International Journal of Business Analytics and Intelligence
7 (1) 2019, 73-87
http://publishingindia.com/ijbai/

Submitted: 06 February, 2019
Accepted: 04 March, 2019

An Inquiry into the Impact of Digitization and Customized ERP Applications on Twin Engineers' Overall Efficiency - An Empirical Study Approach

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Abstract

This research paper entitled "An Inquiry into the Impact of Digitization and Customized ERP Applications on Twin's Overall Efficiency – An Empirical Study Approach" has examined, through exploratory method and robust statistical analysis, whether 'digitization and customized ERP applications in the manufacturing process has affected overall efficiency at Twin Engineers. With data base (2009-10 to 2017-18), through primary and secondary sources and a 'focus group' survey along with the construction of 'efficiency indices' and 'relevant statistical analysis', that consists of 'regressions' and Granger causality tests, the analysis shows that the overall efficiency after digitization period has improved considerably. The hypotheses testing (parametric and non-parametric) done in this case also supports the conclusion cited above. The research work has used a linear regression model which has used 'turnover data' as proxy for efficiency and a host of factors such as persons employed, machines dispatched, different costs etc. as independent predictors which are highly correlated to turnover as predicted variable. The core discussion in the paper consists of analytical and evaluative aspects which are based on 'findings' from the survey. This discussion is carried out through 'a case study approach'. The paper is concluded with important recommendations along with implications and limitations of this work.

Keywords: Efficiency, Digitization, Customized ERP Applications, Regressions, Granger Causality

Introduction and Company Profile

(1.A) This exploratory case-based study is an attempt to examine whether digitization and customized ERP process application has affected Twin Engineer's overall efficiency. This research, for its, comparative study purpose (pre-digitization versus post-digitization) has looked into Twin's strategic policy of growth from the era of 'local excellence' to the 'era of the application of digitization, customized ERP applications and IoTs (Internet of Things)'. Twin Engineers (Pvt. Ltd.) is an ISO 9001 – 2008 Certified company established in the year 1993. It is a leading manufacturer of 'Adhesive and Sealant Dispensing Machines' and 'Industrial Fluid Filling Machines'. Twin Engineers has developed more than 38 products which cater to a diverse and wide market segment including Flexible Packaging, Automobile, Electronics and other industrial sectors. Although Twin is primarily catering to domestic market, its foreign market sweep in terms of exports stands at nearly 10% of the total value of company turnover in 2012 (Focus Group Survey 2018). Twin has its valued customers that include Maruti Suzuki India Ltd., Honda Siel Cars India Ltd., Yamaha Motors Ltd., Honda Motor Cycles and Scooters India Ltd., Toyota Kirloskar Motor Pvt. Ltd., Ford India Pvt. Ltd., Renault Nissan Automotive India Pvt. Ltd.and many more to add to the list.

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Objectives of Research

- To examine and understand the digitization and customized ERP application processes functionally.
- To know the integration process between specific ERP application and a particular manufacturing process.
- To establish a correlation between the turnover as proxy for efficiency and other independent variables such as costs, persons employed and machines dispatched.
- To analyze the efficiency scenario prior to the introduction of the digitization process and post digitization process.
- To analyze whether overall efficiency (measured in terms of saving of time, cost, labour productivity and volume of output) has increased or otherwise.
- To identify the loopholes and improvements in the process of implementing the digitization process and the customized ERP application process in the manufacturing activity.

Hypotheses of Research

- There exists a significant correlation between turnover used as 'proxy' for efficiency and other independent variables such as costs, persons employed and machines manufactured and dispatched.
- The performance of efficiency before digitization and after digitization is different from each other.
- Persons employed alone and/or machines dispatched does not Granger cause turnover to change.

Research Methodology

This research is primarily based on 'case study approach' while understanding Twin Engineers' overall efficiency. To meet with the objectives, the research uses 'exploratory method'. While using exploratory method, the research has used 'primary data' in the form of survey conducted with 'focus group'. To carry forward its efficiency analysis, this research has used 'secondary data' in the form of Company documents which consist of data on turnover, costs, persons employed and machines dispatched, used and installed capacity, activity and department-wise data of time consumed etc. The data on these variables has helped construct 'efficiency index', 'time efficiency and labor efficiency indices etc. The personal survey conducted as 'focus group' consists of 'department heads' who are also the owners of 'digitization and customized ERP application process. Since this is a 'focus group' survey only 5 persons as experts are used as 'sample' of this research. A separate interview was conducted with Company MD. For understanding relationship among dependent and independent variables from the model, a correlation analysis is used. To test two of the three hypotheses, the 'T' paired parametric and 'Sign and Wilcoxon non-parametric tests are used. To find out whether the data used from the questionnaire is reliable or otherwise, the Data Reliability test is conducted and the test result on the Cronbach's Alpha based on standardized items has turned out to be .948.

