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Assessing Enabling Competence of Leagile Manufacturing Model and Its Impact on Performance of Small and Medium Factories in Uganda

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Abstract

Purpose: Leagile manufacturing is one of the time-based manufacturing practices used to improve factory performance. It is a practice that combines initiatives of Lean and agile manufacturing under certain enabling competences. Therefore, the purpose of this study is investigate the combinative nature of time-based manufacturing practices under unique enabling competences and their impact on performance of factories in Uganda. **Methodology:** Firstly, the underlying factor structure of competences and time-based manufacturing was examined was conducted using Principal Component Analysis (PCA). Enabling competences and time-base manufacturing practices were modelled and validated for each using confirmatory factor analysis, particularly composite reliability, average variance extracted and convergent validity. A fully fledged structural equation model was used to test the impact of leagile manufacturing on performance of factories. **Findings:** The study results revealed that time-based manufacturing of lean, and leagile are related but differ, in terms of their enabling competences and philosophical orientation. The findings also revealed that when small and medium factories in Uganda adopt leagile practice, they are likely not improve their performance. This is perhaps due to the fact that small and medium factories have inadequate resources. **Practical Implications:** The study findings shed more insights on the factors that enable adoption and implementation of time-based manufacturing practices. The extent to which these competences are orchestrated determines the benefits derived from the time-based manufacturing practices. In addition, small and medium enterprises should keenly make a choice on the appropriate practices that purposely reduce their lead time and cost of conversion. **Originality:** This study investigated the combinative nature of time-based manufacturing practices under unique enabling competences and their impact on performance of factories in Uganda. It is among the few studies that provide evidence on the leagile model anchored in the appropriate enabling competences in the context of developing countries. The empirical survey was done on small and medium factories to validate a leagile manufacturing model and tested its impact on factory performance.

Keywords

Time-Based Manufacturing, Lean Manufacturing, Agile Manufacturing, Leagile Manufacturing, Factory Performance

1. Introduction

In order to cope with the competitive storms in manufacturing business, manufacturers attempt to exhibit excellence in specific operations by exploiting available competences. Therefore, different firms choose different paths to address specific market needs. Similarly, the fact that capabilities required to respond and provide products to the market at low cost differ from company to company, incorporating customer orientation services into manufacturing remains key in keeping low costs [1]. In some instances, manufacturing companies have chosen time-based manufacturing practices of lean, agile or leagile manufacturing practices [1] [2]. Literature shows that use of these practices have been widely debated especially the contribution of lean and agile manufacturing towards achieving performance [3] [4] [5]. Other streams of research have underscored leagile practice as a tool that delivers the benefit of both lean production and agile manufacturing. Whereas lean production emphasizes reduction in wastage by streamlining production processes, agile manufacturing emphasizes flexibility and responsiveness in a turbulent market [6] [7] [8].

Although scholars delineate lean and agile manufacturing practices as two distinct practices with different underlying emphasis [9], their simultaneous adoption in the context of this study has not been sufficiently addressed empirically. Furthermore, literature indicates that, when a firm pursues a leagile infrastructure, it is able to capitalize on the benefit of lean and agile manufacturing. That withstanding, manufacturers in developing countries tend to earmark key factors that enable them pursue time-based manufacturing practices. More so, in disruptive and customer-based business environment, sustainability and growth have become crucial. As a result, factories need to re-orient their resources to cultivate different competences and become sensitive to delay effects and serve customers at low cost. “Shorter delays lead to greater trades” [10].

Related studies indicate that some companies put their attention on implementation of individual time-based manufacturing practices, yet other streams of thought advocate for combination of two or more practices in the same corporation [11]. The question here is which particular competences enable mutual supportiveness in a single factory? Although literature draws little light on the enabling factors for time-based manufacturing practices [12], identifying the distinctive competence required for each time-based manufacturing practice is very important and thus the first objective of the study:

Objective 1: *Validating multidimensionality of 3 interrelated enabling competences of time-based manufacturing*; *core*, *operational and business transaction*.

