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ORIGINAL ARTICLE

Measuring organisational agility before and after implementation of TADS

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Abstract The ever increasing competition compels the modern organisations to react quickly in accordance with this kind of dynamic demands of the customers, which is referred to as agility, and currently researchers are addressing these capabilities under the field agile manufacturing. The success of achieving agility lies in designing agile-friendly products. In this direction, very little researches have been pursued. In order to fill this gap, a model called total agile design system (TADS) is proposed. The implementation study conducted to examine this model in a traditional manufacturing company is briefly appraised. A scoring model has been used for measuring agility before and after implementation of TADS. The implementation study revealed the improvement of agility by 10%. This improvement is appreciable in traditional manufacturing organisation where only the mass production-based practices are only currently practiced.

Keywords Agile manufacturing · Agility quantification · Computer aided design · Implementation study · Organisational agility

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1 Introduction

The globalisation has been facilitating the entry of numerous competitors in the world market [1, 2]. As a result, modern customers are approached by numerous players in the market to provide varieties of products [3]. This situation has been triggering the modern customers to demand a variety of products in different volumes [4]. This situation has been forcing the manufacturing organisations to spontaneously adopt a manufacturing paradigm for meeting the dynamic demands of the customers. This kind of manufacturing paradigm is today addressed by the researchers and practitioners under the title 'agile manufacturing' (AM) [5]. AM is defined as the ability of an organisation to produce a variety of products within a short period of time in a cost effective manner. A typical AM paradigm blends both management and technology. Though significant number of researches on AM are reported in literature, AM is yet to make an in-road into many traditional manufacturing companies [6]. Furthermore, an overview on AM literature indicates that management-oriented AM research has taken place more in number when compared to technology-oriented AM research [7]. These companies also do not realise the power of integrating AM as well as design engineering for sustaining the global competition. Also, these companies have not been exploiting advanced technologies like computer-aided design (CAD), computer-aided manufacturing (CAM), rapid prototyping (RP) and rapid tooling (RT) [3, 7]. In this context, the first author of this paper conducts a research to investigate the task of implementing AM paradigm in traditional manufacturing companies by adopting digitally programmable technologies like CAD, CAM and RP. The major outcome of this research was the development of a model named Total Agile Design System (TADS) [8].

Subsequently, an implementation study was carried out to investigate the practical feasibility of this model. The experiences of conducting this implementation study revealed that TADS could be implemented smoothly in typical traditional manufacturing organisations. However, its successful implementation shall result in the acquirement of higher quantum and quality of agility characteristics. Agility refers to the ability of an organisation to quickly respond to the customers' dynamic demands without compromising on quality, productivity and cost [4]. Given the conditions prevailing in globalised scenario, the measure of agility would indicate a firm's organisational excellence. In this background, this paper reports a fag end of this research in which the organisational excellence of the traditional manufacturing company in which the implementation study of TADS was conducted using a parameter called 'agility index'. Using this parameter, the organisational excellence of this traditional manufacturing company was foreseen. A parameter named 'agility index' has been used to determine the agility level of organisations. Agility index has been determined before and after the implementation of TADS model. Besides, various proposals for enabling this typical traditional manufacturing company to become an agile enterprise also have been suggested and validated. The experiences of conducting this part of the major research are presented in the following sections of this paper. First, the literature survey conducted to review the research status of measuring agility is reported. Next, the features of TADS model are described. Followed by that, the model used to measure agility index is presented. Subsequently, the efforts are made to utilise this model for measuring organisational excellence before and after the implementation of TADS. Furthermore, the proposals drawn using this model and the activities carried out to validate these are appraised.

2 Literature review

The origin of AM research was marked by the institutionalisation of agility forum at Iacocca Institute, Lehigh University, USA in the year 1990 [9]. Thereafter, a considerable number of researchers have dealt with various issues of AM [10]. Majority of them have been contributing toward the elements that build AM paradigm. Despite this kind of significant progress, very few researchers have contributed models for measuring agility. During this research, after searching two major databases, namely, Emeraldinsight (www.emeraldinsight.com) and Sciencedirect (www.sciencedirect.com), only six papers reporting the researches on measuring agility were found. Their contributions are appraised in this section.

Kumar and Motwani [11] have proposed a model for measuring agility. They have proposed a measure called agility index, which reveals the strategic agile position of an organisation. They have divided the time segments into five categories, and based on this decision, they propose to assign agility weights. Finally, they have proposed a mathematical formula for computing agility index. However, they admit that this mathematical formula has not been validated.

