https://doi.org/10.58195/emi.v2i2.72

Global Science Publishing

EMI

Economics & Management Information

https://ojs.sgsci.org/journals/emi

Article

Explicating Enterprise Modelling As a Driver of the Small and Medium-Scale Manufacturing Enterprises' Effective Performance

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Abstract: Enterprise modelling offers a comprehensive organisational configuration that aids holistic diagnosis to identify and correct areas of deficiencies. This often catalyses a manufacturing entity's overall effective performance. In that context, this empirical research explores the iterative enterprise modelling's edifying effects on the small and medium-size manufacturing entities' (SMEs) effective performance. Using an exploratory case study research design, the empirical research evaluated the perceptions of twenty operational IT support personnel from twenty SMEs that are operating in Glasgow's manufacturing sector on their level of enterprise modelling's utilisation as a performance improvement initiative. Even if some of the narratives indicated some of the SMEs that are operating in Glasgow-Scotland to recognise the business values of enterprise modelling, findings still revealed most of the small and medium scale manufacturing entities to only use certain discrete generic operational diagnostic approaches. Such generic operational diagnostic approaches either entailed the use of less technologically-intensive diagnosis of whether a business' performance is aiding the achievement of the desired outcomes or frequent manufacturing equipments' diagnosis to minimise risks of major failures that often require complex technologically supported interventions. The study concludes with a framework that explicates the required critical iterative enterprise modelling processes that can be replicated by the small and medium scale manufacturing entities not only in Glasgow, but also across the world.

Keywords: effective performance; enterprise modelling; small and medium scale manufacturing enterprises

1. Introduction

Enterprise modelling spawns a manufacturing enterprise's effective performance. It offers a visual representation of the interface and relationship between an organisation's architectures of critical activities, resources, processes and assets as well as the interface and relationship between such processes with the organisational personnel (Barone, Eric, Won, Jiang & Mylopoulos 2010:19) [1]. It also provides a configuration of the interface between the functional network manufacturing architecture, information systems architecture, manufacturing equipment architecture, and human resource and organisational architecture. Such a configuration of critical activities and architectures enhances organisational diagnosis and identification and elimination of the areas of operational deficiencies. This unlocks cost and efficiency advantages that spawn a manufacturing enterprise's capabilities to deliver superior value offerings at a cost that sets it apart from rivals.

It is the emergence of such superior advantages that subsequently catalyse a firm's effective market

Received: 16 April 2023; Accepted: 30 April 2023.

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performance (Rizzolo, Kiringa, Pottinger & Wong 2010: 29) [2]. Enterprise modelling creates a holistic organisational architecture that renders it possible for relevant information technologies such as enterprise resource planning systems to be used to improve not only the level of activities' integration, but also process sychronisation. It creates a basis for a manufacturing enterprise to analyse and re-engineer its critical business processes to spawn the overall level of process synchronisation. All these signify enterprise modelling unlocks cost, efficiency and quality management advantages that in turn bolster the overall effectiveness of a manufacturing enterprise's overall effective performance (Vinodh & Balaji 2010:22) [3].

However, as most of the studies focus on evaluating the efficacy of enterprise modelling methodologies, limited research on the leveraging effects of enterprise modelling on a manufacturing firm's performance seems to have affected discerning how the small and medium-size manufacturing enterprises can utilise enterprise modelling to spawn their overall operational efficiency. It is in response to such gap that this research explores how enterprise modelling creates a preface for undertaking relevant enterprise diagnosis and improvement initiatives that leverage the small and medium-size manufacturing enterprises' (SMEs) effective operational performance. As some of the SMEs in the manufacturing sector continue to struggle to operate more sustainably, such a study is certainly of significant importance for explicating how enterprise modelling can also be adopted as one of the SMEs' performances improve prerequisite.

2. Enterprise Modelling

Enterprise modelling is increasingly emerging as pivotal in most quests for leveraging operational efficiency to create enormous differential values that set businesses apart from rivals. It aids the understanding of the complexities of an organisation's structure as well as their inter-relationships and dependencies (Agyapong, Marzanoa & Ratchev 2012: 543) [4]. This enhances organisational diagnosis to determine the operational transformational initiatives that can be undertaken to turnaround an organisation's operational effectiveness. Besides offering a foundation for business process re-engineering, enterprise modelling also enhances business impact analysis and risk analysis to determine the areas where the business is more vulnerable to threats. It spurs business continuity analysis by enabling the analysis of how a firm's strategy is supported by its internal architecture (Srinoi, Shayan & Ghotb 2006:2183) [5].

Enterprise modelling also enhances business process mapping to discern the extent to which the overall efficiency of activities' flows a long a firm's value chains catalyse the achievement of a business' credo. Business process mapping often offers the foundation for business process re-engineering as well as value chain analysis. It also bolsters the effectiveness of business process management, process simulation and process change and transformation to improve the compatibility of a firm's processes with its strategies. The growing emphasis of the importance of enterprise modelling is derived from the increasing integration of information systems in organisational operations.

As businesses increasingly adopt information systems, enterprise modelling is critical for discerning how information technology can be utilised to leverage a business' overall operational efficiency (Teece 2010:172) [6]. These quests for leveraging operational efficiency are accompanied by the growing need for quality management as a strategy for spawning customer satisfaction and a firm's competitiveness. Yet, as most enterprises continue to expand and grow, the emerging complexities of their structures are also rendering enterprise modelling critical for improving activities' integration and synchronisation of processes between different divisions, functional departments and units.

Enterprise modelling often constitutes of five main processes that encompass the identification of the business area to be modelled, designation of the problem that enterprise modelling seeks to solve, identification of the business assumptions and rules, creation of the meta-model, and integration of the architecture (Giannoulis, Zikra, Bergholtz, Zdravkovic, Stirna & Johannesson 2016: 5) [7]. Enterprise modelling methodologies may tend to vary according to the organisational area to be modelled.

However, to undertake a comprehensive enterprise modelling, Figure 1 implies most of the businesses often apply methodologies such as the IDEFO (Integration Definition) or the Dependency structure Matrix (DSM). Constituting of several methodologies that range from IDEFO to IDEFO14 that are used for modelling different

aspects of an enterprise, IDEFO is often utilised for modelling an enterprise's decisions, actions and activities. It maps and offers a graphical representation of an enterprise's manufacturing and operational activities.

While seeking to model an enterprise's operational activities, IDEFO configures, maps and recreates a system overview of the synergy and linkage of activities' flow according to inputs, controls, outputs and mechanisms (Franke, Charoy & El Khoury 2013: 33) [8]. Inputs are resources such as manufacturing information, raw materials as well as skills and knowledge that are transformed through different operational activities into outputs.

Controls are variables that describe why and how certain functions are performed in certain ways. These controls often constitute of customer orders, business strategy, design requirements, delivery schedules, quality specifications, cost control mechanisms and business policies and procedures (Franke et al. 2013:33) [8]. These control points often constrain, trigger or regulate the process of different activities' accomplishment. Controls measure the extent to which the process for the accomplishment of different activities are aiding a business achieve its business credo which is to deliver superior performance.