In addition, practitioners that compete in a single supply chain the application of lean and agility as inclusive concepts is unavoidable. Evidence derived from developed countries has shown greater and synergetic yield from a combined application of time-based manufacturing practices under ICT innovations [7] [9] [13] [14] [15]. The epistemological argument is that, even though leanness and agility can be caught in a trade-off conflict causing considerable overlap between their characteristics [16], certain unique competences are needed to rightfully fix the burden by dividing it amongst manufacturing components. The theoretical insights drawn from TRIZ-Theory of Solving Inventive Problems, provides ways to overcome psychological barriers and burden of generating solutions to problems associated trade-offs among innovative strategies [16]. Developed by Genrich [17], this theory emphasizes systematic analysis of a problem to be solved and provides a series of guidelines for alternative solutions. TRIZ identifies and predicts the root causes of undesired phenomenon in a manufacturing system and advocates for timely correction to prevent any harmful event. Even though critiques to this theory point to individualized judgment of ideality rendering it biased, its strong hand is devoted to identifying solutions to challenges attributed to practices with conflicting interests [16]. In this study, business transaction competences are identified and how such competences are orchestrated in a leagile system is explained [4] [18]. The theoretical connotations of Hua, Yang, Coulibaly, & Zhang [19] identify leagile distinct practices with particular competences without distortion of overall strategy of lean and agile practices. As recommended by Ketokivi & Schroeder [20], bundles of capabilities are used to better capture the width of multidimensional concepts. Therefore, testing whether lean, agile and leagile manufacturing practices are related but distinct in the context of Ugandan factories is the second objective of this study:

Objective II: *Validating time-based manufacturing practices of lean*, *agile and leagile as distinct and related practices in the context of Uganda*.

In attempt to examine the rationale for the adoption of time-based manufacturing practices in Uganda, leanness and agility should not be confused. Rather, leanness forms the basis for agility and establishment of lean practices does not focus on meeting customer needs in the quickest possible way [4]. Other authors argue that the success of agile manufacturing is determined by adequate lean production strategies [9], regardless of the enabling factors. Nonetheless, Thaeir [13] also argues that lean and agile paradigms are distinct concepts that are not entirely compatible. Therefore, deployment of leagile principles would yield related results from lean and agile initiatives. While there could be different streams of research on the contribution of the hybrid of lean and agile practices, their pragmatic intersection in the context of Uganda has not been fully documented. In a bid to establish the comprehensive hybrid model, the current study also targets at achieving the following objective.

Objective III: *Examining the relevance of combining Lean and Agile manufacturing practices in leagile manufacturing system*.

Finally, researchers claim that leagile system encompasses both lean and agile practices, acting together in order to improve factory performance [3]. The claim is yet to remain a fallacy among small and medium factories (SMFs) in Uganda if not empirically proved. For instance, factories in Uganda suffocate from delayed production and high conversion costs for numerous reasons. For example, being a landlocked country, factories experiences delays transporting imported raw materials, yet they have to meet on-time demands from both local and international markets. World Bank [21] report indicates that Uganda lags behind its counter-parts in terms of production lead-time with 19.03 days compared to Tanzania (10.23 days), Kenya (8.88 days) and South Africa (5.53 days). I addition, Nagaaba [5] indicates that industrial competitiveness and labor productivity in manufacturing sector is low, slowed from about 7 percent in 1991-2002 to 3 percent in 2002-2015. This also intrigued the development of the framework to address the operational gaps in manufacturing industry in the current study. Probably, with new developments and innovation in manufacturing, a leagile based infrastructure would be solution to upscale performance. This study therefore also seeks to address the following objective:

Objective IV: *Examining the contribution of leagile manufacturing in improving performance of small and medium factories in Uganda.*

Overall, in order to address the above four objectives, a leagile manufacturing framework was adopted, validated, and tested to ascertain its contribution in improving factory performance. The hypotheses depicting the conceptual relationships of the factors and their practical contribution towards factory performance are tested in subsequent sections. The factor relationships are hypothesized as follows.

H1: *Enablers of time-based manufacturing are threefold-competences* (*i.e. core*, *operational and business transaction*), *distinct but interrelated in nature*.

H2: *Time-based manufacturing practices of lean*, *agile and leagile are conceptually distinct in context of Uganda*.

H3: *Combination of Lean and agile manufacturing practices contribute to the establishment of a leagile manufacturing system*.

H4: *Leagile manufacturing improves of factory performance of small and medium factories in Uganda*.

In **Figure 1**, the analytical framework for investigating the above hypotheses is provided. Hypothesis 1, proposes that enabling competences of time-based manufacturing practices are in three dimensions. If it is rejected, then the three competences identified are not psychometrically sound in terms of reliability, convergent validity and discriminant validity. Similarly, if hypothesis 2 is rejected, then lean, agile and leagile practices have overlapping characteristics. A