Sharifi and Zhang [12] have contributed a scoring model for determining the agility need level. Their questionnaire was sent to around 1,000 companies. They have shown that the awareness on the agility was 2.8 out of 5. Using this model, it is possible to identify the areas that are either strongly or weakly practiced by an organisation to achieve agility. Zhang and Sharifi [13] have contributed two tools that are encapsulated in a model called agility assessment. While the first tool determines whether a company is required to implement AM programme or not, the second tool assesses the agility level. Following this, the neural network is also proposed to determine the required agile capabilities and providers. The questionnaires containing these models were sent to around 1,000 companies. Furthermore, this model was applied in 12 companies, and its outputs were compared with the performances of those companies. Thus, this model was practically validated.

Yang and Li [14] have proposed a procedure to assess agility using fuzzy logic approach. They have identified the ranges in a scale of 2–10 to indicate whether the company is agile or not. Like Kumar and Motwani [11], Lin et al. [15] have proposed the concept called agility index to measure agility. For this purpose, they have proposed a framework to measure agility using fuzzy logic approach.

Arteta and Giachetti [16] have contributed a methodology to measure agility. They have concentrated mainly on the changes taken to modify the existing system and the system followed to change the existing practices for attaining agility. In the conclusion, they have stated that the model proposed by them fails to identify the potential changes that the company should adopt in order to achieve agility. They have claimed that all other models suffer from this deficiency. However, this claim is not valid, as Zhang and Sharifi [13] have proposed a gap analysis, which is structured to identify the changes that the company should implement.

The review of the above papers revealed certain interesting facts about the researches on measuring agility. Since the characteristics of agility are numerous, it is advisable to group them under different categories while measuring agility in organisations. The current researchers are in the pursuit of applying modern software-oriented approaches, namely, neural network and fuzzy logic for measuring agility in organisations. However, it is not clear whether these principles are simple enough to provide the quantified value of agility. It appears that the scoring approach for quantifying agility would be a feasible proposition. This is indicated by the research reported by

Zhang and Sharifi [13]. A striking feature observed in these researches is that the agile characteristics used to develop the models reported by them have not been well supported by the literature references. In this background, we decided to follow a scoring approach, but to choose a model on AM whose characteristics are supported by the researches conducted in this direction. Hence, a search to identify a paper reporting the characteristics of AM supported by the literature references was carried out. This search resulted in the identification of 20 criteria agile model reported by Devadasan et al. [17] and Ramesh and Devadasan [18]. In this model, all the 20 agile criteria are supported by the literature references.

3 Total agile design system

The results of the literature review on AM revealed that there has been no model specifically brought out for aiding an organisation to acquire agility through the adoption of technologies. In this context, TADS has been designed in the research project being reported here. The features of the TADS model designed during this major research are shown in Fig. 1 [8].

As shown, the customers' varied requirements as well as their proactive anticipations are received from different geographical locations via any electronic media. Those customers' requirements could be vague in nature. These vague requirements need to be translated into design requirements using 'data technology'. In the literature, it has been cited that the popular customer voice translation technique called quality function deployment (QFD) used in total quality management (TQM) field could also be employed for this purpose [19]. Once the design requirements have been finalised, then by making use of CAD software packages, the design engineers can derive digital designs of the customers' aspirations. Before analysing the manufacturing feasibility of the digital designs, scientific analyses (if found necessary) need to be carried out. This phase is termed as CAD/CAM interfacing. This is followed by analysing the manufacturing feasibility of the developed designs using appropriate CAM software packages. After performing the scientific simulation, the manufacturing phase could be initiated. Alternatively, for short-run production, RP and RT technologies could also be utilised. Various RP and RT technologies are exclusively available for performing design visualisation, functional testing as well as for rapid product development. The production in the AM environment is termed as agile customised production or agile customisation as the production process needs to be customised according to the dynamic requirements of the customers.

