# CRITICAL SUCCESS FACTORS OF MANUFACTURING SOLUTION ADOPTION: A QUALITATIVE CASE STUDY IN METAL-STAMPING INDUSTRY

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## ABSTRACT

*Manufacturing solution like Enterprise Resources Planning (ERP) system is designed for the manufacturing organization to link the fragmentation of the data and information because it integrates and streamlines internal processes by providing a suite of software modules that cover all functional areas of a business. However not all ERP system project implementation is successful especially the high-mix industry because the production process is rather complex and requires to involve a lot of resources and time. These have resulted a number of researches focusing on finding the critical success factors (CSFs) of the manufacturing solution implementation. This qualitative research built a case study in a sheet metal-stamping company that operated under Make-To-Order (MTO) and high-mix environment. Face-to-face interviews were conducted and data were coded and analyzed using Nvivo 10 software. Researchers identified 10 Critical Success Factors for high-mix sheet-metal industry. This research also identified 5 success measures on manufacturing solution adoption. Researchers argue that user paradigm on success relied on the system usability and user satisfaction. In conclusion, manufacturing users still have high believed in manufacturing solution implementation because it could bring real benefits to the company eventhough there are implementation challenges.*

***Keywords***— Critical success factors, ERP, manufacturing solution adoption, high-mix industry.

## 1. INTRODUCTION

Enterprise Resources Planning (ERP) is the manufacturing solution that is used by the manufacturing enterprise for business and process improvement. In an effort to remain competitive, there has been increasing needs in organizations to connect the information supplied by each departments into a common entity [1], [2]. ERP systems are designed for the manufacturing organization to address the problem of information fragmentation as they integrate and streamline internal processes by providing a suite of software modules that cover all functional areas of a business. ERP systems are offered as standardized off-the-shelf packages, and have modules that support various business functions such as sales distribution, purchasing, manufacturing, inventory control, supply chain management, accounting and finance. ERP systems usually involve the entire organization and provide opportunities for access to real-time data across the enterprise [3].

However, increasingly we hear of the failures of ERP implementations, or the complete abandonment of the system [4], [5]. Resultantly, there has been expanded research focusing on the implementation process and its critical success factors (CSFs) [6]–[9]. Researchers' epistemology on practicality of CSFs compiled will be served as good reference guide for ERP projects and ultimately, this will enhance the probability of achieving higher success levels and, resultantly, timesaving, cost savings, quality and efficiency in their system [10].

The success rate of the ERP system implementation is low even though companies do not show the failure of their implementation. The literature reviews show there are different factors influence either positively or negatively on the successful implementation of the ERP, and CSFs are the reasons that determine the successful implementation [6], [11]. There are 3 stages of ERP implementation as indicated: pre-implementation, implementation and post-implementation. The CSFs occur in all implementation phases stated above [6].

There are researches pointed out that ERP is more suitable to Make-To-Stock (MTS) than the Make-To-Order (MTO) industry because of the nature of their production environment is different [12]. The small-and-medium-scaled industries (SMIs) operate in a high-mix environment, i.e. they do not have their own product, and they are make-to-order (MTO) according to customers' specifications [13]. Since their product and processes are always different for each MTO case, they may require a dynamic production management system in place in order to run the manufacturing operation smoother. Therefore, the requirement for the ERP is much different and the implementation is more complicated in the high-mix MTO industries.

Researcher's epistemology on CSFs for manufacturing solution implementation in high-mix industries will have differences from those commonly known CSFs that previously compiled or identified in ERP implementation.

### *Problem statement*

The nature of manufacturing environment of the High-Mix Industry is very dynamic and having ever changing ad-hoc issues. It would be more difficult to implement the manufacturing solution in this kind of industry. The Critical Success Factors (CSFs) for the High-Mix industry should

have differences from those commonly known in Low-Mix industry.

***Research questions***

1. What are the CRITICAL SUCCESS FACTORS that contributing towards the success of the manufacturing solution adoption in High-Mix MTO industry?