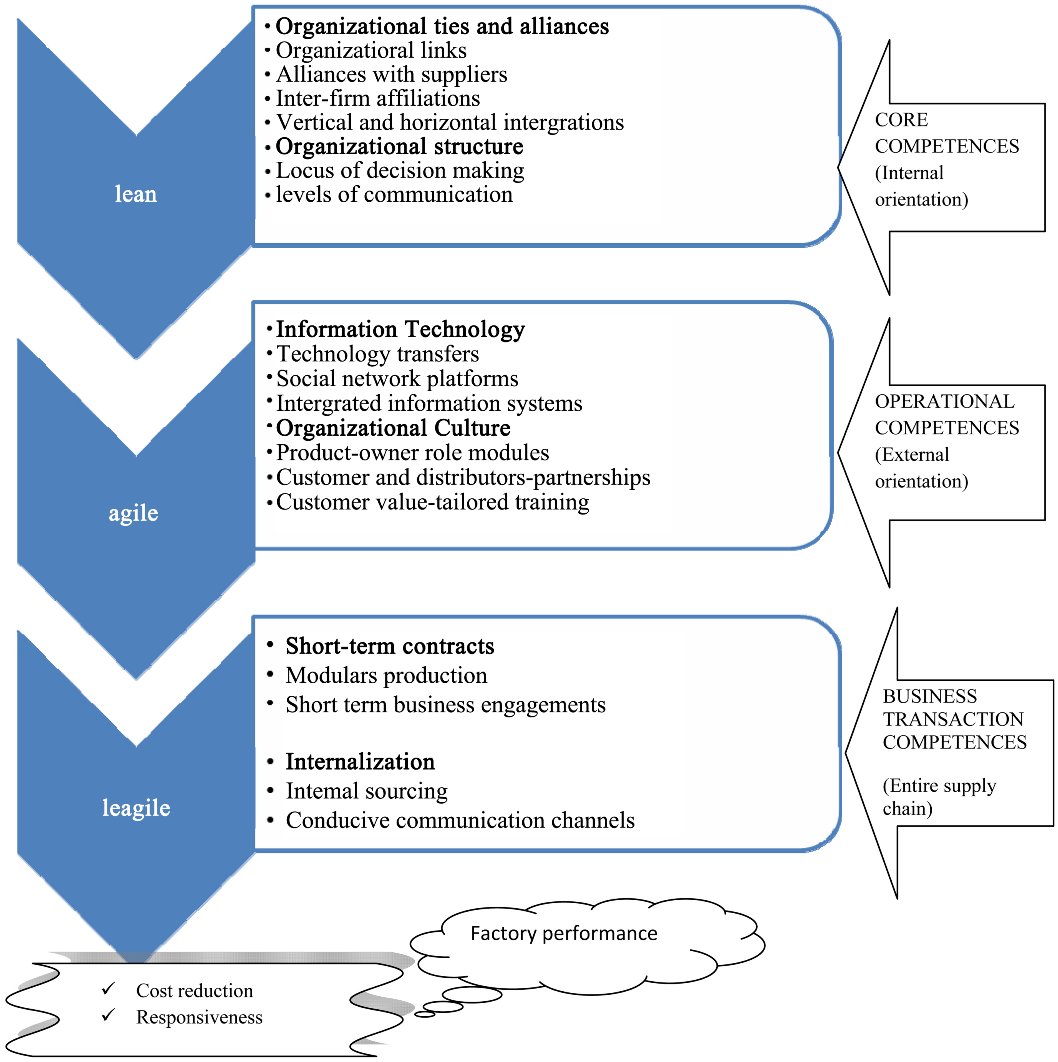

Figure 1. A leagile manufacturing frame work in a developing country's context.

factory can adopt either of the practices without compromising benefits derived from others. The third hypothesis suggests that successful adoption of leagile is preceded by establishment of lean and agile systems in a particular factory. If it is rejected, then factories can uniquely adopt leagile practices at any level of operation without considering lean and agile practices. The fourth and last hypothesis proposes that when small and medium factories adopt leagile manufacturing practice, they are able to improve their performance. This assertion is confirmed if the hypothesis is accepted.

The paper is structured as follows. First, in attempt to investigate these hypotheses, a great deal of attention is first paid to literature review expounding on time-based manufacturing practices and their contribution. The second section depicts time-based manufacturing model in a context of developing countries. The third section presents the methodology. The fourth section presents the results and discussion thereof. The paper ends with the conclusion and recommendation.

2. Literature Review

All manufacturers in any industry focus on the end-user as stepping stone toward profit maximization [22]. In order to achieve this, managers of factories continuously develop new practices as others fade away in trying to be both value qualifiers and winners [23]. As a continuum of innovative strategies is developed, distinctive features are exhibited at different echelons of supply chain to cope up with new market needs. In light of this argument, and as traditional method of production get outmoded, a number of practitioners have embraced time-based manufacturing practices. Proponents of these practices argue that factories regardless of industry type, need to focus at providing products to the customers in the quickest possible manner at the lowest cost possible [5] [14] [24] [25]. In this regard, advocators of time-based manufacturing initiatives have recognized lean, agile and leagile as the most innovative paradigms in operations management that can help to address the needs of the customers. Although there are numbers of researchers that have focused on contribution of these practices, their arguments are contextually diversionary. For example, some studies have focused on individual practices and their relevancy in a developed-country setting with sufficient enabling resources, while other studies, though a few have been conducted in less developed-country contexts.