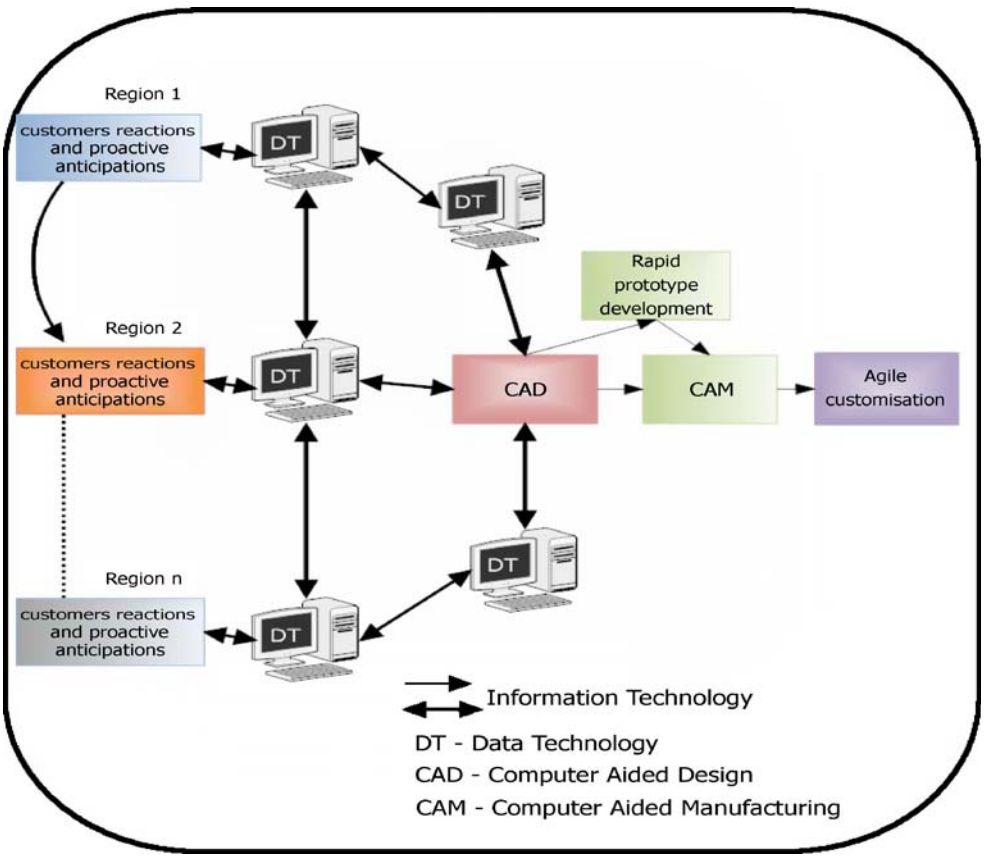

Fig. 1 Total agile design system

4 Agility index measurement

In order to measure 'agility index', an agile quantification tool developed in a previous research project was adopted. This agile quantification tool has its root on the 20 criteria agile model reported in Devadasan et al. [17]. This agile quantification tool is encompassed with a questionnaire to assess the agility level from the perspective of 20 agile criteria. These 20 criteria have been grouped into five agile enablers. During this research, the grouping of agile criteria into these agile enablers was re-examined and then subsequently reorganised to overcome certain deficiencies. Such refined agility enablers and agile criteria are presented in Table 1.

This agile quantification tool determines the agility level of an organisation on a 1,000 score scale similar to the one adopted in Malcolm Baldrige National Quality Award. This tool facilitates the apportionment of scores among the five agile enablers. This apportionment is shown in Fig. 2. As shown, the 'management responsibility' enabler has been assigned the maximum score of 500. This is due to the reason that without the support of top management, new techniques/tools as well as new changes could not be implemented [3]. Thereafter, a company incorporated with agility enablers except management responsibility cannot score more than 500, which is a mark to indicate the AM ability.

The total score of 1,000 is also distributed among the 20 agile criteria. This distribution is shown in Table 2.

During this research, questionnaire-based approach was followed because questionnaire based approach is viewed favourably by authors like Dorabji et al. [20], Chieh-Wen et al. [21] and Anantatmula and Shivraj Kanungo [22]. As mentioned earlier, agile measurement tool is incorporated with questionnaires to measure agility from the context of 20 agile criteria.

As a sample, the questionnaire pertaining to the criterion 'status of quality' is shown in Fig. 3.

As shown, this questionnaire enables the responder to indicate that the agility level forms the point of view of 'status of quality'. After the responder completes the questionnaire, a score allotment table has to be refereed for converting the responses into scores. Such table used for assessing the scores pertaining to 'status of quality' agile criterion is shown in Table 3.