2. What is the paradigm of SUCCESS measured by users after the implementation of the manufacturing solution?

## 2. LITERATURE REVIEW

### 2.1. IS and ERP success models

Bradley in his review paper cited that DeLone and McLean (1992) developed an Information System (IS) success model based on six dimensions:- systems quality, information quality, use, user satisfaction, individual impact and organizational impact [14]. The DeLone and McLean success model has been highly cited by researchers and Google Scholars and was claimed as "the standard for the specification and justification of the measurement of the dependent variable in information systems research."

However, for ERP success model, Seddon (1997) and Rai et. al (2002) argued that the DeLone-McLean model used "must precede impacts and benefits, but does not cause them" and the model was developed from their review of literature in a period before ERP emerged. Therefore it might not fit to the ERP success model. Gable et al. address the issue of "use" in the ERP success model, which eliminated both "use" and "user satisfaction" from the DeLone–McLean IS Success model. Both of their argument point was "satisfaction" was treated as a measure of success rather than a dimension of success [14]. Ifinedo et.al further proposed the ERP success model dimension that related to Gable et. al. model by adding-in the Workgroup quality and Service Impact [15].

Table 1: IS and ERP Success model comparison.

| Success Dimension | DeLone and McLean (1992) | Gable et al. (2003) | Ifinedo et. al (2010) |
|---|---|---|---|
| System quality | ✓ | ✓ | ✓ |
| Information quality | ✓ | ✓ | ✓ |
| Use | ✓ | | |
| User satisfaction | ✓ | | |
| Individual impact | ✓ | ✓ | ✓ |
| Organization impact | ✓ | ✓ | ✓ |
| Service impact | | | ✓ |
| Workgroup quality | | | ✓ |

### 2.2. Critical Success Factors (CSFs)

The high failure rate of ERP implementation has resulted a numbers of studies have attempted to find out the Critical Success Factors (CSFs) in the implementation of ERP.

Ngai, Law and Wat (2008) conducted a comprehensive search through the relevant literatures between year 2006 and 2007 and 18 CSFs have been identified from the 48 articles that were located in 12 groups of regions and countries around the world [8]. In these 18 CSFs, 'top management support' and 'training and education' were the most frequently cited as the critical factors to the successful implementation of ERP systems.

In another CSFs research, Finney & Corbett (2007) identified 26 CSFs and categorized them into Stratigics CSFs and Tactical CSFs [10]. Hundreds of journals were searched using key terms identified in a preliminary literature review and successive rounds of article reviews resulted in 45 articles being selected for the compilation. A subsequent critical analysis identified gaps in the literature base, Finney & Corbett pointed out there was a need to study the CSFs to the perspectives of the key stakeholders and the concept of change management [10].

A recent research conducted by Ahmad et. al (2013) presented the results of a study to identify and analyze the interrelationships of the critical issues involved in the implementation of ERP in small and medium sized enterprises (SMEs) [16]. Over 50 relevant papers were critically reviewed to identify the main critical success factors (CSFs) for ERP implementation in large organizations. Then, the applicability of the identified CSFs to SMEs was investigated. In their findings, the 33 CSFs were identified and they are mainly contributed by organization factors, neutral factors, and operational factors.

The above 3 papers presented a total of 77 CSFs of manufacturing solution adoption analysed based on 143 research articles selected from over hundreds of research journals. Researchers recognized that the compiled CSFs have provided sufficient guideline to be used in this research.


Figure 1: CSFs word cloud on frequency

Researchers analyst the word frequency of these CSFs using Nvivo and discovered the top 20 CSFs words as in Figure 1, were related to "project", "management", "erp", "business", "implementation", "process", "software",

"strategy", "team", "change", "data", "communication", "culture", "organizational", "support", "vendor", "appropriate", "clear", "consultants" and "plan".

### 2.3. Manufacturing Solution for SMIs and High-Mix industries

SMEs have less resources and competencies about complex ERP systems compared to larger companies. Thus ERP projects have proven to be risky and costly for SMEs. SMEs can easily be an easy prey for experienced vendors and consultants and end up with a system far from what they expected [3].