However, generally speaking empirical literature shows that many companies pursue time-based manufacturing practices. Japanese experience provides the most instructive examples [11] [25]. However, even though there are number debates on developments of lean, agile and leagile in operations management, many researchers have drawn lines between these practices. Advocators of time-based manufacturing argue that lean, agile and leagile are paradigmically different with diverse orientations [26]. In particular, with the conceptual lenses, Webster's Dictionary makes a clear distinction between lean and agile referring lean as a paradigm that contains "little fat" and agile as a practice that emphasizes nimbleness [18]. Proponents of leagile manufacturing argue that lean practices focus at make-to-stock operations, while agile practices are for make-to-order operations. In other word, the two can be combined to simultaneously stimulate assemble-to-order operations [18].

Other authors view the practices of lean, agile and leagile in progression and complementary in nature as they burgeoned differently in different times [27]. Lean practices for instance, were first introduced in the production of Toyota in the 1970s. As markets became more unpredictable, flexibility and responsiveness became the main concerns. In the end, numerous market forces rendered lean practice as non-competitive and unsustainable strategy [15] [28]. In USA, practitioners and academicians on realizing new trends in competition in late 1990's, re-assessed lean manufacturing practices and developed a more sophisticated manufacturing paradigm called, agile manufacturing. The focus of this new era of manufacturing goes beyond ensuring continuity, but rather exploiting opportunities, raising the clock rate and reinforcing resilience to daily shock. The key aspects at forefront included: a customer is a priority and change is an opportunity for improvement [28] [29]. In late 20th century, manufacturers' attention focused on how to integrate lean and agile philosophies in managing manufacturing operations with the main focus of growth and sustainability [30]. These new strategies have raised a number of queries. For example, is it possible for the new wave of manufacturing characterized by more than one strategy to create competitive advantage? In terms of application, are these strategies mutually exclusive or complementary in nature? These unanswered questions stampeded into controversies among scholars and thus quest for hybrid approach referred to as "leagility", designed to take advantage of both lean and agile practices [3].

Other scholars connote that a leagile infrastructure demonstrates a cost effective supply chain [27]. Arnab [14] adds that optimization of lean and agile practices requires an IT enabling infrastructure in order to build a strong supply chain. Denise [4] points out that leagilitiy of a manufacturing firm is determined by the extent to which upstream and downstream partners are linked in converting the basic commodity into final product. His argument is premised on differing philosophical orientations of agile and lean practices at different echelons of entire supply chain. In sum, leagile model provides a logical approach that identifies and concentrates on value adding activities. Despites contradicting emphases of leanness and agility [9], recent explorations show that the most compelling reasoning behind integrating lean and agile manufacturing lies in the cost structure and the benefits of adding customer value in a sustainable manner.

Furthermore, Mason-Jones, Naylor, & Towill [7] argued that leagility is only anchored by successful adoption of lean and agile principles. It is on this development that Thaeir [13] advocates for decoupling point which allows concurrent implementation of both practices. Scholarly attempts have been made to throw more light on how lean and agile work together especially in areas of inventory and capacity. On contrary, the fundamental concern in this paper is on competences of the SMFs in Uganda that enable successful implementation of individual practices of lean, agile and leagile. The model developed and presented in this paper (**Figure 1**), sheds light on factors anchoring the SMFs for successful implementation of leagile practices in Uganda. A more robust demonstration on how time-based manufacturing practices are enabled by certain competences in developing countries which Uganda forms part is explained in the next section.

3. Time-Based Manufacturing Model in a Context of Developing Countries

Notwithstanding extant theoretical postulations that emphasize notions of trimming and standard solution, the time-based manufacturing model has been constructed to fit developing countries manufacturing environment. This paper suggests a specific and appropriate model under the prism of Small and Medium Factories' behavior in Uganda. The model suggests a cohesive leagile framework that can deliver responsiveness and cost reduction themes in a factory and puts forward implementation tools that have been virtually missed out in extant literature.

Due to drastic changing demands; factories have redirected their strategies towards sophisticated manufacturing tactics [31]. In order to remain on the contour of competition, SMFs move away from long term to short-term engagements to allow alternative streams of growth opportunities. As acknowledged by Arnab [14], changes in customer demand calls for innovative strategies that are cost friendly and relevant to the global market. In supplement, Duc & Andrew [32] advocates for a panoramic view of the firm beyond its operational boundaries where certain competences are embedded in entire system.