The Model

With a view to examining Twin's efficiency, the researcher has employed turnover as proxy for operational efficiency. Further, it has been understood that efficiency is a function of a host of independent variables along with an error term. Our model, therefore, looks as follows:

TUR = f (PER, MACH, TC, DC, IC)

In this function the meaning of the subscripts used is as follows:

TUR = Turnover, PER = Persons employed, MACH= Machines dispatched, DC = Direct Cost, IC = Indirect Cost

$$TUR = \alpha + \beta_1 PER + \beta_2 MACH + \beta_3 DC + \beta_4 IC + u$$

TUR = 1103815.017-.058 PER + .412 MACH + .496 DC + .183 IC + 5717336.132 u

(.044) (-.467) (1.377) (3.182) (1.679)

The model summary through SPSS output (Annexure, (C)) states that the R = .996, R Square = .992, adjusted R Square = .985. These numbers suggest that coefficient of correlation between dependent and independent variables is very high. Except the variable 'number of persons employed' all other variables have positive correlation with turnover used as proxy for efficiency. Number of persons employed shows a negative correlation with

turnover. But its coefficient is not very high and therefore insignificant. Rests of the independent factors do have their correlation with turnover but even they also do not show a very noticeable coefficient of correlation. In our model the independent factors do not show multicolinearity since the Durbin Watson statistics has turned out to be 2.17. The regression we have run and used does not show causality between our independent variable and a host of independent variables. To find out whether any causality exists between dependent and independent variables we have done the Granger causality test through 'R'. We have made more relevant use of the outputs of the Granger causality in our analysis of hypothesis testing.

(1.F)Testing of Hypothesis (Annexure, (E and F)

In this research out of the three major hypotheses the researcher has tested the following two immediately relevant hypotheses.

Hypothesis 1

- H_{01}: The performance of efficiency before digitization and after digitization is not different from each other.
- $H_{11:}$ The performance of efficiency before digitization and after digitization is different from each other.

To test this hypothesis the secondary data on time taken (time efficiency) to complete a specific activity before digitization and after digitization has been considered. To do that, the two activities have been considered. One consists of 'design' activity and the other consists of 'procurement' activity. The parametric "paired't' test has been conducted on the available data. The test results show that the mean score (4.0833) on the completion of design activity before digitization is considerably higher and the 'p'value (.02) denoting significance is lower than .05. The coefficient of correlation between design to design is .891 which is highly significant. With the similar test conducted on 'procurement' data the results are similar. For example, the mean score (1.8333) on the completion of procurement activity before digitization is considerably higher and the 'p'value (.04) denoting significance is lower than .05. The coefficient of correlation between the two pairs is .867 (considerably higher) at significance level .000. The 'Wilcoxon Signed Ranks Test', a non-parametric, has also been conducted on time taken to complete design activity before digitization and after digitization. The time taken after digitization is greater than time taken before digitization shows all 'negative differences (all 6 are negative differences) and time taken after digitization is greater than time taken before digitization shows positives equal to zero. The ties between the two are also equal to zero. The test statistics is .02 which is less than 05. And the Binomial distribution test statistics is also significant at the level equal to .03 which is also less than .05.

From the above discussion we can reject the null hypothesis and accepts the alternative hypothesis.

Hypothesis 2:

- $H_{02:}$ Persons employed alone and/or machines dispatched does not Granger cause turnover to change.
- $H_{22:}$ Persons employed alone and/or machines dispatched does Granger cause turnover to change.

To test this hypothesis the researcher has run the Granger causality test (Annexure, (D)) through 'R' software. In the causality function it was tested that whether persons employed alone as independent factor granger causes turnover to change as a dependent variable? The test statistics shows the 'p' value equal to 0.20 which is greater than .05 at significance level of 0.006. The 'F'statistics estimated is 2.0726 is far greater than the 'p'value. This result suggests that persons employed alone does not Granger cause turnover to change. This further suggests that it might be a combined effect of digitization and customized applications along with factors from our original model that affect turnover to change. Based on this result we accept the null hypothesis and reject the alternative hypothesis.

