definitions of productivity, employee skill and Information Technology. IT is more focused because it is the one on which productivity and worker skills are defined. This study also explains the relationship between IT investments and productivity with some examples and how worker skills or human resources effects the situation. Further it describes the worker composition in an industry depending on their level of job which are divided as managers, professionals and clericals. How introduction of IT investments effect on the following worker groups and how to face them. When new applications take over instead of individual responsibilities involvement of new strategies are required from which everyone has their own responsibilities. Regarding IT single measure IT is too vast to operate and control so they can be further divided to different management purposes. Profits on investing in Information technology is shadowed from an organizational imperative even when there is a loss in productivity due to IT. As this is the case of valve manufacturing industry it described the process of manufacturing and how introducing IT sector in the manufacturing firm changed the performance and productivity. Use of CNC machines initial stages were a little lag but less human work, as advancement technologies came by CNC machines got updated and can perform faster by reducing the inspection time, run time and set up times. This paper states the importance of IT sector in manufacturing firm (valve unit) due to which there was a large increase in their productivity. New 3D design models like solid works and 3D CAD softwares helped in reducing the both costs and time of the customers and manufacturers. Value of IT investments are not only showed as returns but also in organizational structures. There are 2 imperatives discussed technological imperative and organizational imperative and their effect on Total performance. If a business installs the new IT based machines, then there will be a drastic change of how work is done and its productivity. In methodology we described some of the questions which are linked to IT services, employee skills and productivity and by accepting those there is a clear view of work is done and operated. In future as the technology advances day by day we can expect more new variables and changes in machines or models which will be more effective and reduce the costs.

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