The progressive nature of the model further provides a systematic roadmap toward factory performance. The framework (**Figure 1**) encompasses three major echelons of leagile system in line with specific competences. As result, factories must pay attention to core, operational and business transaction competences to thrive and survive [23]. The foregoing model presented addresses the most logical approaches that allow sustainability and achievability of leagile manufacturing in pursuit of performance improvement goal. The next section clearly articulates competences required of individual time-based manufacturing practices and explains the legitimacy behind each in the model by addressing the core, operational and business transaction domains.

3.1. Core Competences

The organizational core competences exist at the corporate level and are embedded in cross-business interactions and governance structures [33] [34]. One way of supplementing internal assets and capabilities is to share core competences [35] [36]. This can only be explained by the extent to which firms agree with other parties to pursue the common set of objectives without necessarily having legal attachment but rather maintaining independence among parties [37]. Steffen, *et al.* [38] elude that for the organization to achieve high level of flexibility, organizational framework must be aligned. Thus, even though employees play a number of roles in a factory, they must be enabled by technology especially in dissemination of information. Warren [39] also states that specialization and bureaucratization intensify with a sense of ties between local and large organizations. From a system theoretical vantage, such ties and alliances are bound to be identifiable and recognized and virtually express overarching domination of resource [37]. Considering the notion of homeostasis, a supply chain will not be interfered with, if firms continue gaining access to the certain resource pool [40]. This is a key aspect in manufacturing industry especially in developing countries where resources are inappropriate. It allows promulgation of lean culture. Therefore, SMFs gazed at in this study need to keenly observe the nature of affiliation and alliance not to indulge themselves in unsustainable struggle in case of sudden changes in the "big fish" affiliates.

Hong-Chang, Rong, & Song [34] also assert that core competences are established by appropriate managerial structure and how well production factors relate in terms of time and space. Certain aspects like, locus of decision making and levels of communication have been identified as essential elements of lean production. However, a successful lean production is manifested in a structure with strong sense of autonomy among teams and self-reliance. These doctrines continue to be emphasized under organic structure of postindustrial mode of manufacturing [41].

3.2. Operational Competences

To quicken customer service, production systems must be realigned with advanced technologies and higher degree of concession among teams. Factories' core competences can be derailed if organizational teams do not shift their emphases from mass production to mass customization. In this case, a visionally production firm aligns its operational objectives with core strategic resources [20] [42]. As William [43] and Brown & Bessant [44] explain, such alignments are deemed attainable when organizational components are integrated using information technology. In other studies, it is evident that when firms are limited with innovative technological, ability to fulfill customer specifications in correct quantities and in a timely manner is impractical [14]. As the next best alternative, manufacturer in the context of this study opt for imitation of imported technologies though it requires specific training of workers for specific tasks as recommended by Ketokivi & Schroeder [20]. Further explorations indicate that information technology and organizational culture expedite customer service. For instance, Steffen, *et al.* [38] and Narasimhan, Swink, & Kim [45] argue that flexible production can be instigated when employees are involved in so called grey collar work. This in end creates deeper insights into their working environment. However, such motives should not be taken out-rightly as stimuli for agile culture. Instead, they spice agile manufacturing process [42] [44].

3.3. Business Transaction Competences

Manufacturing business is increasingly becoming diverse and unpredictable [23]. For a factory to stand the test of time, the entire supply chain must be engaged [27]. In addition, the whistle brow for factory performance has awakened new wave of competence mix. As new demands come along, business partners tend to share resource and task among business partners [46]. Li, Lin, Wang, & Yan [47] also connotes that timely sharing of supply chain information, helps to spot disruptions at downstream stages alerting the factories to make suitable decisions to encounter adverse effects. Therefore, engaging all partners in transaction process is essential. To this end, different practitioners and theorists have also put forward a number of manufacturing paradigms suitable for an entire supply chain. Most notably, Naylor, Muhamed, & Danny [27]; Vom [23] underscore leagile manufacturing as a practice that guarantee quality and continuity of supply [3] [7]. Under this theme, two Canadian economics Hymer [48] and McManus [49] postulate the importance of internal sourcing using a theoretical lens of internalization. Dunning [50] further relates this theory with organizational and acknowledges ownership advantage. Therefore, building on this theoretical background, factories can only exploit growth opportunities by internalizing capabilities and component instead of outsourcing. In the end, this builds confidence, trust and ownership within the entire supply chain.

In addition, when business environment is volatile, transaction costs tend to be high [31]. Therefore, short term contract and engagements allow flexible operations. This is one of the common characteristics of SMFs that renders them more competitive than large firms due to smaller chain of command. As prior researches emphasize, factories can only establish growth streams, when agility and lean competences are exhibited successfully at different stages in a supply chain [32]. As suggested in the model (**Figure 1**), factories are encouraged to identify and demarcate their core, operational and business transaction competences to effectively instigate a time-based manufacturing culture.