Review of Literature and Identification of Gaps

Since this research work is an independent case study which has its own problem area and strategies of growth, there are hardly any previous studies which can be compared with this research on the basis of 'similarities or differences'. In the past there appear a good number of studies which have gone into examining the impact of ERP product and processes on productivity and profitability. But the problem areas of such studies are found to be entirely different from what has been discussed in this paper. Also important is the fact that the previous studies

have not used in multiple numbers the case study form in their development of research studies. Notwithstanding, a few studies need to be mentioned.

- A study (2016) entitles 'Enterprise Resource Planning ……..Operational Efficiency' by Madanhire, Ignatio and Mbohwa, Charles discusses how ERP framework was designed to reduce work in progress on the shop floor and inventory of South African Company.
- In another study (2006) entitles 'Improvement in Operational Efficiency Due to ERP Systems Implementation: Truth or Myth? by Memuri, Vijay and PalviaShailendrathe authors investigated the impact of ERP systems implementation on operational efficiency of medium sized firms in the pharmaceutical and chemicals industry. Their analysis of the data indicates that for a majority of the firms improvement of operational performance expected due to ERP systems did not materialize.

In addition to these major efforts, a number of other studies have just examined the significance of application of either SAP or ERP in the context of specific manufacturing processes without going into any serious analytical research. These many studies have provided a descriptive case approach without making any data-based analysis. This research primarily looks at this major gap and bridges the same through a combined analysis of primary and secondary data with construction of linear regression model and hypotheses testing. The general framework used is a case approach. Most of the previous works in this context have not brought out the limitations of their research and have also not included in their research the implications of their studies for respective companies. This research has also made a conscious effort to take care of these gaps.

Discussion: Analysis and Evaluation

Findings from 'Focus Group Survey

- It has been found from the survey that Twin Engineers has been using digitization process and customized ERP applications in the entire assembly process of adhesive dispensing technology and in all its corresponding and relevant departments for more than 5 years. This seems to be reasonably adequate period to look into the results of the impact of digitization technology and customized ERP on the overall assembly process of adhesive dispensing technology machines.
- Among the reasons that have prompted Twin Engineers to use digitization and customized ERP applications include product suitability, cost saving thought and most prominently efficiency improvement criterion.
- It has also been noticed through the survey that prior to using digitization process and the customized ERP applications; a few of the manufacturing and non-manufacturing processes were carried out manually. Even during this time period, a few of the processes were digitized. When a few important processes were manually carried out, there were important issues related to operational efficiency. In a descending order of importance, the issues observed included high time consumption in implementing processes, loss of resources, high cost, low efficiency and finally quality compromise.
- Through the survey conducted with a 'focus group', it is found that the digitization process and customized ERP products are partially integrated with required select processes. This, therefore, suggested that there exists a greater scope for complete integration of digitization processes and customized ERP products with the existing required processes.
- Since there has been partial integration of digitization processes and the customized ERP variants, the existing processes are subject to multiple issues related to low efficiency. The issues included are the existing processes prior to digitization and /or with partial digitization have been greater time consuming, partial digitization appeared to be technically complicated and therefore required process specific training to technical and non-technical employees.
- In spite of partial integration of digitization and customized ERP variants, a considerable improvement took place in overall efficiency. The variables in which a noticeable improvement is being noticed are considerable time saving in implementing processes, considerable improvement in labor productivity, and improvement in quality of applications and products and considerable saving in cost.
- If we need to use the number to show the average rise in efficiency level, it is found from the focus

group that as compared to pre-digitization situation the efficiency level grew by 20 to 25% after digitization.

- While setting up digitization process and using customized ERP applications, the overall costs have increased to an average level of 10 to 20%. In some exceptional applications the costs have increased by 30 to 40%. The increase in costs has been witnessed since 2014-15 when digitization process and customization of ERP applications are setting their tone.
- Through the survey it has also been found that the RoI, after the implementation process of digitization and customized ERP application, has stood at nearly 10 to 15%. Since customized ERP applications and digitization process have been helping reduce costs and increase turnover, the overall profitability of the Company has been growing. Looking at the present RoI, the company has greater scope to enhance its RoI through the application of ERP processes which are in their initial stages of development and still getting streamlined.
- Since the introduction of digitization and application of ERP customized solutions, it has now been 3 years that the RoI has been growing steadily. There are three specific reasons or factors accountable for the growth in RoI. First, in last three years the number of machines dispatched has been on the rise. Second, labor efficiency has been improving (labor efficiency index) and total cost to turnover ratio has fallen after digitization and customized ERP applications to the existing processes.
- Our survey has also found that though the pace and impact of digitization process and the ERP application drive have been quite satisfactory, there are important issues that need to be taken care of on priority basis. These issues include important problems such as how to make structural adjustments and bring improvements in the initial stage of the development of digitization and ERP application process, how to improve on the present level of employee training specifically required for enhancing the speed of implementation process, how to reduce the cost of establishment and implementation of digitization process and customized ERP applications to the existing processes and with these important issues how to improve upon the overall efficiency after introducing digitization process.
- It has been found through the survey that each crucial department is trying at its best level to adapt to structurally new design of assembling and manufacturing processes. To overcome the problems cited earlier, different improvements are taking place department wise. For example, they include such things as employee training and empowerment, new knowledge addition and enhancement, online help in acquiring new skills and digitized processes and enhancement of reporting system. These steps will take care of improving on time, cost, quality and overall efficiency.
- There is a general feeling among employees and medium and higher cadre management people that the digitization and customized ERP application have been a successful drive from the point of view of bringing about a structural change that has taken care of overall productivity and efficiency.