Outputs are the results of the process of the accomplishment of different activities. These results are often reflected in the final product or service as well as how such products or services conform to different quality specifications. Mechanisms constitute of the resources such as technology, machines, software, human resources and equipments that are used in the accomplishment of different business activities (Chiara, Kump & Lindstaed 2010: 19) [9]. As Figure 1 illustrates, IDEFO is a top-down diagramming technique that decomposes a system overview of the business to specific details to illustrate how different subsystems work. This aids the analysis and improvement of how the synergy and linkage between different subsystems and functions spawn the overall operational efficiency.

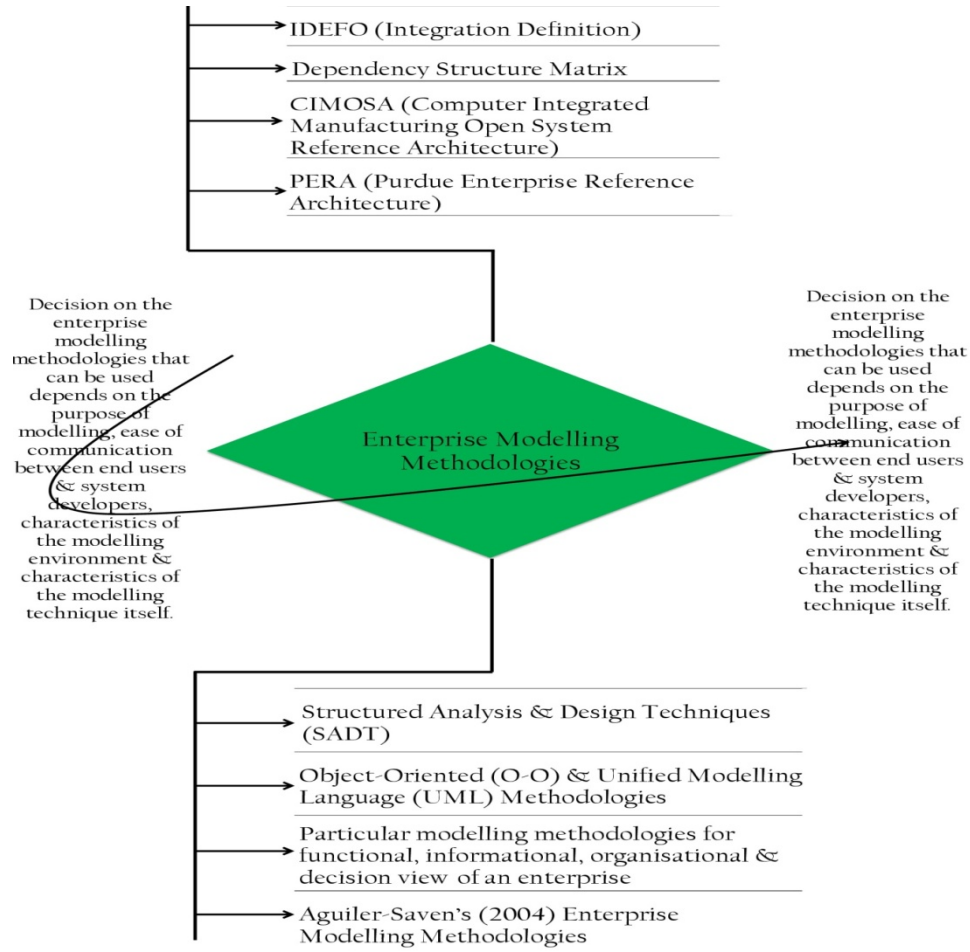

Figure 1. A typology of enterprise modelling methodologies. Source: researcher's own construct.

If used in conjunction with Stewart's (1981) Dependency Structure Matrix [10], IDEFO can also spawn process synchronisation as well as activities' integration to bolster the overall efficiency of the activities' coordination. Improved activities' coordination spawns a firm's overall level of operational efficiency. This is attributable to the fact that Dependency Structure Matrix aids logical analysis of the systematic flow of tasks by evaluating the interface between business tasks and functions that arise from the exchange between inputs and outputs.

DSM, a system analysis as well as a project management technique accomplishes this by analysis the information flow in a particular system or process to identify the dependencies between tasks and to sequence different processes (Chiara et al. 2010: 19) [9]. As it analyses task relations and dependencies, it aids identification of mismatches and operational glitches that often constrain operational efficiency. This enhances the creation of new processes to leverage a firm's overall effective performance.

If the use of any DSM or IDEFO methodologies seems not suitable to induce the achievement of the outcomes that a business is seeking to achieve, it could opt to apply any of Shen's (2004) enterprise modelling frameworks [11], general system modelling methodologies or particular modelling methodologies for individual views. Enterprise modelling methodologies constitute of the techniques that aim to undertake thorough system analysis and design for the whole life cycle of the system. Such techniques encompass CIMOSA (Computer Integrated Manufacturing Open System Reference Architecture) and PERA (Purdue Enterprise Reference Architecture) (Panetto & Cecil 2013:5) [12].

Based on the system life cycle concept and relevant supportive modelling language, methodology and technology, CIMOSA often aims to facilitate the integration of machines, computers and people. PERA is used for generating a configuration of different enterprise architectures and the interface between such architectures (Turk & Mohamad 2011: 19) [13]. In a manufacturing enterprise, such architectures often constitute of the functional network manufacturing architecture, information architecture, information systems architecture, manufacturing equipments architecture, and human resource and organisational architecture.

The process for the integration of different enterprise architectures commences with the analysis of the potential benefits and costs for the business to undergo the proposed enterprise integration programmes(Jardim-Gonçalves & Grilo 2013:5) [14]. If costs arising from the disruption of the operational performance outweigh benefits, then, enterprise modelling is not worth undertaking. Such analysis must be accompanied by the evaluation of how enterprise modelling would bolster the capabilities of the business to achieve its mission, vision and values. It must also assess the extent to which the results of enterprise modelling would induce values that are compatible with the operational philosophies and mandates of the enterprise.

General system modelling methodologies comprise of structured methodologies like Structured Analysis and Design Techniques (SADT) and Object-Oriented (O-O) methodologies such as Unified Modelling Language (UML) (Jardim-Gonçalves & Grilo 2013:5) [14]. Whereas SADT aids analysis and description of the functions and relationships between different tasks, O-O and UML apply certain notations and semantics to leverage the overall effectiveness of an enterprise's software development. However, due to its complexities, UML is often more difficult for users to easily understand and use. In effect, UML is not suitable for conceptual modelling or end user requirement gathering. Particular modelling methods for individual views offer the functional, informational, and organisational and decision view of an enterprise (Ulmer, Belaud & Le Lann 2013:61) [15].