Although the literature describes a nexus of strategies and how they have been interchangeably used in manufacturing process, no apparent research efforts have been made to test the extent to which leagile practices relate to leanness, agility under certain conditions. Nonetheless, empirical evidences explaining extent to which leagile manufacturing influence factory performance, are none existent in this context. In order to widen the scope of knowledge regarding time-based manufacturing practices, an appropriate methodological approach in the following section has been adopted to address the objectives of study.

4. Methodology

4.1. Instrument Development and Description of Data

Instrument development began with theoretical development and literature review. Items were evaluated through interactive discussion with 3 experts from manufacturing business. Items were evaluated and suggestions regarding deletion and modification to fully cover the domains were received. Further scrutiny of the instrument was done through pre-test to ensure that the instrument is clear and has meaning in the context of Uganda. A pilot study was done on 20 SMFs to check the validity and reliability of the constructs. Exploratory factor analysis and promax rotations were used to establish the dimensions underlying the set of variables in each scale and to explore the underlying theoretical structure of the constructs using pilot data. Variance of factors extracted and the pattern of Eigen values of measurement items were examined. In particular, two factors' solutions accounting for 67.6 percent of variance in factory performance emerged. Similar analysis was performed on items explaining enabling competences. Three factors emerged with the cumulative percentage of variance of 71.3 percent. On the other hand, three factors' solution emerged from factor analysis on time-based manufacturing accounting for 71.6 percent. In all cases, the eigen values were more than 1. The details of the principal component analysis are provided in **Table 1**. Reliability analysis was performed based on Cronbach's alpha coefficient. The reliability indices are also provided in **Table 1**. A variable was considered reliable if the coefficients for scale items were greater than 0.7 [51].

4.2. Model Operationalization

4.2.1. Core Competences

Core competences were captured using conceptual lenses, *i.e.* organizational ties and alliances. Four items were used to reflect organization ties and alliances. Two items were used to explain organization structure. Drawing on the contribution of previous researchers, it is conjectured that building strategic ties alliances and organic structure would allow smooth flow of components and information [52] [53] [54] [55] [56]. The items used in this case were modified to fit the context of SMF's in developing countries. The measurement of core competence was further verified for internal consistence using Cronbach's reliability alpha. The results indicated that the Cronbach's α for the six items was 0.887.

4.2.2. Operational Competences

Operational competences that enable agile manufacturing were measured based on agile model of [57]. Given that the center nerve of agile manufacturing is customer centricity; operational competences are conceptualized based on two enabling factors that expedite customer service: information technology and organizational culture. In each case three items were generated. In this regard data obtained were related to degree of utilizing of information technology and the extent to which organization culture is inculcated. The literature on agile manufacturing environment was used to identify likert scale items for each dimension. The measurement of operational competence was further verified for internal consistence using Cronbach's reliability alpha. The results indicated that the Cronbach's α for the 12 items was 0.876.

4.2.3. Business Transaction Competences

The measurements of this combinative paradigm focus on the operation of entire supply chain [3] [58] [59]. Therefore, theoretical insights and empirical evidences of previous research were profoundly utilized in developing the measurement scale. The items that were captured here were distinctly generated. Consequently, two dimensions were used to reflect leagile manufacturing practices. These are: Short-term contracts and Internalization. In this study, data on these aspects were also obtained by asking the respondents to rate on a five-point Likert scale the level of implementing short term contract and internalizing transactions. The measure was further tested for internal consistence and Cronbach's coefficient determined. The results indicate that the construct is reliable with 5 items whose coefficient was 0.724.

Table 1. Underlying factor structure of the constructs (PCA).

Codes	Constructs	Mean	Std. Deviation	loadings	Alpha (α)	Eigen Values	% variance explained	Cumulative % variance
	Core competences				0.88	1.56	27.29	27.29
	Organizational ties and alliances							
COC1	Our firm partners with government in infrastructure development	3.81	1.302	0.7				
COC2	Our firm is affiliated to other organizations to allow smooth flow of resources	2.7	1.622	0.7				
COC3	We have improved our creativity and innovation using imitative technology	3.28	1.526	0.5				
	Organization structure							
COC4	Our structure has rule and procedure that encourage creativity and learning	3.19	1.529	0.4	0.743			
COC5	Our employees are empowered to work autonomously	3.6	1.491	0.6				
COC6	In our firm, we have proper channels of communication	3.57	1.43	0.5				
COC7	In our firm, we prioritize internal sourcing	3.22	1.298	0.8				
	Operational competence				0.876	1.712	25.28	52.57
	Information technology							
OC2	Conducive communication channels have improved performance	3.48	1.356	0.8				
OC3	Our most important tasks are operated by machines and computers	3.54	1.349	0.8				
OC4	In our firm, we have imported technologies to improve customer value	3.19	1.449	0.7				
OC5	In our factory there is possibility of transfer of technology	3.23	1.323	0.8				
OC6	in our factory we have social network platform	3.3	1.327	0.8				
OC7	in our factory we use integrated information systems	3.42	1.257	0.7				
	Organization culture							
OC8	In our firm, there is a collaboration between production unit and selling units	3.99	1.107	0.6				
OC9	Our firm has two autonomous divisions one for production and another for distribution	3.78	1.275	0.7				
OC10	Our firm has systems that allow smooth flow of materials and components	3.76	1.256	0.7				