After the scores against all agile criteria are calculated, the agility index is computed using the following formula:

$$\text{Agility index} = \frac{\text{Total score}}{1,000}$$

If an organisation is scoring less than 500, then it is not a suitable candidate to become an agile enterprise, whereas an organisation scoring more than 500 is a suitable candidate to become an agile enterprise.

5 Background about the company and market dynamism

The implementation study on measuring organisational excellence before and after TADS implementation using agility index was carried out in Salzer Electronics Limited (hereafter referred to as Salzer). Salzer is located in Coimbatore city of India and was started in the year 1986 with the collaboration of Saelzer Scaltgeratefabrik, Germany. Salzer's products are sold in 45 countries. The products manufactured by Salzer include cam-operated rotary switches, modular switches, and relays. In this research project, the cam-operated rotary switch has been considered. As the name implies, the cam-operated rotary switch is incorporated with a cam mechanism to allow different and desired sequence of operations. The operations carried out by the switch are making and breaking the power circuits and diverting the power line to auxiliary circuits. The design of the switch is so flexible that according to the customers' varied requirements of operating sequence, the cam can be positioned and the required operations pertaining to each switch can be made.

Currently, Salzer faces little competition from 38 prominent competitors. Since modern electronic gadgets are fast spreading across India, very soon, Salzer is going to face competition from competitors. There is likelihood that these competitors will invade markets by bringing out new models of switches. Before this kind of invasion occurs in the market,

Table 1 Agility enablers and their criteria

Agility enabler	Agile criteria
1.Management responsibility enabler	Organisational structure, devolution of authority, nature of management
2.Manufacturing management enabler	Customer response adoption, change in business and technical processes and outsourcing
3.Employee enabler	Employee status and employee involvement
4.Technology enabler	Manufacturing set-ups, product life cycle, product service, design improvement, production methodology, manufacturing planning, automation type and information technology integration
5.Manufacturing strategy enabler	Status of quality, status of productivity, cost management and time management.

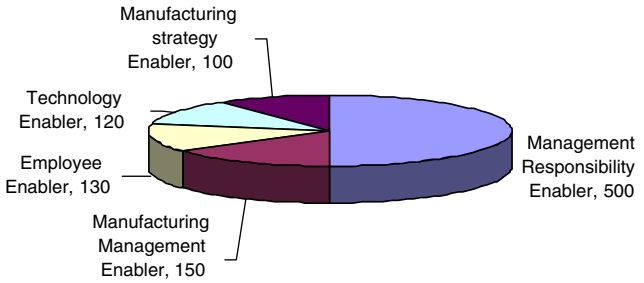

Fig. 2 Distribution of scores among the five agility enablers

Salzer must make efforts to produce new models of switches. However, such kind of efforts by adopting AM principles is not currently being practiced at Salzer. Hence, currently, Salzer possesses very little capability in facing market dynamism in the form of evolving new switches in an agile manner.

6 Agility index measurement before TADS implementation

This implementation study began by measuring agility index before TADS implementation at Salzer. To start with, the TADS team members were explained about the features of agile quantification tool. After that, the questionnaires pertaining to all 20 criteria were given to them. The TADS team members respond to the questions in consultation with the first author.

After the TADS team members completed the questionnaire, their responses were converted into scores. The mean scores calculated by referring to the responses of the TADS team members against the corresponding agile criterion are shown in Table 4. Finally, the total score was obtained. As shown in Table 4, the total score was 846, and hence, the agility index before TADS implementation was 0.846 (that is, 846/1,000). The agility index measured is found to be 0.846.

7 Implementation study of TADS

The TADS implementation study carried out at Salzer is briefly explained as follows. First, the customers' voices were translated into product design requirements using a technique named as agile innovative total QFD. This technique has been encompassed with quality, innovation, and agility principles. Then, the existing switches as well as the new customer requirements were digitalised using CAD package to generate the digital designs. This led to the generation of CAD models of existing and new switches. In the CAD/CAM interfacing phase, mould analysis as well as finite element mould analysis were carried out to analyse the part designs and existing mould designs as well as to generate new mould designs. The CAM phase was then initiated where the NC codes required for manufacturing the dies have been generated. Four types of cam-operated rotary switches are manufactured at Salzer. They are known as S, TP, RT, and PS types. During this research, prototypes of certain components of 'S' type switch (hereafter referred to as switch) were made using 3D printer. These prototypes were tested for functionality in a virtual environment. Finally, an agile customisation programme was designed and developed, which would allow the customers to select the product variety according to their likeness and aspirations.