In spite of the existing problems, there seems to be a general consensus among employees of Twin Engineers that the success level of the positive impact of digitization and customized ERP applications on the overall improvement in operational efficiency has been more than 'least successful' on the Likert Scale of 1 to 5 where 1 being 'least successful' and 5 being 'most successful'

Analysis of Efficiency

To understand overall operational efficiency of assembling and manufacturing processes, we have used 'capacity utilization' as a proxy to analyze operational efficiency. In this case, therefore, we have constructed 'efficiency index' by taking into account a ratio between actual capacity utilized against installed capacity built-up over a variety of product category. Although data is available on product-wise category, we have not constructed product-wise efficiency index. Instead, we have taken a total of installed capacity and actual capacity by simply adding a number of machines in each category of product. Secondly, the efficiency index is constructed over a period from 2015 to 2018. The reason for considering these three years has been the fact that Twin Engineers has started digitization process after 2012 and the robust results of the impact of digitization process and the customized ERP applications

are being witnessed after 2015 onwards. The first three years have been utilized to streamline and strengthen the structural changes introduced in the assembly line and manufacturing processes. A few analytical underpinnings of overall operational efficiency are as follows:

Efficiency Index (Efficiency Through Capacity Utilization) (Annexure, Table 4)

- Owing to improvement in time, labor and cost efficiency the efficiency index (capacity utilization) is ranging in the band of 0.77 and 0.88.As compared to the pre-digitization period (in the years before 2012) when the efficiency index was in the range of 0.55 and 0.65 due to greater structural bottlenecks. After a few years of digitization process, there has been a definite improvement in the efficiency index.
- A product-wise analysis shows that the efficiency index is steady (except for the year 2017-18) primarily due to satisfactory performance on efficiency level by product and process categories such as packaging, MMD, Filling (this is one activity where actual capacity surpasses the installed capacity), SPM, SCDM (actual capacity is greater than the installed capacity) etc. In the year 2017-18, the efficiency index shows a noticeable fall mainly due to unsatisfactory performance in categories of product such as ROBOTIC and SCDM. In that specific year the capacity utilization in the category of ROBOTIC was just 16.66% of the installed capacity (Annexure, LEI)
- During the same period, labor efficiency index has also fallen considerably from its previous level of 1.75 (2016-17) to 1.50 (2017-18). This suggests that labor productivity (machines dispatched to labor employed ratio) experienced a fall in that specific year.

Efficiency Through Costs

To know about operational efficiency from a different dimension we have considered 'total cost to turnover ratio' (Annexure, Table 1) as another proxy. The behavioral pattern of this ratio is analyzed over two time periods. The first period looks at the pattern from 2009-10 to 2012-13; which is essentially a pre-digitization period. And the second period takes into account the behavioral pattern from 2013-14 to 2017-18; which is post-digitization period. Our analysis in this regards is as follows:

- In the pre-digitization period the total cost to turnover ratio was in the band of 91 to 95%. During the same period, the direct cost to turn over ratio was in the range of 71 to 81 percent. The direct costs mainly comprised of the cost of purchases and the cost of salary. This range was, by any standard, very high in any organization. During this period there was hardly any digitization or the use of ERP related customized application to the existing processes. Most of the processes were done manually. What went true with direct costs was also valid in the case of indirect costs. The indirect cost to direct cost ratio (Annexure, Table 2(b)) was in the range of 26 to 39%. The indirect costs mainly comprised of such costs as cost of sales promotion, cost of travel, cost of electricity used, high office expenses, high cost of depreciation including insurance costs, professional, and legal and consultancy charges (The Company hired German Technical Consultancy).
- During post-digitization period the total cost to turnover ratio has declined and now it stands at the range of 86 to 87% specifically since the year 2015-16. During this period, the direct cost to turnover ratio (Annexure, Table 1(a)) has shown a considerable decline and has stood in the range of 62 to 71%. This has been mainly due to effective input utilization owing to digitization and the application of customized ERP processes. Along with this, the indirect cost to direct cost ratio has also declined and has stood at the range of 25 to 31% except for the year 2016-17. In spite of this, we may argue that the present level of indirect costs is high. This is high mainly because of the fact that digitization and application of customized ERP processes have yet to produce optimum results because they are, at present, in the nascent stage of development.
- In the post-digitization period it can also be seen that the rate of growth in total cost as compared to the rate of growth in total revenue (Annexure, Table 3, (a and b)) is found to be marginally low. This has also added to the overall cost efficiency.

Efficiency Through Labor Productivity (LEI, Annexure, Table 5)

Company's overall operational efficiency is also affected by labor utilization process along with machines. To understand the impact of labor productivity on overall operational efficiency, we have constructed 'labor efficiency index' (Table 5) To construct labor efficiency index, we have used a ratio between number of machines manufactured and dispatched and number of persons employed. Our logical analysis in this regard is as follows:

- In the pre-digitization period, most of the manufacturing processes were being done manually. With limited market size and process bottlenecks, the 'labor efficiency index' during this time period was in the range of 1.11 to 1.44.
- In the post-digitization period the labor efficiency index has gone up and has stood between the range 1.50 and 1.83. This upward shift in the labor efficiency index was mainly due to the introduction of digitization and customized ERP application processes.
- The improvement in labor efficiency is also viewed from the point of view of total time taken by labor along with digitization in specific activity carried out in specific department. The time taken is measured in terms of number of days utilized in completing total activities in various departments. The data on time taken to complete activities department-wise comparing pre-digitization period performance with post digitization shows some interesting results. For instance, in Design department, having considered various activities taken together, in the post-digitization period the total time taken to complete activities shows a big fall to the extent of 72%, in the case of Procurement activity the fall in taken has been 57%, in the case of Stores it has been 68% followed by activities such as Sales and Marketing, HR, Administration and Accounts and Finance showing fall in timings to the extent of 58%, 45% and 29% correspondingly. From these findings our analysis shows that in Design, Stores, Sales and Marketing departments the impact of digitization and customized ERP applications on total time saving is much greater than the impact realized in departments such as HR and Admin and Accounts and Finance. In fact, it can be argued that the activities carried out in Accounts and Finance department need a wider level of integration with digitization and customized ERP application processes.

Analysis of Strategy for Growth and Efficiency

Strategic Perspective for Efficiency

After having encountered a few structural issues related to lack of up-gradation of the previous technology, rigid organizational structure, low labour productivity, higher degree of price competition etc., Twin Engineers has made a strategic shift in its overall operational functioning. Its new strategic plan comprises three innovations under 'technological enhancement'. They include such things as "machine up-gradation, complete solution/plant, updated technology- IoT (Internet of Things) and global presence". We shall discuss these innovations in details given as follows:

- *Machine Up-gradation:* During the pre-digitization period, Twin Engineers employed in its manufacturing process the 'basic customized machine' such as basic machine for automation in process. During the post-digitization period, the earlier basic machine has been up-graded. This has helped reduce the existing cycle time of machine to half cycle time for completing the whole process (The Focus Group Survey). Owing to this innovative change, the volume of production has increased and wastages have been reduced. The wider production base has helped customer base grow along with an increase in market size. For example, the Robotic Machine has increased customer production by 35 % and has reduced wastages by 30% (Focus Group Survey and Personal Interview with MD).
- *Complete Solution/Plant:* Earlier, Twin Engineers was engaged in providing its clients with product-specific solution. For example, 'standalone machine'. During the post-digitization period, the Company has started providing its clients with 'complete integrated customized solution'. For example, a complete integrated system is part of complete solution that consists of the MMD machine with Oven, Conveyor System and Robotic Dispensing Machine.

- *Updated Technology – IoT (Internet of Things):* Twin Engineers was earlier working with 'basic machine with MES System'. It is a centralized system with MES/ANDON/ERP. In the operational mechanism of this system the machine used to get connected with the centralized master. This is subsequently followed by the process of the master deciding upon the parameters. In the continuing process the machine sends back to the master a few cycle parameters. At the same time, the machinestores the parameters locally. In this entire mechanism the machine operation is decided centrally and is not fully in control of the operator.