High-Mix industries is normally refer to the Make-To-Order (MTO) companies, which produce high-variety and bespoke products, have particularly challenging decision support requirements and it remains unclear whether ERP systems can meet their needs. MTO features considered include: decision support requirements at critical Production Planning and Control (PPC) stages, idiosyncratic market-related features, typical company size and supply chain positioning, and shop floor configuration [13].

The ERP system selection process for MTO companies is more difficult than MTS companies and some have perceived ERP is unsuitable for MTO environment. The poor match for ERP to MTO environment was due to the dynamic decision support requirements of MTO companies and that was not originally offered by general ERP functionality [12]. MTS companies make more use of planning tools within ERP systems, and it is concluded that production strategy is an important contextual factor affecting both applicability and impact.

The authors suggested that there should be a MTO-specific planning method could be embedded within ERP systems to improve alignment. Therefore, the CSFs for ERP implementation may have differences compared to that publication and shall be further investigated by the researcher.

## 3. RESEARCH METHODOLOGY

### 3.1. Research method

Literature reviews found there were researches conducted CSFs in the similar fields using the qualitative method, quantitative method and mix-mode of quantitative-qualitative method. There were 40 reviewed papers related to CSFs were collected and researchers found that more than two-third were using the quantitative methods or mix-mode methods. Since Researchers were intended to get in-depth investigation to determine the CSFs therefore has chosen qualitative method by following the Yin (2009) case study approach guideline.

Researchers have put the focus of CSFs investigation in the post-implementation phase in the High-Mix Industries because users have put a measure of success of their past project experience in order to better determine the CSFs.

Our target focus group was the SMIs based in Malaysia and it must be a High-Mix MTO company. The other selection criteria was they must have experience in manufacturing solution implementation for more than one year. The target respondents would be the key persons in the organization and they could be from the top management, middle management and executive level.

### 3.2. Research approach

The following was the research approach adopted by researchers.

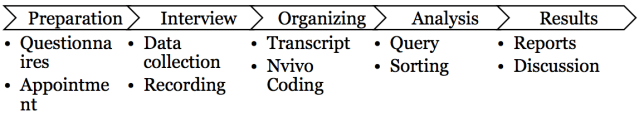


Figure 2: Research approach

Researchers prepared set of questionnaires to conduct a semi-structred interview. The content of questionnaires was related to the CSFs that identified through the literature study.

Prior to the selection of the CSFs, researcher conducted query in Nvivo for the 40 selected papers (partially listed in references) related to ERP, CSF, MTO with key word "CSFs" and "Critical Success Factors". After few rounds of queries and fine-tuning the search criterias, researchers managed to identify 10 highest-rank CSFs that most related to the focus group. The results were then compared to the top 20 keywords of CSFs captured from the word cloud as indicated in Figure 1. With respect to that, researchers identified the top 10 CSFs were related to "Communication", "Corporation", "Culture Change", "Data Analysis", "Evaluation Progress", "Experienced Project Manager", "Management Support", "Project Team Skills", "Resources" and "Use of Consultant". These top CSFs were used as the main discussion points in the interview session.

The interview was conducted onsite at respondents' office. It was a semi-structured interview session that the pre-prepared questionnaire used as a guideline for interview. The information collected were the audio recordings, Microsoft Word Audio Memo, company's profile and company background information e.g. photo, organization chart etc. Subsequently, the interview transcripts were prepared according to the audio recording. The transcripts were then check-in to Nvivo 10 for coding. The unstructured data were sorted into each node accordingly.

All data and information were futher analysed in Nvivo 10. Multiple search criterias were used in order to get the information and desired results. The queries could be easily conducted to mining the information from the raw data for initial results, either by searching into each nodes or the respective classifications.

The detail analysis could be carried out after the data were sorted in theme. The output results could be obtained from the query summary, Word Cloud, Tree Map and Cluster Analysis. Reports could be generated using the Reporting function. This research findings were based on the study and investigation on the reports generated from the

software, with subsequently getting validation from the respondents.

## 4. DATA COLLECTION

The case study company (MfgCom) was a Malaysian owned company located in the industrial park in the central region of Penisular Malaysia and currently having about 50 employees with business turnover around RM150 million.