This enhances the determining of the modelling techniques that can be used. In contrast, Aguiler-Saven (2004) classifies enterprise modelling techniques according to the purpose of the model and the model change permissiveness [16]. The purpose of the model may be descriptive, learning, decision support for process design, decision support for process execution and IT enactment support. Model permissiveness explores the level of active or passive degree of permissiveness that modelling techniques may permit. Whereas active modelling permits change and modifications, passive modelling does not allow change and modifications without remodelling the process. Even though, most enterprise modelling methodologies often cause advantages that spawn a firm's overall operational efficiency, the enterprise model methodology that an enterprise adopts may tend to vary according to the type of modelling initiative that a business aims to accomplish (Hachani,

Gzara & Verjus 2013:79) [17].

In effect, the selection of the appropriate enterprise modelling methodologies that can be used may depend on the purpose of modelling, the ease of communication between end users and system developers, the characteristics of modelling environment as well as the characteristics of the modelling technique itself. Enterprise modelling spawns enterprise integration and interoperability. Enterprise integration refers to the unification of the enterprise through the development of coherently linked and coordinated interfaces of different architectures (Hachani et al. 2013: 79) [17]. Enterprise interoperability connotes the co-existence of relatively autonomous and federated environments that influence the coherent accomplishment of different business activities to achieve the desired strategic business outcomes.

Enterprise integration can be achieved at three levels that encompass physical integration, application integration and business integration. Physical integration facilitates the unification and interconnection of devices, equipment and machines via a computer network (Fitkov 2010:3) [18]. Application integration aids the interoperability of software applications and database systems in heterogeneous computing environments. Business integration enhances the coordination of functions that manage, control and monitor business processes. All these induce efficiency and cost advantages that in turn spawn a manufacturing firm's overall cost competitiveness as well as enormous points-of-difference resulting superior operational efficiency.

However, as most of the studies focus on evaluating the efficacy of enterprise modelling methodologies, this research seeks to fill that gap by exploring how enterprise modelling creates a preface for undertaking relevant enterprise diagnosis and improvement initiatives that leverage the small and medium-size manufacturing enterprises' (SMEs) effective operational performance.

3. Research Problem

Limited research on the leveraging effects of enterprise modelling on a manufacturing firm's performance seems to have affected discerning how the small and medium-size manufacturing enterprises can utilise enterprise modelling to spawn their overall operational efficiency.

4. Research Purpose

The purpose of this research is to explore how enterprise modelling creates a preface for undertaking relevant improvement initiatives that leverage the small and medium-size manufacturing enterprises' (SMEs) operational performance.

5. Methodology

Besides noting that this research uses a case study research design, this section also offers insights on the techniques for sampling, data collection and analysis as well as the measures for enhancing validity and reliability that were used in the study(Cohen, Manion & Morrison 2011:19) [19].

5.1. Research Design

To explore the leveraging effects of enterprise modelling on the operational performance of the small and medium-size manufacturing enterprises, the study used a case study research design and a qualitative-interpretivist research paradigm. A case study research design connotes a research approach where the study is based only a few a sample from which necessary generalisations are drawn about the phenomenon being researched (Wynn & Williams 2012:787) [20].

Considering that enterprise modelling is not widely undertaken by most of the small and medium-size manufacturing enterprises, the use of a case study research design was critical for undertaking thorough analysis of only a selected few small and medium-size manufacturing enterprises to draw conclusions that can be generalised on how enterprise modelling can be utilised to bolster their operational performance of the small and medium-size manufacturing enterprises.

On the otherhand, the use of a qualitative-interpretivist research paradigm was critical for eliciting in-depth

information from the participants from which a theory would be extracted to illustrate the leveraging effects of enterprise modelling on the operational performance of the small and medium-size manufacturing enterprises. To accomplish this, the study used purposive sampling to identify the criteria that would be used for drawing each business from the larger target population that constitutes of the small and medium-size manufacturing enterprises into a sample of 20 small and medium-size manufacturing enterprises that are operating in Glasgow-Scotland (Chen, Shek & Bu 2011:129) [21].

5.2. Sampling

Even if the term enterprise modelling was not evident, some evidence of business process review and modelling, asset, resource, information system or structural modelling was considered a critical criterion for inclusion in the study. In addition to displaying some evidence of enterprise modelling, the sample small and medium-size manufacturing enterprises were also expected to have relatively larger scale of operations that not only span across three sub regions, but also that employs about 500 personnel with a net turnover of about 5 million pounds and above per annum.

To ascertain compliance with such criteria, thorough review of the websites, archives, operational strategies, financial statements and annual reports of the selected small and medium-size manufacturing enterprises were undertaken in conjunction with brief interviews of the selected employees and personal references and contacts. From these selected 20 small and medium-size manufacturing enterprises, purposive sampling was further used to draw only the operational managers or IT personnel into the sample population of about 20 participants.

The operational managers or IT personnel were selected due to the fact that by the nature of their work, they were in the position to understand and explain how enterprise modelling works as well as how it leverages a manufacturing enterprise's operational performance. The implications were that 12 operational managers from 12 enterprises and 8 IT personnel from 8 manufacturing enterprises that are operating Glasgow-Scotland were accepted to participate in the study.

5.3. Data Collection

Qualitative data from these 20 sample participants was collected using open-ended interviews that were accomplished using face-to-face interviews, e-mails or telephone interviews (Bryman & Bell 2007: 19) [22]. Each of the 20 sample participants was asked to provide an overview of the enterprise modelling initiative that has ever been undertaken in their manufacturing entities. This was followed by the probe of the types of enterprise modelling initiatives that have been undertaken as well as the reasons why they prefer to undertake such enterprise modelling initiatives.

If not, the participants were also asked to elaborate on why as well as on the alternative approaches that they usually use when faced with performance related challenges. The participants were also asked to provide detailed descriptions of the enterprise modelling methodologies that they have ever used as well as how enterprise modelling leverages the operational performance of the manufacturing enterprise.

In this analysis, each of the participants were also asked to comment on whether there is a particular type of enterprise modelling or methodology that impacts directly on leveraging operational performance as compared to others. Such a question was accompanied by the eliciting the views of the participants on the common constraints that are often experienced when using enterprise modelling methodology to bolster operational performance.

5.4. Data Analysis

The obtained qualitative interview data was analysed using inductive-thematic approach. As contrasted to the deductive approach that relies on a predefined framework to extract relevant themes and subthemes, the application of the inductive-thematic approach requires reading and familiarisation with the collected data. This enables discerning how each participant's explanation as well as the emerging themes and subthemes offer coherent description of the phenomenon being researched. To accomplish this, the study used Fetterman's

(2009) Three Stages' Framework to identify, define and interpret the emerging relevant key concepts like operational efficiency, cost management and quality management [23]. This was accompanied by mapping and creating a typology of such relevant key concepts and subthemes, as well as creating and extracting a thematic framework to discern how the results of the analysis offer coherent explanations of the leveraging effects of enterprise modelling on the small and medium-size manufacturing enterprise's operational performance.