  In the innovative centralized system the machine is IoT compatible. Through this compatibility, the IoT compatible machine can communicate with adjacent machines. The mechanism assures that the machine performs self diagnostically and generates preventive maintenance alerts. The IoT compatible machine can be operated from anywhere with internet connectivity. Through the internet facility the machine can generate e-mails and SMS.

- *Global Presence:* As part of Company's overall growth and expansion strategy, along with technological advancement, the Company has also been making headway towards expanding its global base through enhancing exports. Earlier, Twin Engineers was just confined to domestic market through their participation in domestic product exhibitions. In last couple of years, the Company is expanding its activity base and has been participating in overseas product exhibitions. For example, earlier the Company was exporting only to 1 or 2 countries. At present, its export base has been expanding and the Company is exporting to 10 to 12 countries (Twin's Documents). This suggests two things. One, as its strategic growth plan, the Company is also using actively the option of 'exports' in recent times. Second, as compared to the previous times, the Company is becoming more price competitive.

- *New Product Development (NPD)after digitization:* New product development has been a continuous activity at Twin Engineers. During digitization process, this activity has been scaled up even further. For example, after the initial level of digitization, a few important products have been developed. For example, the products such as MMD, Fluid Filling and Robotic have been developed through extensive R&D. These products have a wide domain of applications in many sectors such as renewable energy, power sector, auto electrical, automotive, wind energy, mining, elevator and solar etc. These, being highly digitized products, have helped speed up the manufacturing process on one hand and reduce labour time used in various activities in number of departments.

Conclusion/s

This research on understanding the impact of digitization and the application of customized ERP processes on the overall operational efficiency at Twin Engineers distinctly recognizes the following conclusions. These conclusions have obviously emanated from the findings and the analysis of the findings.

- We can firmly conclude that the operational efficiency at Twin Engineers, after and during the process of digitization, has gone up considerably.
- The pre-digitization era of 'local excellence' has definitely shown a considerable progress in terms of overall company growth. Albeit this, the Company has had a couple of structural issues related to labour and resources efficiency along with high costs and competitive price. During the digitization era, these issues are being tackled with the introduction of new technology which is based on digitization and customized ERP application processes.
- Since 2012 and more importantly 2015 onwards a variety of new products and processes have been developed whose basis is 'technological advancement' with the ERP and IoT. These newly developed products have improved overall operational efficiency.
- Although digitization and customization through ERP products and processes are very much in place, their activity-wise and department-wise impact is not uniform. For example, the department such as stores, administration and accounts need a greater degree of integration with digitization.
- The improved operational efficiency is a matter of a combined result of various factors such as time, labour and cost which are being satisfactorily integrated with digitization process. In spite of this, the

present pace, degree and level of these new applications have been in nascent stage and they require a considerable amount of time to strengthen their operations andstreamline the overall integration process.

- The original model (1.E) which uses turnover as a proxy for efficiency shows a significant correlation with such predictors as total cost, direct and indirect costs, labour efficiency index and number of machines produced.
- Although this research paper has analysed the impact of digitization on overall operational efficiency, our regression outputs on turnover as predicted variable and direct and indirect costs as predictors suggest multicollinearity (Durbin Watson = 1.73) between cost variables. So, we have room to argue that even predictors need a separate analysis to understand correlation and regression between them.
- As against the suggestion number (7), one more regression between turnover as predicted variable and labour efficiency and machines manufactured as predictors have not shown multicollinearity (Durbin Watson= 2.17) between the predictors. This observation has made us conclude that these two predictors have separate association with turnover used as a proxy for operational efficiency.
- Much greater drive towards digitization of processes will certainly help the Company enhance its present RoI (return on investment).
- Twin's long-term growth strategy may focus on two important aspects. One is widening the base of 'technological advancement' along with greater level of digitization and deeper use of IoTs and the second aspect is exploring better opportunities for strengthening its present export base. Twin has to converge its 'local excellence' policy with better use of AIs, Robotics, and Machine Learning and wide spread of digitization.