MfgCom offered wide range of cable support systems such as cable trays and truncking systems made of metals and aluminum. The end products or finish goods needed to go through with varies surface treatment process such as hot dip galvanized and electro epoxy powder coating in the same manufacturing plant or outsourcing. MfgCom also offered cable support systems made of Fiber Glass and stainless steel for special purpose usages. MfgCom was high-mix because their product variety and they were MTO for most of the customer orders. MfgCom only MTS for certain products to few regular customers.

MfgCom implemented an intergrated manufacturing solution for about 2 years. Before the manufacturing solution adoption, MfgCom used Microsoft Excel as the main operation management tool. The current implemented system consisted of sales module, purchasing module, manufacturing module, stock and inventory module and integration to financial module. The project implementation took around 12 months and had completed 1 year ago. The system is currently under the maintenance mode and is supported by the vendor.

The interviews were carried out onsite with the plant manager, operation manager, production manager and project manager. The Plant Manager (MfgUsr#1) joint MfgCom for about a year and he took care of the overall plant operation. MfgUser#1 was an engineering graduate and had more than 10 years hands-on experience in manufacturing operation. He had experience to drive the manufacturing solution implementation in his previous company.

The Operation Manager (MfgUsr#2) took charged of the purchasing and administration works. She has a degree in business administration and already had 6 years experience in manufacturing operation management. She joint MfgCom for 4 years and was the key member in implementing the manufacturing solution in MfgCom.

The Production cum Store Manager (MfgUsr#3) looked after the production, stocks and inventory. MfgUsr#3 has high-school certificate and had more than 20 years of working experience in manufacturing companies. MfgUsr#3 joint MfgCom for 3 years and was one of the key members who involved fully in the manufacturing solution implementation.

The project manager (MfgUsr#4) was assigned by the vendor of the manufacturing solution to implement the manufacturing solution in MfgCom. MfgUsr#4 was a graduate of computer science and has 7 years of working experience with 3 years to lead and managed the manufacturing solution implemention for customers.

The first meeting was a group interview conducted with MfgUsr#1, MfgUsr#2 and MfgUsr#3 that took about 2 hours. The entire session was audio recorded and photos were taken with permission. The interview with MfgUsr#4 was conducted outside the premisis of MfgCom for about 30 min with audio recording.

Few follow-up interviews were conducted over telephone calls with respondents to get clarification for unclear information. A meeting was conducted with all respondents after 2 weeks to discuss on the findings and re-organizing the data and subsequently fine-tuning the facts based on the new inputs given before generating the results and reports.

## 5. DATA ANALYSIS

The interview transcripts for MfgCom were analyst with Nvivo software. The query on the text frequency has generated tree map for MfgCom as shown in Figure 3.

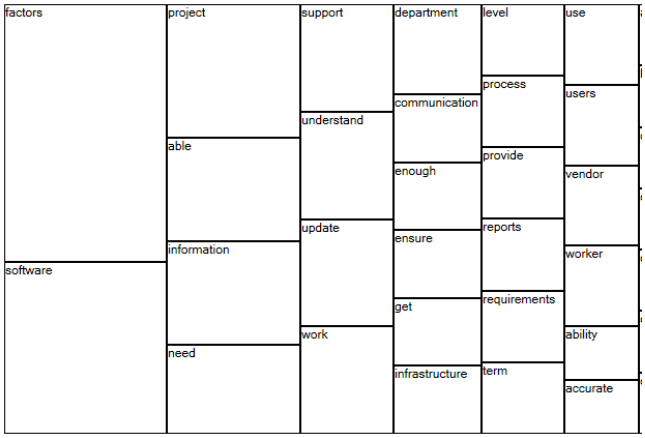


Figure 3: Tree map of Top CSFs for MfgCom

Researchers did the coding based on the keywords obtained above and run the queries based on some summary and highlights prepared from the transcripts. Few key factors were identified and coded with keyword “factors”. The output of tree map results as shown in Figure 4.