Continued

OC11	We have Product-owner role modules	4.51	0.839	0.6				
OC12	Customer and distributors-partnerships are emphasized	3.91	1.011	0.7				
OC13	We have customer value-tailored training	4.2	0.867	0.6				
	Business transaction competences				0.724	1.78	19.8	71.37
	Short term contracts							
BT2	Our factory we have short term engagements	3.75	1.355	0.5				
BT3	In our firm, we have modular production systems	3.82	1.274	0.4				
	Internalization							
BT5	In our firm, we prioritize internal sourcing	2.53	1.631	0.7	0.721			
BT6	We partner with suppliers and distributors	3	1.698	0.7				
BT7	we have short-time contracts and tenders	3.74	1.482	0.7				
	Lean production				0.778	1.496	23.47	23.47
LN1	In our firm only essential items are kept in manufacturing area.	3.25	1.398	0.5				
LN2	Our employees are trained to handle specific task	3.44	1.405	0.5				
LN3	Our production routines and schedules are properly maintained	2.87	1.466	0.6				
LN4	Our firm can identify causes of quality problem	3.04	1.306	0.6				
LN5	We conduct process capability studies and training to avoid defects	3.11	1.335	0.7				
LN6	Our employees understand their influence on the organization overall efficiency	3.22	1.298	0.8				
LN7	Our production targets and goals are always revised	3.27	1.345	0.7				
LN9	In our firm feedback on work done is provided to avoid delays	3.59	1.277	0.6				
LN10	Our firm always collects and analyses production data	3.48	1.297	0.6				
	Agile manufacturing				0.711	1.723	20.89	44.36
AG3	Our product are differentiated regularly	2.98	1.488	0.4				
AG4	Our suppliers are involved in new product development	3.74	1.428	0.5				
AG5	Our firm has a plant that can be set to produce new products quickly	3.68	1.33	0.5				
AG6	Our firm has reliable suppliers in terms of delivery time	3.5	1.54	0.5				

Continued

AG7	Our firm changes internal processes and products quickly	2.84	1.595	0.6				
	Leagile manufacturing				0.905	1.617	27.25	71.61
LG1	Our employees quickly develop new manufacturing strategies	3.5	1.29	0.8				
LG2	In our firm, there production unit is independence from selling units	3.61	1.262	0.8				
LG3	Our firm has two autonomous divisions one for production and another for distribution	3.33	1.389	0.7				
LG4	Our firm has systems that allow smooth flow of materials	3.36	1.357	0.8				
LG5	In our firm, there is no excessive inventory movement	3.37	1.245	0.7				
LG6	In our firm, there is coordinated flow of components (raw materials, work in progress and final products) between functions	3.53	1.334	0.8				
LG7	Production is delayed until the order is received	3.41	1.339	0.8				
	Factory performance							
	Cost of conversion				0.876	1.87	35.192	35.192
FP1	Our firm does not find it costly to introduce new product	3.41	1.06	0.6				
FP2	Cost of holding inventory has reduced	3.38	1.07	0.7				
FP3	Costs of conversion have significantly reduced	3.44	1.32	0.7				
	Responsiveness				0.812	1.612	32.392	67.583
FP4	Our company has short lead time	3.33	1.39	0.7				
FP5	We fulfil orders in the shortest possible time	3.36	1.44	0.8				
FP6	Our suppliers are reliable in terms of time and quality	3.37	1.34	0.6				
FP7	We have proper communication channels with our customer and suppliers	4.00	0.92	0.7				

4.3. Factory Performance

To measure factory performance, extant literature was adopted. Perceptual data was utilized regarding responsiveness and reduction of cost of conversion. Although perceptual data is regarded as subjective, Ketokivi and Schroeder [20] recommend it as the most viable alternative in absence of the objective data. What is important is the extent to which such data is subjected to rigorous reliability tests. In this case, data on responsiveness and cost of conversion were obtained by asking the respondents to indicate on a five-point Likert Scale the extent to which they agree with the statement provided. It was also deemed necessary to determine unidimensionality of the measures using principal component analysis and results are reported in **Table 1**. The reliability index for all the dimensions were above 0.812.