8 Agility index measurement after the implementation of TADS

After computing agility index before TADS implementation, the activities for determining the agility index after the anticipated TADS implementation were carried out. For this purpose, the TADS team members were requested to foresee the performance of Salzer from the point of 20 agile criteria after the implementation of TADS. Subsequently, the questionnaires of agile quantification tool were

Table 2 Distribution of scores among the agile criteria

Criterion number	Criterion	Marks
1	Organisational Structure	50
2	Devolution of authority	150
3	Manufacturing set-ups	10
4	Status of quality	50
5	Status of productivity	10
6	Employees' status	30
7	Employee involvement	100
8	Nature of management	300
9	Customer response adoption	100
10	Product life cycle	20
11	Product service life	10
12	Design improvement	20
13	Production methodology	10
14	Manufacturing planning	10
15	Cost management	20
16	Automation type	20
17	Information Technology integration	25
18	Change in business and technical processes	25
19	Time management	20
20	Outsourcing	20
Total score		1,000

Fig. 3 Questionnaire pertaining to 'status of quality' criterion

4. STATUS OF QUALITY

Agile enterprises need to be quality conscious. Quality is exceeding the expectations of customers. It means all the processes in the firm should be customer centric. Each activity should assist in adding value to the customer. There must be a culture of total quality throughout the business. The role of quality control is to audit quality and feedback long term process control information. Every fault found must be seen as an opportunity to improve the quality of the product, the basis of blame free quality control.

1. Do you believe that your products exceed the expectations of your customers?
   a. Yes [ ] b. No [ ]
2. Do you keep looking for new ideas that can be incorporated in your products?
   a. Yes [ ] b. No [ ]
3. Are you conducting survey/ studies to improve the status of quality?
   a. Yes [ ] b. No [ ]
4. Is at every stage, the quality characteristics ensured?
   a. Yes [ ] b. No [ ]
5. Do the operators have the authority to "stop the line" in case of detecting quality problems?
   a. Yes [ ] b. No [ ]
6. What is the minimum quantity to be produced with the highest quality level if customer wants a new product?
   a. Below 10 [ ] b. Between 10 and 100 [ ] c. Above 100 [ ]
7. Are TQM (Total Quality Management. tools like bar charts, Kaizen etc. used?
   a. Yes [ ] b. No [ ]
8. Is quality improvement done at the expense of productivity?
   a. Yes [ ] b. in some cases [ ] c. No [ ]

given to the TADS team members. Subsequently, their responses were used to calculate the scores against each agile criterion as well as the total score. As shown, the total score after implementation of TADS is 944.5. Therefore, the agility index is 0.9445. As shown in Table 4, the percentage improvement in agility as a result of TADS implementation against all agile criteria was computed. The results of this computation are shown in the last column of Table 4.

As shown, the percentage improvement in agility is to be highest in the case of cost management criterion (75%), whereas it is expected to be lowest in the case of time management criterion (5%). The overall improvement in agility is expected to be 10.4%

Table 3 Score allotment table pertaining to 'status of quality' criterion

criterion number	Criteria	Question number	a	b	c
4	Status of Quality Score : [/50]	1	5	0	–
		2	5	0	–
		3	5	0	–
		4	5	0	–
		5	10	0	–
		6	10	5	0
		7	5	0	–
		8	0	3	5

9 Drag factors and proposals

As presented in the previous section, the AI before TADS implementation is found to be 0.846, whereas it is 0.945 after its implementation. Besides determining AI, various drag factors that prevent the achievement of agility has been identified. Also, the various proposals for suppressing drag factors have been proposed. An excerpt of the proposals drawn against the agile criterion 'status of quality' is shown in Table 5.

An important consideration is that, when an organisation implements all these proposals, then the organisation can become agile enterprise with significant improvement in agility level.

Also to validate the suggested proposals, the team members were asked to indicate their responses against the drag factors as well as the proposals suggested against the drag factors.