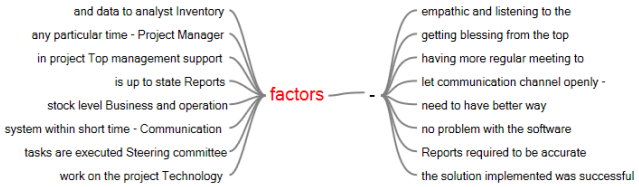


Figure 4: Tree Map Analysis of CSFs for MfgCom

### 5.1 CSFs identified

Based on the results obtained for MfgCom, the CSFs were determined as below:

**i) Software capability**

Manufacturing software solution should be able to support the requirements and needs of the organization. The software functionality should be suitablilty used by the

company. It should be handling dynamic environment for the high-mix company that need to make changes frequently. The software should be easily learnt up and operated by the users.

**ii) Project members and skills**

Right project members should be chosen to implement the manufacturing solution. They must have relevant knowledge and skills especially the key users. Project manager should be knowledgable enough to manage the changes and requirements raised by the users

**iii) Sufficient information**

Information should be enough and sufficient in order to make the system work. Essential information should be prepared and input to the system in order to build a centralized data repository system. Information were referred to product, resources, work processes, job status and work-in-progress (WIP), timeline. Information should be easily accessed and visibile by the users.

**iv) Support from project members**

The project implementation should be supported by the project team members. All users should follow the instruction and tasks assigned and ensuring the executions were carried out according to the requirements set. The top management should support the project and allocated enough time for the key project users to work on the system besided their daily routine jobs. The key persons or the project champions should be committed to drive the project towards successful implementation.

**v) User's understanding**

The users should understand what were the purposes of implementing the manufacturing solution at the first place. They should learn about the benefits and functionalities of the software that could help them in their works. If the key users understood what benefits and improvement they could gain from the software, they tend to be more corporative and willingly to make the system worked for them.

**vi) Regular system update**

The manufacturing solution required inputs in order to have sufficient information to run the system. Manufacturing solution was an execution system, i.e. required frequent update to ensure users could get the latest information, especially the live production reports. Users could make better decision based on the current info and status but not the obsoluted info.

**vii) Effective communication**

Let the communication channel opened to all users and willingly to accept ideas and suggestion on how to make the system better. Users should discuss on challenges faced and seeking for solution, therefore need to have more regular meeting among the project team members. Company should also need to establish an effective communication channel to get enough supports from the software vendors.

**viii) Infrastructure**

Essential ICT infrastructure should be in place. Computers, networking and ICT peripherals should be meeting the software specifications as recommended by the vendors.

**ix) Defined processes**

Product process flow planning should be captured in the earlier stage. System should have the functionality to handle the changes when there was a dynamic processes involved. Workflow and processes should be properly followed by the users. Since the high-mix production environment was ever changing, user needed the flexibility of the system to allow them to make process changes easily. Good work procedures and guideline should be clearly and made known to all users.

**x) Useful reports**

All kinds of informative and useful reports should be able to generate from software. Users would use the software if the system could generate the reports that allowed them to take actions based on the information and data captured. The accuracy of the data and quality of the reports could help the users to make wise decision for the changes with speed and facts.

### 5.2 Success measured

The users were also asked to share their view about the success measure after the manufacturing solution implementation. The reported outcome as below:-

**i) Operational improvement**

Successful implementation should bring significant improvement in business operation. Manufacturing solution adoption should automate some business operations and established better workflow control. Users could get things done faster and reduce errors made. Business operation of the organization has become smoother and more efficient.

**ii) Productivity improvement**

Successful implementation could be seen when the user productivity has increased. More things could get done within the same time compared to previously. More jobs and tasks could be processed and accomplishied compared to last time.

**iii) Tracking and tracibility improvement**

Users should be able to track the job status easily. Accurate and correct information could be obtained from the system faster and easier. Issues and problems could be identified and traced back from the system history and audit trials. The system provided a platform to do root cause analysis and making improvement from there.

**iv) Resources management improvement**

Users were more deciplined and could work on system with the operating guideline. Machines capacity and utilization could be computed easily. Material usaged could be better controlled. Product costing could be calculated with better accuracy.

**v) User satisfaction**

Users should have the feelings that they were satisfy with the system and would like to continue using it. They should see the system could help them reducing their burden and works. Inter-departmental communication has been improved and conflicts have reduced.