5.5. Validity and Reliability

As the study was being undertaken, measures for enhancing validity and reliability were also undertaken to improve the overall credibility, dependability and transferability of the study (Babbie & Mouton 2008:10) [24]. To accomplish this, the study was based only on the opinions of the operational personnel or IT personnel that have clear understanding of how enterprise modelling works as well as how it influences operational performance. This not only improved the credibility and dependability of the study, but also transferability of the study on the basis that if this study was to be undertaken again, similar findings would still be obtained.

The other measures for improving validity and reliability of the study entailed comparing and contrasting the opinions of different participants on the same concept to test and improve the overall veracity of the findings. During the presentation of findings, these were followed by insertion of verbatim quotes from the participants to avoid distorting the opinions that the participants could have aimed at conveying. Besides constant fact checking with relevant experts and audit trail, triangulation of the interview findings with the theories was also undertaken to discern whether interview findings are confirmed or disputed in different theories. The obtained findings were as presented and discussed in the sections that follow.

6. Findings

As some of the small and medium scale manufacturing entities were found to engage in generic simple routinal operational diagnosis which are frequently undertaken to create and maintain more efficient operational systems to minimise risks of major failures that require complex technologically supported interventions, others were found to instead undertake frequent complex diagonal-operational diagnosis to unlock cost and efficiency advantages to spawn continuity of a firm's effective market performance. Such a finding resulted from the extraction of two concepts that included:

6. Generic Operational Diagnosis
7. Complex Diagonal-Operational Diagnosis

The details of the findings are as follows.

6.1. Generic Operational Diagnosis

Instead of using enterprise modelling methodologies to undertake relevant holistic organisational diagnosis, most narratives indicated most small and medium scale manufacturing entities to only use certain discrete generic operational diagnostic approaches. Such generic operational diagnostic approaches either entailed the use of less technologically-intensive diagnosis of whether a business' performance is aiding the achievement of the desired outcomes or frequent manufacturing equipments' diagnosis to minimise risks of major failures that often require complex technologically supported interventions.

6.1.1. Outcomes' Diagnosis

Quests of most of the small and medium scale manufacturing enterprises to analyse the state of their performance and discern whether the desired outcomes are being achieved were reiterated to not to entail the use of any complex structural or process modelling methodologies. Instead, most narratives indicated only the use of certain generic simple analysis of whether or not the manufacturing entity was achieving its objectives. In such analysis, some of the operational managers argued that since a business' motives is often to induce the achievement of the desired returns; it is often the results being achieved and not structural or process efficiency that matters.

The implications are latent that in the fact that as the business focuses on evaluating the returns being achieved, attempts are often to discern all the ways of utilising the existing processes, machineries or equipments even if they seem to be deficient to aid the achievement of the desired results. In such situations, findings indicated most small and medium scale manufacturing firms not to recognise the values of enterprise modelling because the attention is often directed on the analysis of the results being achieved and not the structures.

Such a view was mainly evident in most of the responses to the interview question that explored the approach that small and medium scale manufacturing use in the analysis and improvement of process and structural efficiency. In such responses, it was not only evident that the returns of a manufacturing entity are what determine its performance, but also the fact that one of the operational managers explained that:

"Structural and process analysis is usually the last thing if things are not going well. The business is usually focusing on the analysis of sales, revenues as well as profitability and not the processes or the structures."

Even in the event where the returns of the manufacturing entity are not that impressive, findings still indicated enterprise modelling to mainly be undertaken by the businesses that have significantly large scale of operations. In such analysis, some of the operational managers argued that it aids the analysis and understanding of the more complex structures and inter-relationships between different processes. However, for businesses which are not very large, narratives from most of the operational managers indicated such businesses to use some other ways and strategies of diagnosing and improving their performance. In case of declining performance, findings indicated that while using simple IT systems, some of the manufacturing entities tend to engage in less technologically supported evaluations of whether the problem is arising from poor quality control, poor operational management or cost control. If the declining performance is arising from poor market performance that affects sales and revenues, some of the manufacturing enterprises were found to frequently use such simple IT systems to continuously evaluate the unfolding tends and determine the change in the market strategies that can be undertaken.

However, findings indicated such analysis and response to the declining performance to be mainly reactionary after the occurrence of the events. In the context of the performance of the small and medium size manufacturing entities, such approach was found to affect the proactive identification and response to the unfolding trends before they become devastative. Even if reasons for such deficient approach to enterprise modelling was found to emanate from the scale of a business' operations, findings still suggested that it is not only the size of the business that limits the utilisation of relevant enterprise modelling methodologies.

Instead, some of the operational managers reiterated enterprise modelling to be costly. They explained that enterprise modelling do not only require the utilisation of more superior technologies and software, but also expert knowledge and understanding of how it can be applied. All these were found to require funds that most of the small and medium size enterprises often do not possess. As the small and medium scale manufacturers focus on discerning how different competing priorities must be balanced, one of the operational managers argued that they often find investment in enterprise modelling initiatives to be less of a priority.

Most of the businesses were found to often perceive that they can always use other means for assessing and improving the state of their performance. One of such initiatives was highlighted to entail the use of ordinary process analysis that utilise methodologies such as sigma analysis to evaluate the overall efficiency and effectiveness of the operational processes. Such a view was also echoed in the opinions of one of the operational managers who argued that:

"Enterprise modelling is important for undertaking process diagnosis to improve operational efficiency. But it is a luxury because most of the activities that it can accomplish can also be done using other ways that may not necessarily require the use of enterprise modelling."

It is not only such a view that suggested that enterprise modelling is a luxury, but also the other operational managers' narratives that indicated that since thy have not invested in relevant enterprise modelling enhancing systems, they often apply ordinary processes of structural and process analysis. In such analysis, one of the operational managers explained that "if the structure is redundant or overstaffed, one may not require any technology to highlight that there is a problem." He added that "if the problem is poor quality which is arising

from defective machineries and poor quality control, one may still not require any technology to highlight that such area is the problem".

Certainly, there was a strong view in most of the participants' narratives that most of the small and medium scale manufacturing entities tend to find enterprise modelling to perform functions that can easily be accomplished using alternative cheaper non-technologically supported ways. In such analysis, some of the operational managers reiterated that some of their quests for leveraging their operational performance have often not entailed the use of any enterprise modelling systems, but constant investment in more efficient machineries, improvement of supply chain efficiency and the adoption of the appropriate maintenance systems.

In otherwords, it was not only skewed use of more generic outcome based diagnosis in almost all situations that emerged as one of the generic operational diagnosis that which is often undertaken as part of the general initiatives for leveraging the effective performance of the manufacturing plant, but also proactive reliance on equipments' diagnosis and maintenance.

6.1.2. Equipment's Diagnosis

Proactive reliance on equipments' diagnosis and maintenance was evident in most of the findings. When asked to elaborate on the approach that small and medium scale manufacturing use in the analysis and improvement of process and structural efficiency, equipments' diagnosis and maintenance emerged from most of the operational managers' narratives are critical for bolster a manufacturing plant's operational efficiency. If the manufacturing machineries and equipments are all functional, findings indicated most of the manufacturing executives to be quite contented. It is often such contentment that affects the utilisation of complex methodologies like enterprise modelling to undertake holistic diagnosis to improve an enterprise's performance.