Recommendations

- Although, at present, the digitization process and the application of customized ERP have been resulting in positive outcomes, the process is in its nascent stage. Its scope and speed need to be elaborated.
- Our analysis of efficiency based on capacity utilization makes it clear that the efficiency in the categories of product such as ROBOTIC and SCDM should improve in recent future.
- Our analysis related to time efficiency also makes it clear that the activities carried out in Accounts and Finance department need a wider level of integration with digitization and customized ERP application processes.
- Although total cost to revenue ratio has fallen after digitization period, we can argue that the Company should control indirect costs in future.
- On one hand, the Company is focusing on 'technological advance' through digitization and customized ERP applications; it should also lay a greater emphasis on 'human resource skills development'.
- To enhance the participation rate of employees in various activities and in different departments, the employees should be given training which would help them handle digitized and IoT processes smoothly and with greater accuracy.
- Twin's present organizational excellence is weak. To enhance it, employees need flexible deadline schedule, greater technical compatibility, proper training on quality performance of quality products and improvement in the present information network for employees.
- Our earlier survey conducted in 2012 (Employee Survey, 2012) and our observations through our recent survey (Focus Group Survey, 2018) make it clear that a few things on the level of organizational excellence have not changed much. For example, a small section of employees (36% of the surveyed in 2012) feel that the rigid attitude to work culture should change. This will change through better understanding of functional responsibilities (10% of the employees surveyed in 2012) and cooperative learning (12% of the employees surveyed in 2012). It will also improve through enhancing organizational coordination (8% of the employees surveyed) with digitization process.
- Although, at present, Twin Engineers has shown a definite progress towards 'exports' when compared with pre-digitization period, the number of countries to which the Company is exporting may be

increased through 'achieving greater price competitiveness' and 'quality consciousness'.

- Twin has just spent nearly 5 years' of 'digitization and customized ERP process application. In its long-run growth strategy it should spend more on R&D and achieve a much better diversification in the present range of products. This long-term strategy will help Twin Engineers achieve consistent and sustainable growth.

Implications

This research has the following implications so far as Twin's day-to-day operational activities and policy for growth is concerned.

- This research may turn handy for Twin to clearly segregate and better understand the operational efficiency scenario prior to digitization and post digitization.
- Twin can strategize its future plan to enhance integration process of digitization in the case of those activities and departments where the present degree of digitization is less.
- Twin can take definite steps to control its indirect costs and monitor better its competitive price policy and market expansion strategy.
- This research may help Twin to take concrete steps to improve upon its 'organizational excellence' through improving human resource skills and imparting training.

Limitations of Research

The following are some of the important limitations of this research.

- The questionnaire used to conduct survey with 'focus group' is relatively a small sample and the responses to the questions are found to be very uniform.
- The time series data used on such variables as 'turnover, total cost, direct and indirect costs, persons employed and machines dispatched are based on just 10 years' period. Such small time series does not produce robust statistical results.
- Presently, this research has used 'turnover' as proxy for efficiency. If 'profitability' were usedas proxy for efficiency, the results could have been marginally different from the present results.

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Annexure

Tables

Table 1: a) Total Cost to Turnover Ratio (Cost Efficiency)

Pre-digitization Period

Year	*Ratio*
2009-10	0.9528
2010-11	0.9257
2011-12	0.9502
2012-13	0.9099

Source: Author's Calculation

Digitization Period

Year	*Ratio*
2013-14	0.9212
2014-15	0.9258
2015-16	0.8624
2016-17	0.8766
2017-18	0.8773

Source: Author's Calculation

Table 2: a) Proportion of Direct Cost to Turnover Ratio

Year	*DC/Turnover Ratio*
2009-10	0.81
2010-11	0.73
2011-12	0.71
2012-13	0.65
2013-14	0.72
2014-15	0.71
2015-16	0.68
2016-17	0.62
2017-18	0.66

Source: - Author's Calculation

b) **Proportion of Indirect Cost to Direct Cost**

Year	*IC/DC Ratio*
2009-10	0.16
2010-11	0.26
2011-12	0.33
2012-13	0.39
2013-14	0.27
2014-15	0.29
2015-16	0.25
2016-17	0.39
2017-18	0.31

Source: - Author's Calculation

Table 3: a) Rate of Growth in Total Revenue

Year	*ΔTR/TR*
2010-11	0.14
2011-12	0.0053
2012-13	0.22
2013-14	0.25
2014-15	0.0655
2015-16	0.0085
2015-17	-0.0236
2017-18	-0.0281

Source: Author's Calculation

b) **Rate of Growth in Total Cost**

Year	*ΔTC/TC*
2010-11	0.11
2011-12	0.0320
2012-13	0.17
2013-14	0.27
2914-15	0.0707
2915-16	-0.0605
2016-17	-0.0075
2017-18	-0.0274

Source: Author's Calculation

Table 4: Efficiency Index (Capacity Utilization = Actual Capacity/Installed Capacity *100)