These proposals may be used to further strengthen the implementation of TADS so as to speed up the Salzer's

Table 4 Comparison of the scores before and after TADS implementation

Criterion number	Agile criterion	Score before TADS implementation	Score after TADS implementation	% improvement in agility (criterion wise)
1	Organisational structure (50)	46.8	50	6.4%
2	Devolution of authority (150)	100	125	20%
3	Manufacturing set-ups (10)	7	9.5	26.3%
4	Status of quality (50)	43	43	–
5	Status of productivity (10)	8	9	11.11%
6	Employee status (30)	20	29	31.03%
7	Employee involvement (100)	100	100	–
8	Nature of management (300)	300	300	–
9	Customer response adoption (100)	85	85	–
10	Product life cycle (20)	19.5	19.5	–
11	Product service (10)	4.2	9.5	55.8%
12	Design improvement (20)	19	20	5%
13	Production methodology (10)	3	7.5	60%
14	Manufacturing planning (10)	5.6	10	44%
15	Cost management (20)	5	20	75%
16	Automation type (20)	7	18	61.11%
17	Information technology integration (25)	20	25	20%
18	Change in business and technical processes (25)	23	25	8%
19	Time management (20)	19	20	5%
20	Outsourcing (20)	11	19.5	43.6%
	Total score	846.1	944.5	10.4%

journey towards the acquirement of agile characteristics. A unique feature of the estimation and analyses carried out in this module of research is that they are free from assumptions and complicated mathematical calculations.

10 Validation of agility index measurement

After the end of conducting implementation studies on TADS, its overall performance with that of the existing practice was compared by gathering the reactions of the team members. This research was conducted out of curiosity of the authors. Hence, actual implementation of TADS could not be carried out. Therefore, the executives were asked to foresee the possibility of implementing TADS at Salzer. Thus, the agility index after implementation of TADS at Salzer is only a projected value. A comparative table for gathering the performance of TADS from the point of agility performance measures was developed [23]. A session was conducted to gather the data by supplying this comparative table to the team members. The photograph shot during this session is shown in Fig. 4. The consolidated data gathered at the end of this session are shown in Table 6. As shown, the performance of TADS from agility point of view is expected to increase from the value of 6.7–9.5 (in a Likert's scale of range 0–10). This increase in value nearly corroborates the outcome of agility index measurement. Therefore, use of agility index value as a measure of organisational excellence of a company by implementing TADS model is validated.

11 Statistical validation and reliability analysis

In order to conduct a detailed statistical analysis of the feedback of the executives, their responses were entered in

Table 5 Proposal pertaining to status of quality criterion

Factors that drag agility	Proposals for suppressing drag factors
Minimum number of new units produced when a customer asks for new products is between 10 and 100	Manufacturing procedure shall be developed which can enable the manufacturing of even one unit of a new product (in case of few numbers, even outsourcing can be done with reliable vendors, with testing and marketing done by the company). This practice shall be done with the help of consultants and trainers

Fig. 4 Photograph shot during the feedback session

Software Package for Social Sciences (SPSS). This package was also used to conduct *t* test in order to examine the acceptance of 'Improvement of organisational agility after TADS implementation'. In the first case, the test value assigned was 10, which affirm that "90% of the executives' opinions favoured the successful improvement of organisational agility after TADS implementation in practice at 95% confidence interval." As the Sig (two-tailed) values for some cases are less than 0.05, this null hypothesis was rejected.

In the second case, the null hypothesis was set, as "80% of the executives' opinions favoured the successful improvement of organisational agility after TADS implementation in practice at 95% confidence interval." In this case, the Sig (two-tailed) values are greater than 0.05. Hence, this null hypothesis was accepted. As a sample, the screen displayed by SPSS pertaining to this null hypothesis is shown in Fig. 5.

On the whole, this validation study indicates the feasibility of significant improvement in agility level after the implementation of TADS using the tool presented in this paper in practice with a success rate of 80%.

In order to check that reliability of the questionnaire, SPSS package was used to determine the value of alpha. The purpose of this study was to check whether the questions truly reflected the intention for which they were designed. The data displayed by SPSS in this regard is shown in Fig. 6.

If the correlation value is more than 0.5 for all questions as well as alpha is more than 0.7 for the entire questionnaire, then it should be construed that the questionnaire truly reflects the intention for which it was designed, and thereby it indicates its reliability in drawing inference. As shown in Fig. 6, correlation value is more than 0.5 against all questions, and the alpha value is also more than 0.7. Hence, it reveals that the questionnaire is reliable enough to gather the feedback data and draw inferences with regard to improvement of organisational agility after TADS implementation.