Efficiency and effective functionality of the manufacturing equipments and machineries were found to be at the heart of every business. As the manufacturing executives take the initiatives to commit the necessary resources on equipment and machineries' maintenance, structural and process related challenges were reiterated to often be treated as ancillary issues that can be addressed and fixed anytime. Such a view was corroborated in the opinions of one of the operational managers who argued that:

"It is the machineries and equipments' state of performance. If they are effectively functional, you can say you have a manufacturing plant. But if they are down, then, I think you can still call such a business as a manufacturing plant."

As the manufacturing entities commit the necessary financial resources on the manufacturing equipment and machineries' maintenance, it was found to unlock the desired consistent level of operational efficiency. Frequent equipment and machineries were found to not only leverage operational efficiency, but also process efficiency, cost minimisation, increased throughput and significant returns on investments.

However, it was also some of these resulting values of proactive equipment and machineries' maintenance that were also found to inhibit investment in more complex mega and holistic operational performance diagnosis and improvement methodologies such as enterprise modelling. Findings indicated the application of such complex, mega and holistic operational performance diagnosis and improvement methodologies were often feared for causing instabilities and disruptions.

Yet, as such instabilities and disruptions occur; most of the manufacturing executives were often to be sceptical on whether or not they would inhibit the realisation of the values already being induced by the application of other operational management approaches. Since most of the operational managers reiterated most of the small and medium scale manufacturing entities not to use enterprise resource planning, such views were mainly discernible in most of the responses to the probe and re-probe question that explored why some of the SMEs do not use enterprise modelling methodologies. In one of such responses, one of the operational managers argued that:

"Enterprise modelling is usually motivated by the need to address serious organisational or business related problems. The plant is usually having problems of machine break down and leaking here and there, but it has not yet experienced such challenges to require enterprise modelling, may in future when the business has grown."

Certainly, such a view seems to corroborate the narratives that indicated that good operational performance which is resulting from the proactive analysis and application of relevant operational improvement efficiency render the use of enterprise modelling unnecessary in certain situations. Yet, as findings indicated, some of the manufacturing plants do not only rely on the efficiency of the maintenance systems, but also the efficiency of production scheduling, enterprise resource planning, process diagnosis and improvement.

Combined with the adoption of better and more efficient supply chain systems, all these were found to render the application of any enterprise modelling methodology not only unnecessary, but also a waste of resources. However, as some of the small and medium scale manufacturing entities were found to engage in generic simple routinal operational diagnosis which are frequently undertaken to create and maintain more efficient operational systems to minimise risks of major failures that require complex technologically supported interventions, others were found to instead undertake complex diagonal-operational diagnosis.

6.2. Complex-Diagonal Operational Diagnosis

Even if the plant is operating and performing more efficiently and effectively, some of the small and medium scale manufacturing entities were still found to engage in complex diagonal operational diagnosis that diagonally links cost with quality diagnosis to unlock cost and efficiency advantages that in turn catalyse a manufacturing enterprise's effective performance. It was in such initiatives that some of the small and medium scale manufacturing entities were found to some of the enterprise modelling methodologies to induce new cost and quality control advantages.

6.2.1. Cost Drivers' Diagnosis

Motivated by the constant quests to reduce costs, findings indicated some of the small and medium scale manufacturing enterprises to engage the application of some complex methodologies to diagnose and improve the management of different cost drivers. Attributable to such a view is the fact that as the manufacturing entities seek to minimise their overall operational costs to catalyse the improvement of a manufacturing enterprise's operational performance, they were often lured into trying all more complex models of analysis of how such quests can be achieved. In the situations of declining performance, some of such methodologies were found to entail complex statistical and sigma analysis, as others entailed the application of some simple enterprise modelling techniques.

Even if some of the businesses insinuated using only some aspects of enterprise modelling processes, most narratives still reiterated enterprise modelling to be often preferable for diagnosing and managing relevant cost and efficiency drivers. However, as compared to resource modelling or information modelling, some of the participants noted that it is often business process modelling which is preferred in the diagnosis and improvement of the management of relevant cost drivers. In such instances, business process modelling was found to aid process mapping and understanding of the cost drivers that are often ingrained in different critical business processes.

This improves the identification and reduction of the process mismatches that often constrain process efficiency to undermine a manufacturing firm's overall operational efficiency. Improved process efficiency translates into better quality of customer services. This in turn induces improved customer satisfaction to bolster a firm's overall market competitiveness. Such a view was corroborated in the views of one of the operational IT personnel who stated that:

"Of course, we also use methodologies such as process analysis and mapping, compatibility analysis, machine diagnostics as well as sigma analysis as more frequent operational improvement approaches. But also once in a while, we undertake a comprehensive enterprise modelling to gain a snapshot of the inter-connectivity of everything in our operational systems. As a once in while performance improvement initiative, enables us to identify areas that need to be reviewed to save costs and improve our performance as we grow."

Such a view corroborated some of the operational managers' narratives that indicated that even if cost management is not a challenge, enterprise modelling is often still used as a once-off initiative to discern new improvement initiatives that can be undertaken. In such instances, of one of the IT operational managers argued

that "enterprise modelling is used for smoothening changes that the plant undertakes as it grows". Considering that most of the manufacturing entities are increasingly becoming technologically intensive, she explained that "enterprise modelling is not only a process of using computers to generate and analyse a network of the interwoven manufacturing structures and processes".

Instead, she argued that it is a scientific process of analysis that enables evaluation of how different systems in the plant technically relate to each other. In such analysis, enterprise modelling was noted to also be critical for minimising risks of incompatibilities not only of processes, but also machineries that can easily cause risks of accidents. Yet, as business process modelling leverages process mapping, some of the narratives also reiterated it to catalyse manufacturing value chain analysis. As most of the cost and efficiency drivers are often inherently integrated in a manufacturing entities' value chain, process mapping and analysis were reiterated by most of the operational managers to catalyse the analysis and evaluation of the efficiency of the flow of activities from the points of sourcing, storage, manufacturing, distribution and sale to the final customers.

Process mapping enables a business configure its critical internal and external business processes to determine how such critical business processes can be re-engineered to unlock the desired cost and efficiency advantages that bolster a manufacturing firm's overall operational efficiency. This view is derived from one of the operational manager's explanations that indicated that:

"Enterprise modelling is not just undertaken for the sake of understanding a configuration of the critical business dimensions. It is motivated by the quests to solve the operational challenges that the business is facing. In most of the cases, without operational deficiencies, we have often not thought of undertaking enterprise modelling. However, as the business grows, with time, mismatches between processes tend to emerge. This is also often exercabated by the emergence of the operational challenges such as process and structural duplications, and in certain cases, multiple sources of operational deficiencies where it is difficult to discern where the problem is actually emerging from. Hence, using certain specific software, we undertake enterprise modelling as a preface for undertaking holistic organisational diagnosis to identify the sources of the problem, and to undertake relevant structural and process changes to induce advantages that lower costs whilst also leveraging our operational efficiency. With such organisational diagram on your computer screen, it becomes easier to evaluate the entire flow of activities right from the suppliers until the point of sale. This enables identification of whether the source of the problem is internal or whether it is arising from suppliers, logistic handlers and transporters or warehousing."