Year	*Efficiency Index*
2015-16	0.88 (88.00%)
2016-17	0.87 (87.68%)
2017-18	0.77 (77.21%)

Source: - Author's Calculation

Table 5: Labour Efficiency Index (LEI)

(No. of machines dispatched / No. of persons employed)

Year	*LEI*
2009-10	1.11
2010-11	1.30
2011-12	1.41
2012-13	1.44
2013-14	1.83
2014-15	1.76
2015-16	1.83
2016-17	1.75
2017-18	1.50

Source: Author's Calculation

Table 6: Efficiency of Time*

Sr No.	*Department/ Activities*	*Pre-digitization time required*	*Post-digitization time required*	*% Change*
1	Design	25	7	72%
2	Procurement	7 (6hours)	4 (6 hours)	57
3	Stores	22	7 (6hours)	68
4	Sales and Marketing	12 (2 hours 40 minutes)	5 (2hours 40 minutes	58
5	HR and Admin.	22	12	45
6	Accounts and Finance	57	40	29

* Time measured in terms of number of days required to complete specific activity

Source: Twin's Activity List and Author's Calculation

(B) Twin Data Table 7

1) Quantitative Details

Year	*Turnover*	*Direct cost*	*Indirect Cost*	*Total Cost*	*No. of Persons*	*No. of Machines Dispatched*
2009-10	124106807	101179817	17074429	118254246	51	57
2010-11	142059255	103862463	27643533	131505996	52	68
2011-12	142825294	101872478	33843745	135716223	55	78
2012-13	175412806	114703659	44921658	159625317	58	84
2013-14	220273447	158636020	44299886	202935906	60	110
2014-15	234714580	167503106	49798953	217302059	65	115
2015-16	236713380	162712664	41429033	204141697	65	119
2016-17	231106340	145383281	57217363	202600644	70	123
2017-18	224596161	150092264	46956162	197048426	85	128

Source: Twin's Data Sheet on Quantitative Details

Table 8: Installed Capacity

Product Category	*2015-16 Installed Capacity*	*2015-16 Actual Capacity*	*2016-17 Installed Capacity*	*2016-17 Actual Capacity*	*2017-18 Installed Capacity*	*2017-18 Actual Capacity*
PACKAGING	60	56	60	36	60	48
MMD	27	16	29	25	36	28
FILLING	9	15	10	8	12	21
ROBOTIC	18	12	19	16	24	4
SPM	9	6	10	8	12	13
SCDM	9	10	10	25	12	7
PROJECT	2	4	2	3	2	1
TOTAL	134	119	138	121	158	122

Source: Twin's Data Sheet on Installed Capacity

Table 9: Activity List

Sr.No.	*Department*	*Name of the Activity*	*No.of Days Pre-digitization Time Required*	*No.of Days Post Digitization Time Required*
1	Design	Design Calculation	0.50	0.25
		DAP document	2.00	1.00
		Drawing 3D	8.00	3.00
		Drawing 2 D	8.00	2.00
		File Release	4.00	0.50
		RPO Release	2.00	0.25
2	Procurement	Study the requirement	1.00	1.00
		Verify the availability	1.00	0.25
		Floating requirement in the market	1.00	0.25
		Costing, comparison negotiation	1.00	0.25
		Release of P.O.	0.25	0.10
		Follow, D/W/M	1.00	1.00
		Updation of the receipt	1.00	0.25
		Payment to vendor	1.00	1.00

Source: Twin Engineers Activity List

Regression Outputs

Model Summary[b]					
Model	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*	*Durbin-Watson*
1	.996[a]	.992	.985	5717336.132	2.814

a. Predictors: (Constant), Indirect Cost, Persons, Direct cost, Machines

b. Dependent Variable: turnover

ANOVA[b]

Model		*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
1	Regression	1.688E16	4	4.220E15	129.096	.000[a]
	Residual	1.308E14	4	3.269E13		
	Total	1.701E16	8			

a. Predictors: (Constant), Indirect Cost, Persons, Direct cost, Machines

b. Dependent Variable: turnover

Coefficients[a]

Model *B*		*Unstandardized Coefficients*		*Standardized Coefficients*			
		Std. Error	*Beta*	*t*	*Sig.*		
1	(Constant)	1103815.017	2.502E7		.044		.967
	Persons	-253437.982	543076.229	-.058	-.467		.665
	Machines	718848.406	521957.588	.412	1.377		.240
	Direct cost	.812	.255	.496	3.182		.033
	Indirect Cost	.689	.410	.183	1.679		.168