12 Conclusions

In the contemporary market scenario, customers demand varieties of products in varied volumes. This situation indicates the dynamic nature of customers demands. Hence, the modern manufacturing organisations should be capable of reconfiguring their manufacturing system to suit the dynamic customers' demands [5]. This condition necessitates the importance of acquiring agility through the implementation of AM paradigm. The researchers have established that AM encompasses lean manufacturing and flexible manufacturing system concepts. Currently, many organisations have been successfully implementing lean manufacturing strategies like 5S, TQM, total productive maintenance, Kanban, and Kaizen etc. [4]. The missing entity is the flexibility which is required to impart agility in traditional companies. Some sectors like mobile phone manufacturing have shown the signals of acquiring agile characteristics by bringing out numerous varieties of products within a very short span of time [24]. But the situation is not so in the case of traditional manufacturing companies. The traditional companies like

Table 6 Consolidated data on performance measures of TADS

Serial number	Agility performance measures	Current level (before implementing TADS) (please use Likert's scale of range 0–10)	Future level (after implementing TADS) (please use Likert's scale of range 0–10)
1	Responsiveness	7.2	8.7
2	Competency	7.2	8.3
3	Flexibility	6.8	9
4	Quickness	7.3	9.2
5	Re-configurability	7.2	8.7
6	Manufacturing speed	7.5	9.5
7	Information management	7	8.3
8	Innovativeness	7	9
9	Proactivity	6.7	9
10	Market competitiveness	7.2	9.2

	N	Mean	Std. Deviation	Std. Error Mean
A	6	8.00	.894	.365
B	6	8.17	.753	.307
C	6	8.33	.516	.211
D	6	7.83	.753	.307
E	6	8.17	1.169	.477
F	6	8.33	.516	.211
G	6	7.83	.983	.401
H	6	8.00	.894	.365
I	6	8.17	.408	.167
J	6	7.83	.753	.307
K	6	8.50	.548	.224

One-Sample Test

	Test Value = 8					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
A	.000	5	1.000	.00	-.94	.94
B	.542	5	.611	.17	-.62	.96
C	1.581	5	.175	.33	-.21	.88
D	-.542	5	.611	-.17	-.96	.62
E	.349	5	.741	.17	-1.06	1.39
F	1.581	5	.175	.33	-.21	.88
G	-.415	5	.695	-.17	-1.20	.87
H	.000	5	1.000	.00	-.94	.94
I	1.000	5	.363	.17	-.26	.60
J	-.542	5	.611	-.17	-.96	.62
K	2.236	5	.076	.50	-.07	1.07

Fig. 5 Output of the SPSS package pertaining to the statistical analysis

those manufacturing pumps, compressors and machine tools have not been fully utilising advanced technologies like CAD, CAM, RP and RT to configure and reconfigure their systems quickly to meet varied demands of the customers. The core aspect lies in integrating design engineering concepts with AM strategies and also checking the impact of agility by means of an appropriate agile quantification tool. This article has addressed these core issues by contributing a model called TADS, test implementing its practical feasibility and also the method of determining agility level before and after its implementation. The practitioners' opinions are in favour of successful implementation of TADS. The improvement in agility level after the implementation of TADS is found to be approximately 10%. The validation study also indicated the practical feasibility of the agile quantification tool as well as the various proposals suggested for suppressing the drag factors. The improvement in agility will have to be reflected in the form of highly satisfied customers, increase in customer domain and increase in sales volume and profitability. However, these results can be checked only if

Reliability

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****** Method 1 (space saver) will be used for this analysis ******

R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

Item-total Statistics

                Scale Mean if Item Deleted   Scale Variance if Item Deleted   Corrected Item-Total Correlation   Alpha if Item Deleted
A                       81.1667                          28.5667                          .8786                        .8842
B                       81.0000                          32.4000                          .5601                        .9031
C                       80.8333                          33.7667                          .6221                        .9016
D                       81.3333                          31.0667                          .7309                        .8941
E                       81.0000                          27.2000                          .7545                        .8960
F                       80.8333                          32.9667                          .7645                        .8965
G                       81.3333                          28.2667                          .8162                        .8884
H                       81.1667                          29.7667                          .7377                        .8934
I                       81.0000                          35.2000                          .4954                        .9070
J                       81.3333                          35.8667                          .6435                        .9232
K                       80.6667                          31.4667                          .9764                        .8875

Reliability Coefficients

N of Cases =      6.0                    N of Items = 11

Alpha =     .9068
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Fig. 6 Output of the SPSS package pertaining to the reliability analysis

Salzer management actually implements TADS. Hence, at this moment, it is very difficult to correlate 10% improvement in agility with the business results. Due to paucity of time, the agility quantification could be carried out only in one organisation. In future, exclusive researches involving agility quantification could be conducted by gathering appropriate data from many organisations. The results of this quantification could be utilised to improve the accuracy of the agility quantification model contributed in this paper.