Such a view substantiates the opinions of most participants who reiterated that enterprise modelling discerns how critical enterprise architectures such as the manufacturing, process, resource, machinery, supply chain and sales and distribution can be integrated and synchronised to spawn the manufacturing enterprise's overall level of operational efficiency. Yet, as the manufacturing firm diagnoses its critical business processes, it emerged from the findings that it also identifies and corrects not only areas of glitches that constrain operational efficiency, but also areas in the manufacturing processes that cause wastes to affect the application of the overall cost minimisation initiatives.

As one of the IT personnel from a company in Centurion that manufactures and sells housing utensils noted, this often arises in the instances where the holistic enterprise modelling is used to undertake business process modelling in conjunction with asset, equipment and resource modelling. In such instances, she explained that enterprise modelling enhances detailed analysis and modelling of the manufacturing processes as well as how such processes coherently link with the other internal and external business processes. Quite often, the motive of such analysis is to discern how the existing configuration of the relationship between the existing processes, asset, equipment and resources is aiding or constraining the achievement of the desired business outcomes.

As such analysis enhances the application of business re-engineering, findings revealed that it also bolsters discerning and application of the improvement initiatives such as machine replenishment, investment in IT or training to improve the process personnel's understanding of the critical business processes and policies.

Whereas machine replenishment improves the functionality of the machineries, it was common across the views of most participants that investment in IT leverages activities' integration to spawn the overall level of operational efficiency. Training improves the personnel's competencies to effectively and efficiently accomplish

different activities to achieve the desired business outcomes. As it emerged from the findings, this not only spawns the manufacturing enterprise's operational efficiency to unlock cost and efficiency advantages that leverage its overall cost competitiveness, but also quality management that create enormous points-of-difference to set the business apart from rivals.

6.2.2. Quality Drivers' Diagnosis

Concept analysis of most interview responses indicated that enterprise modelling induces advantages that spawn the efficiency of the manufacturing enterprise's quality management. It enhances the evaluation of quality management systems that constitute of quality control, design specifications, quality specifications, prescribed input formulas, quality control procedures and policies, and personnel capabilities and competencies.

While diagnosing the effectiveness of such quality management systems, the modelling of quality management architecture also enhances the analysis of the relationship between the established quality control systems and specifications with the personnel's capabilities to apply such control systems. Such a finding is derived from the views of one of the operational managers who stated that:

"Using the diagram generated from the enterprise modelling systems, it becomes easier for you to analyse the interface between quality management systems and the procurement architecture that constitutes of suppliers, transporters as well as logistics handling and storage companies. This enables the identification and correction of the areas causing quality management challenges to leverage a manufacturing enterprise's capabilities to deliver superior value offerings."

In most of the cases, findings imply enterprise modelling is motivated by the quests to bolster a manufacturing enterprise's operational efficiency, cost management as well as quality management. Without the constant quests to discern ways to efficiently and cost-effectively deliver superior value offerings, most of the manufacturing enterprises would not engage the application of any of the enterprise modelling methodologies.

In effect, as enterprise modelling diagnoses the effectiveness of the manufacturing architecture, most of the operational managers noted that it aids the evaluation of how the configuration of the existing machineries, processes, resources and personnel is leveraging not only manufacturing efficiency, but also the production of the desired quality outputs. This enhances the analysis of whether the functionality of the existing machineries combined with the supportive processes is spawning the production of the desired quality outcomes. It also aids the identification and correction of the sources of errors that undermine quests to deliver superior value offerings. Such a view echoes the reasoning of one of the IT personnel who stated that:

"From my experience, one of the immediate direct benefits of enterprise modelling is that it enables intervention to improve the efficiency of the flow of activities. This impacts positively and directly on the ability to respond to customer needs as well as the quality of customer services."

Even if the challenge is not diagnosed and identified to arise from the configuration of the machineries, processes, resources and personnel, findings still reiterated that modelling of business policies and procedures would also enhance discerning whether the sources of the challenges that are affecting quality management are arising from the existing business policies and procedures. Quests to comply with the existing business policies and procedures were reiterated by most of the operational managers to cause delays and deficiencies that in turn induce redundancies of certain aspects of the manufacturing processes. This is reflected in the fact one of the operational personnel from the electronics assembling plant noted that:

"Delays and deficiencies that are arising from lengthy waiting for management approval or the need to comply with certain minor policies and procedures cause shortages that affect the continuity of the production processes. It also affects the quality of customer services."

Yet, as enterprise modelling leverages such analysis, concept analysis of the findings revealed that it bolsters not only how such business procedures and policies spawn operational efficiency, but also compliance with the necessary quality specifications. In such analysis, some of the operational managers explained that the modelling of the manufacturing architecture enhances the evaluation of the personnel's competencies to understand and apply policies and procedures that would aid conformance with quality specifications.

As these enhance the evaluation of the effectiveness of the existing design requirements and quality

controls, modelling of the manufacturing architecture was also found to induce advantages that spur the improvement of the quality of customer services. It enhances the diagnosis of the effectiveness and efficiency of cycle time, customer order handling and delivery schedules to deliver superior customer service quality. In otherwords, these findings imply that enterprise modelling breeds results that not only create cost and efficiency advantages, but also significant improvement of a manufacturing firm's quality management capabilities.

7. Discussion

Quests for leveraging the overall operational efficiency to spawn a firm's overall effective performance are driving manufacturing executives to explore different strategies for bolstering their operational efficiency. As firms seek to achieve such quests, enterprise modelling is increasingly emerging as a critical preface for undertaking effective organisational diagnosis. Enterprise modelling aids the development of a configuration of the enterprise architecture that reflects the relationship and interface between critical tasks, processes, resources, equipments and personnel (Jardim-Gonçalves &Grilo 2013:5) [14]. This improves the understanding of how activities flow through the interfaces of different architectures. Improved understanding of the patterns of activities' flow influences the identification and correction of the areas that cause operational deficiencies to undermine a manufacturing enterprise's effective performance.

Such a finding is at tandem with the results of this empirical research that indicated that even if the plant is operating and performing more efficiently and effectively, it is often such values of enterprise modelling that motivate some of the small and medium scale manufacturing entities to engage in complex diagonal operational diagnosis. In such diagonal analysis, the aim is often to diagonally link cost with quality diagnosis to unlock cost and efficiency advantages that can in turn catalyse a manufacturing enterprise's effective performance. This is accentuated in the fact that the application of enterprise modelling methodologies such as Dependency Structure Matrix aids logical analysis of the systematic flow of tasks by evaluating the interface between business tasks and functions that arise from the exchange between inputs and outputs (Panetto & Cecil 2013:5) [12]. This aids the identification and elimination of process mismatches to a bolster the overall level of process synchronisation.