## 6. DISCUSSION

Researchers managed to identify 10 top CSFs and the results were compared to the CSFs models presented by Ngai [8], Finney [10] and Ahmad [16].

Table 2: CSFs comparision

| No | CSFs Identified | Ngai [8] | Finney [10] | Ahmad [16] |
|---|---|---|---|---|
| 1 | Software capability | ✓ | ✓ | ✓ |
| 2 | Project members & skills | ✓ | ✓ | ✓ |
| 3 | Sufficient information | ✓ | ✓ | ✓ |
| 4 | Support from project members | ✓ | ✓ | ✓ |
| 5 | User's understanding | ✓ | ✓ | ✓ |
| 6 | Regular system update | ✓ | ✓ | |
| 7 | Effective communication | ✓ | ✓ | ✓ |
| 8 | Infrastructure | ✓ | ✓ | ✓ |
| 9 | Defined processes | ✓ | | ✓ |
| 10 | Useful reports | | | |

Most of the CSFs indentified in this research have been reported by other researchers. However, based on Table 2, researchers noticed that regular system update, defined processes and useful reports were not fully matched with earlier literatures [8],[10],[16].

Regular system update was important to MfgCom because they felt that the production environment was ever changing, therefore regular system update was critical. MfgUsr#2 and MfgUsr#3 expected the system should allow them to know the work-in-progress (WIP) in order to make faster decision. Hence they spent time to educate the users to learn how to update the system.

It was also learnt that some of the product work process was not able to decided initially especially when making new products. MfgCom came out with a draft process plan and then only made changed along the production process. This was a big challenge for the software to handle such ad-hoc changes for usual manufacturing solution. A similar case study has been reported for dynamic manufacturing solution adoption in high-mix industry [17]. MfgUsr#3 felt that it was critical their manufacturing solution could provide some flexibility for MfgCom to handle this requirements.

All MfgUsr#1, MfgUsr#2 and MfgUsr#3 recognized that useful reports generation would be the CSF for MfgCom although MfgUsr#4 indicated that reports could be under the category of software capability. This CSF was not reported in the literatures reviews [8],[10],[16]. MfgUsr#1 explained that as soon as the system could produce the reports, the users could see that as the results outcome and therefore have confident to continue supporting the software implementation. This CSF has become the driver to motivate and encourage the users to use the system.

With regards to the user paradigm of SUCCESS, operation improvement has to been seen as success measure because that could bring individual and organization impacts [14],[15]. MfgCom has seen the productivity improvement as another success measure after using the system for a year. They have seen improvements in job and tasks tracking that allowed them to have more useful information in hand and effective communiction among employees. These were aligned to the literatures in respect to system quality, information quality and workgroup qualiry [14],[15].

Researchers discovered that user satisfaction was an important measure to learn the success of solution adoption. That was aligned to the DeLone and McLean (1992) IS success evaluation model which discussed the "USE" and "User Satisfaction" factors were critical factors for the measure of success. The paradigm of SUCCESS come from the ability of the user to use the system, and user's satisfaction on how the solution could help them in their job and ability to increase their work productivity. Therefore these two factors should not been taken out from the IS success evaluation factors, though a lot of researchers trying to eliminate them [15].

## 7. CONCLUSION

This qualitative research has achieved its objectives, i.e. has identified 10 CSFs and 5 Success measures for the manufacturing solution adoption in the high-mix sheet-metal industry. The case study was based on one company only and did not represent the entire industry. However the research outcomes could provide researchers a good understanding and guideline to learn the CSFs of manufacturing solution adoption in high-mix industry. It was important to know the user paradigm of Success because organization and solution implementor could set a measureable guideline to achieve project milestone.

Researchers have learnt that the SUCCESS measure somehow related to the human phsycology aspects and human's personal feelings that were not easy to measure; e.g. well "use" the system and "user satisfaction" of the system. Based on research outcome, researchers argue that "use" and "user satisfaction" are still applicable and should not be eliminated from the DeLone and McLean's IS Success Evaluation Model.

Although there are many challenges to implement a manufacturing solution, the users in MfgCom generally still believe in manufacturing solution implementation could bring long term benefits to the individual and the organization.

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