References

1. Gunasekaran A, K-h L, Cheng TCE (2008) Responsive supply chain: a competitive strategy in a networked economy. Omega 36 (4):549–564
2. Saisse MCP, Wilding RD (1997) Short-term strategic management in mass customized markets. Logist Inf Manag 10(5):199–207
3. Maskell B (2001) The age of agile manufacturing. Supply Chain Manag: Int J 6(1):5–11
4. Jin-Hai L, Anderson AR, Harrison RT (2003) The evolution of agile manufacturing. Bus Process Manag J 9(2):170–189
5. Brown S, Bessant J (2003) The manufacturing strategy—capabilities links in mass customisation and agile manufacturing—and exploratory study. Int J Oper Prod Manage 23(7):707–730
6. Yusuf YY, Adeleye EO (2002) A comparative study of lean and agile manufacturing with a related survey of current practices in the UK. Int J Prod Res 98:4545–4562
7. Gunasekaran A (1998) Agile manufacturing: enablers and an implementation framework. Int J Prod Res 36(5):1223–1247
8. Vinodh S, Sundararaj G, Devadasan SR, Kuttalingam D, Meenakshi Sundaram PL, Rajanayagam D (2008) Enhancing competitiveness through CAD phase of total agile design system. Int J Process Management and Benchmarking 2(3):197–220
9. Meredith S, Francis D (2000) Journey towards agility: the agile wheel explored. TQM Mag 12(2):137–143
10. Yusuf YY, Sarhadi M, Gunasekaran A (1999) Agile manufacturing: the drivers, concepts and attributes. Int J Prod Econ 62:33–43
11. Kumar A, Motwani J (1995) A methodology for assessing time-based competitive advantage of manufacturing firms. Int J Oper Prod Manage 15(2):36–53
12. Sharifi H, Zhang Z (1999) A methodology for achieving agility in manufacturing organizations: an introduction. Int J Prod Econ 62 (1–2):7–22
13. Zhang Z, Sharifi H (2000) A methodology for achieving agility in manufacturing organizations. Int J Oper Prod Manage 20(4):496–512
14. Yang SL, Li TF (2002) Agility evaluation of mass customisation product manufacturing. J Mater Process Technol 129(1–3):640–644
15. Lin C-T, Chiu H, Tseng Y-H (2006) Agility evaluation using fuzzy logic. Int J Prod Res 101(2):353–368
16. Arteta BM, Giachetti RE (2004) A measure of agility as the complexity of the enterprise system. Robot Comput-Integr Manuf 20(6):495–503
17. Devadasan SR, Goshteeswaran S, Gokulachandran J (2005) Design for quality in agile manufacturing environment through modified orthogonal array-based experimentation. Journal of Manufacturing Technology Management 16(6):576–597
18. Ramesh G, Devadasan SR (2007) Literature review on the agile manufacturing criteria. Journal of Manufacturing Technology Management 18(2):182–201
19. Franceschini F, Rossetto S (1999) Tools and supporting techniques for design quality. Benchmarking: An International Journal 6(3):212–219
20. Dorabjee S, Lumlee CE, Cartwright S (1998) Culture, innovation and successful development of new medicines—an exploratory study of the pharmaceutical industry. Leadersh Organ Dev J 19 (4):199–210
21. Chieh-Wen S, Shen M-J, Chen M-C (2008) Special interest tour preferences and voluntary simplicity lifestyle. International Journal of Culture, Tourism and Hospitality Research 2(4):389–409
22. Anantatmula V, Kanungo S (2006) Structuring the underlying relations among the knowledge management outcomes. J Knowl Manag 10(4):25–42
23. Sherehiy B, Karwowski W, Layer JK (2007) A review of enterprise agility: concepts, frameworks and attributes. Int J Ind Ergon 37:445–460
24. Sigala M (2006) Mass customisation implementation models and customer value in mobile phones services- preliminary findings from Greece. Manag Serv Qual 16(4):395–420