As this spawns process synchronisation, the use of SADT also aids analysis and description of the functions and relationships between different tasks to enhance the undertaking of the initiatives such as investment in IT and software such as enterprise resource planning systems to bolster the overall level of activities' integration. Improved level of activities' integration leverages the effectiveness of management control to ensure that a manufacturing enterprise delivers on its critical business credo (Panetto & Cecil, 2013: 5) [12]. Enterprise modelling also enhances the identification and mitigation of the operational glitches that cause wastes and cost escalations.

Significant reduction of wastes and cost minimisation arise from the fact that enterprise modelling creates a comprehensive overview of the firm that aids thorough diagnosis of a firm's value chains. While using methodologies such as IDEFO, enterprise modelling configures, maps and recreates a system overview of the synergy and linkage of the flow of activities according to inputs, controls, outputs and mechanisms. As this enhances the analysis and improvement of the activities' flow along a firm's value chain, it also aids diagnosis and improvement of the effectiveness of sourcing strategies as well as quality control systems.

The analysis of the effectiveness of the sourcing strategies enhances the identification of the activities that must be eliminated or combined to unlock cost and efficiency advantages to spawn a manufacturing enterprise's overall market competitiveness. In terms of the diagnosis of the effectiveness of quality management control systems, enterprise modelling uses IDEFO to create a configuration of management control architecture that constitutes of customer orders, business strategy, design requirements, delivery schedules, quality specifications, cost control mechanisms and business policies and procedures (Turk & Mohamad 2011:19) [13]. This leverages the identification and elimination of the areas of quality management deficiencies to enhance the use of the effectiveness of the manufacturing enterprise's quality management systems to create points-of-difference that set it apart from rivals.

Even if the positive effects of enterprise modelling on the improvement of product quality are only minimal,

enterprise modelling can still induce improved quality of customer services. As the use of methodologies such as CIMOSA facilitates the integration of machines, computers with people, PERA offers a configuration of different enterprise architectures and the interface between different architectures such as functional network manufacturing, information, information systems, manufacturing equipments, and human resource and organisational architectures (Jardim-Gonçalves &Grilo 2013:5) [12]. The creation of a synergy between these architectures aids the improvement of the level of activities' integration to not only leverage the quality of customers, but also significant reduction of cycle time and lead time.

In otherwords, enterprise modelling unlocks cost, efficiency and quality management advantages that in turn bolster the effectiveness of a manufacturing enterprise's overall operational performance. Even if it so, the results of this empirical research seem to imply that it seems most of the small and medium scale manufacturing entities have not yet realised the enormous values that enterprise modelling offers. Instead of using enterprise modelling methodologies to undertake relevant holistic organisational diagnosis, most small and medium scale manufacturing entities were found to only use certain discrete generic operational diagnostic approaches.

Such generic operational diagnostic approaches either entailed the use of less technologically-intensive diagnosis of whether a business' performance is aiding the achievement of the desired outcomes or frequent manufacturing equipments' diagnosis to minimise risks of major failures that often require complex technologically supported interventions. However, given the fact that only limited research has explored the leveraging effects of enterprise modelling on a manufacturing firm's performance, the managerial implication section of this research sought to address such challenges by offers a framework that the small and medium-size manufacturing enterprises can replicate to undertake the required iterative enterprise modelling processes.

8. Managerial Implications

Utilisation of different enterprise modelling methodologies was certainly found to be underrated by most of the small and medium scale manufacturing entities. In effect, it is argued in Figure 2 that the use of the appropriate enterprise modelling framework catalyses a manufacturing entities' effective market performance. As the small and medium scale manufacturing entities grow, risks of process and structural mismatches often arise from the emerging complex processes and structures.

Quite often, it is also often such process and structural complexities that tend to induce cost and quality disadvantages that undermine a firm's effective market performance. Certainly, enterprise modelling is not an initiative that can be frequently undertaken. However, if the manufacturing entity experiences of such often interwoven complex structural and process deficiencies, enterprise modelling may tend to aid relevant diagnosis to unlock new cost, quality and efficiency capabilities. Given the constantly changing modern business environment, it is often through such frequent review and changes that the manufacturing businesses are able to bolster their sustainability.

To accomplish that, it is argued in Figure 2 that it is not only critical for the manufacturing executives to not only invest in relevant enterprise modelling technologies and software, but also to adopt and apply the sequential iterative processes of enterprise modelling. The first step would require defining the motive and purpose of enterprise modelling of the manufacturing systems. Depending on the challenges that the manufacturing entity is facing, some of such motives of enterprise modelling could be to minimise costs or leverage operational efficiency.

It may also encompass quests that seek to improve product quality or improve quality of customer services. Yet, as the manufacturing entity seeks to spawn its cost competitiveness, it may also explore how enterprise modelling can be utilised to develop new business approaches that create points-of-difference that set the manufacturing enterprise apart from rivals. The clear designation of such motives of enterprise modelling must be accompanied by the use IDEFO (Integration Definition). Certainly, there are several enterprise modelling methodologies. However, it is IDEFO that seems to offer a holistic approach that can be replicated by the small and medium scale manufacturing entities when undertaking enterprise modelling.

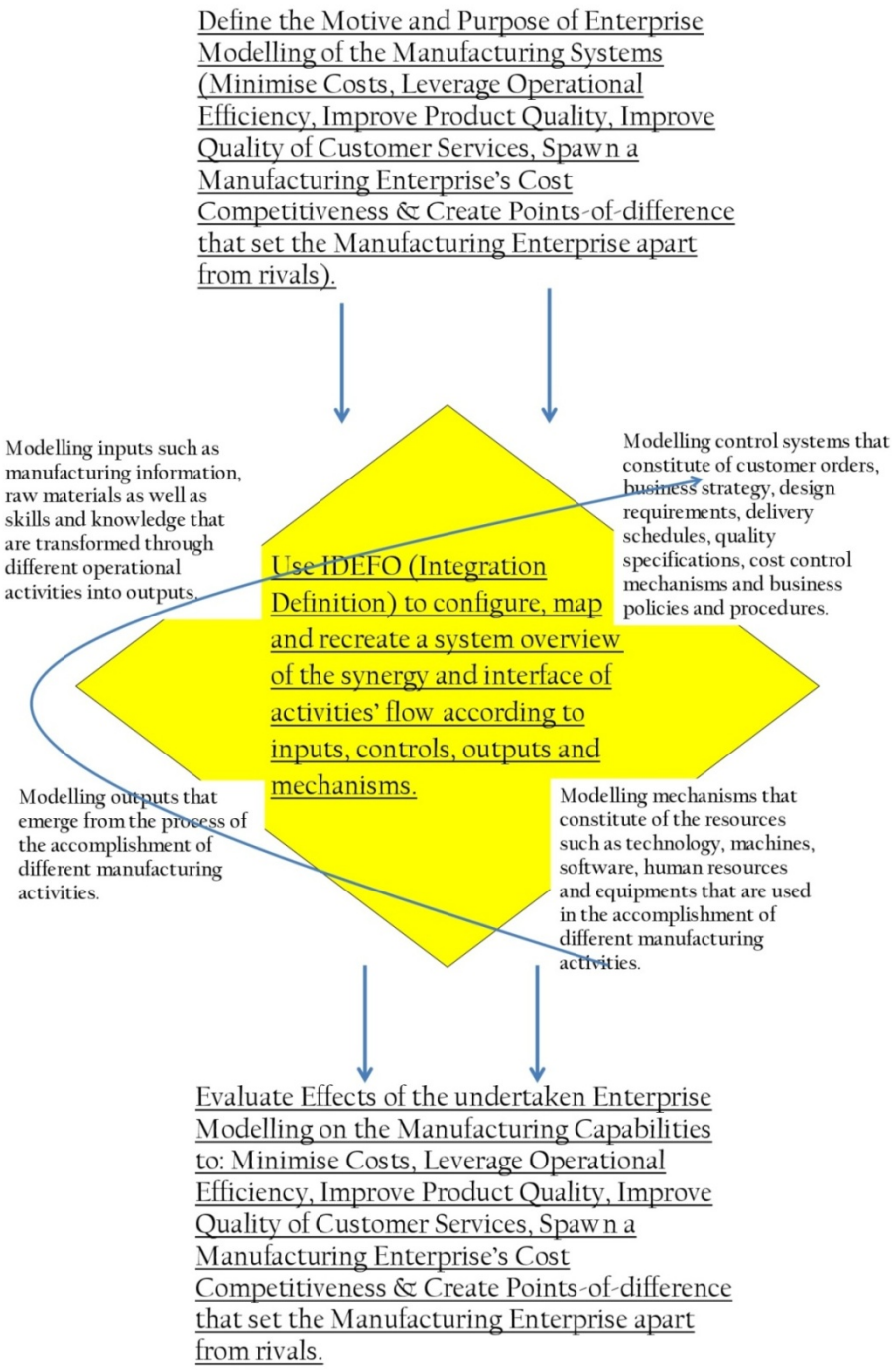

Figure 2. Explicating iterative enterprise modelling process as a driver of the small and medium-size manufacturing enterprises' (smes) effective performance. Source: researcher's own construct.

The use IDEFO (Integration Definition) will enable the manufacturing entities configure, map and recreate a system overview of the synergy and interface of activities' flow according to inputs, controls, outputs and mechanisms. This must be accompanied by the modelling of inputs such as manufacturing information, raw materials as well as skills and knowledge that are transformed through different operational activities into outputs. In cost or quality related deficiencies, inputs' modelling will aid the identification of cost and quality related constraints that must be addressed.

It will also require the executives to model control systems that constitute of customer orders, business strategy, design requirements, delivery schedules, quality specifications, cost control mechanisms and business policies and procedures. As control systems are being modelled, the manufacturing entity will also have to consider modelling outputs that emerge from the process of the accomplishment of different manufacturing activities. It is through such analysis that the manufacturing entities would be able to improve throughput, but

also the quality of the emerging outputs.

In case of quality or cost related challenges, the manufacturing entities may also be required to model mechanisms that constitute of the resources such as technology, machines, software, human resources and equipments that are used in the accomplishment of different manufacturing activities. Completion of the modelling all such different aspects of a manufacturing plant must be accompanied by the evaluation of the undertaken enterprise modelling on leveraging the manufacturing capabilities to minimise costs, leverage operational efficiency and improve product quality.

Such analysis must be accompanied by the evaluation of the undertaken enterprise modelling initiatives on improved quality of customer services, a manufacturing enterprise's cost competitiveness as well as the inducement of the points-of-difference that set the manufacturing enterprise apart from rivals. Such analysis must inform the new iterative enterprise modelling processes that can be further undertaken to catalyse a manufacturing entity's effective performance in the midst of the constantly changing modern business environment.

9. Suggestion for Further Research

As manufacturing entities seek to bolster their competitive edge in the midst of the proliferation of the increasingly cheaper rivals' quality products, enterprise modelling is increasingly emerging as critical for unlocking new cost and quality advantages. It is the inducement of such cost and quality advantages that often catalyse the improvement of a manufacturing entity's capabilities to respond to such changes.

Using relevant software and technologies, enterprise modelling offers a comprehensive configuration of the interface and inter-relationships between different enterprise architectures. It aids mapping and drawing a visual representation of an organisation's critical activities, architectures, resources, processes, assets as well as the relationship between such processes with people. Through such initiatives, manufacturing executives may tend to be able to undertake holistic organisational diagnosis and identification of the areas of deficiencies that undermine a manufacturing enterprise's operational performance.

This enables relevant interventions to be undertaken to improve a firm's process, structural and control capabilities to unlock cost and efficiency advantages as well as improved quality management capabilities. Such a view echoes the results of empirical research that indicated that even if the plant is operating and performing more efficiently and effectively, it is often such values of enterprise modelling that motivate some of the small and medium scale manufacturing entities to engage in complex diagonal operational diagnosis.

In such diagonal analysis, the aim is often to diagonally link cost with quality diagnosis to unlock cost and efficiency advantages that can in turn catalyse a manufacturing enterprise's effective performance. It enables managers undertake relevant analysis of the organisation's operational processes and activities to determine the improvement measures that can be undertaken to spawn the improvement of a firm's overall operational efficiency.

Certainly, it is inherently evident that enterprise modelling catalyses a manufacturing enterprise's operational performance. However, even if it so, most narratives indicated that most of the small and medium scale manufacturing entities seem to have not yet realised that it is so. Such a view was accentuated in the findings that implied that instead of using enterprise modelling methodologies to undertake relevant holistic organisational diagnosis, most of the small and medium scale manufacturing entities were found to only use certain discrete generic operational diagnostic approaches.

Such generic operational diagnostic approaches either entailed the use of less technologically-intensive diagnosis of whether a business' performance is aiding the achievement of the desired outcomes or frequent manufacturing equipments' diagnosis to minimise risks of major failures that often require complex technologically supported interventions. In pragmatic conventional manufacturing operational approaches, such generic operational diagnosis and improvement approaches may seem right.

However, its stronger emphasis may still mar the enormous business values that enterprise modelling often induces. To respond to such a finding, the study used the enterprise model framework in Figure 2 to explicate how the small and medium scale manufacturing entities can undertake the required iterative enterprise

modelling process as a critical prerequisite for leveraging their overall effective market performance. However, future research can still explore how data optimisation can leverage enterprise modelling.

Funding

Not applicable.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Data is available upon request from the corresponding author.

Conflicts of Interest

The author declares no conflict of interest.

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