4.4. Data Collection

The quality of the data obtained in a survey research design, largely depends on knowledge of the respondents and diversity of the industry [1]. To attain this goal, SMFs of different ages, sizes (number of employees) and product types were sampled. Of the 148 formerly registered SMFs located in Western Uganda and Kampala Capital city, 129 SMFs were sampled. UBOS [60] was used to identify the number of SMFs operating in two regions (Western Uganda and Kampala Capital City) that form the largest industrial hub in Uganda. Using Uganda Investment Authority definition of small and medium factories, only factories with employees between 5 and 100 were included in the sampling frame. The instruments were delivered to the factories and respective managers requested to respond to the questions in the instrument. 103 questionnaires were successfully filled and corrected back, accounting for 79.8 percent response rate. The factories were units of analysis. Responses were later examined using Levene's test to examine equality of the error variances regarding the size, age and industrial type of the factory. Since the significance value of the tests were all greater than 0.10, there is no reason to believe that the equal variance assumption was violated.

4.5. Analysis of Data

The analysis of data was performed using SPSS version 23. All structural equation modeling analyses were conducted using AMOS 22. Structural equation modeling was used for the following reasons: First, the fact that it can examine a series of dependence relationships simultaneously at the same time it provides statistical efficiency. Secondly, confirmatory factor analysis emphasizes stricter interpretation of unidimensionality than traditional methods [61]. Thirdly, with structural model, one can be able to analyze the relationships among multiple exogenous and endogenous variables and between endogenous variables simultaneously.

In order to achieve all the objectives, three stages of multivariate analysis were followed. First, dimensionality was assessed using principal component analysis based on promax rotation method to explore the nature of the constructs. Next, Confirmatory Factor Analysis (CFA) was run using AMOS (Version 22.0) to validate the measurement models. As indicated in the literature, unidimensional and reliability are important for establishing the validity of constructs [1]. Therefore, it was important to demonstrate that the instruments for measuring variables were valid and reliable. Lastly, full-fledged Structural Equation Modeling (SEM) was carried out to verify the model fit and calculate the prediction estimates as hypothesized.

5. Results

The first objective hypothesizes that enabling competences of agile, lean and leagile manufacturing are threefold and distinct. The mean scores and standard deviations for all items are provided in **Table 1**. The results reveal that all the means are above the hypothesized value of 2.5. An indication that all factory managers appreciate the role of competences in fostering time-based manufacturing. In addition, the internal consistency is not violated as indices of respective items were all above 0.7 [62]. To establish the underlying factor structure of competences, Principal Component Analysis (PCA) was conducted. It is important to note PCA help in checking the adequacy of the sampling frame and assesses the degree of inter-correlation among the items. Accordingly, Kaiser-Meyer-Olkin (KMO) values of more than 0.6 indicate that the sample size is adequate [62] [63]. In this case the KMO measurement value was 0.91, which falls within the range. This revealed that the study sample was adequate for factor analysis. PCA results revealed that the items explaining competences and time-based manufacturing both loaded to three factors. Items for factory performance loaded respectively to 2 factors. In all cases the cumulative percentage of variance was more than 50 percent. PCA also revealed that all Eigen values were more than one. The PCA results helped to partially confirm hypotheses *Hi.*

Further analysis was performed using confirmatory factor analysis (CFA) technique to confirm H_I, and validate the measurement model and the underlying theoretical structure of competences. Various model fit indices were examined in assessing the model fit. These include: root mean square error approximation, the comparative fit index (CFI) [64] and χ^2/df (normed χ^2). The χ^2/df ratio show a rough estimate of the statistical fit of the model versus the number of factors estimated. The results of the measurement model are shown in **Figure 2** below. The results show that the three-factor structure was adequate. It is evident that the proposed structural model fits well the data as indicated by the fit statistics (χ^2/df = 2.742, CFI = 0.92 and RMSEA = 0.071). These indices lie within the range suggested. The cut-off point of RMSEA and χ^2/df are respectively less than 0.8 and 3 and CFI should be greater than 0.9 [64].

Multidimensionality of the competences was further validated using composite reliability, convergent and discriminant validity. The results are presented in **Table 2** below. The results indicate that the average variance extracted (AVE) for each construct exceeds the threshold of convergent validity of 0.5. In addition, discriminant validity was tested by comparing the average variance extracted with the squared correlation between constructs [65]. Ziat [65] connotes that discriminant validity exists if the observed variables share more common variance with their respective latent construct than any other inter-construct variances. Therefore, the AVE for a construct should be higher than the squared

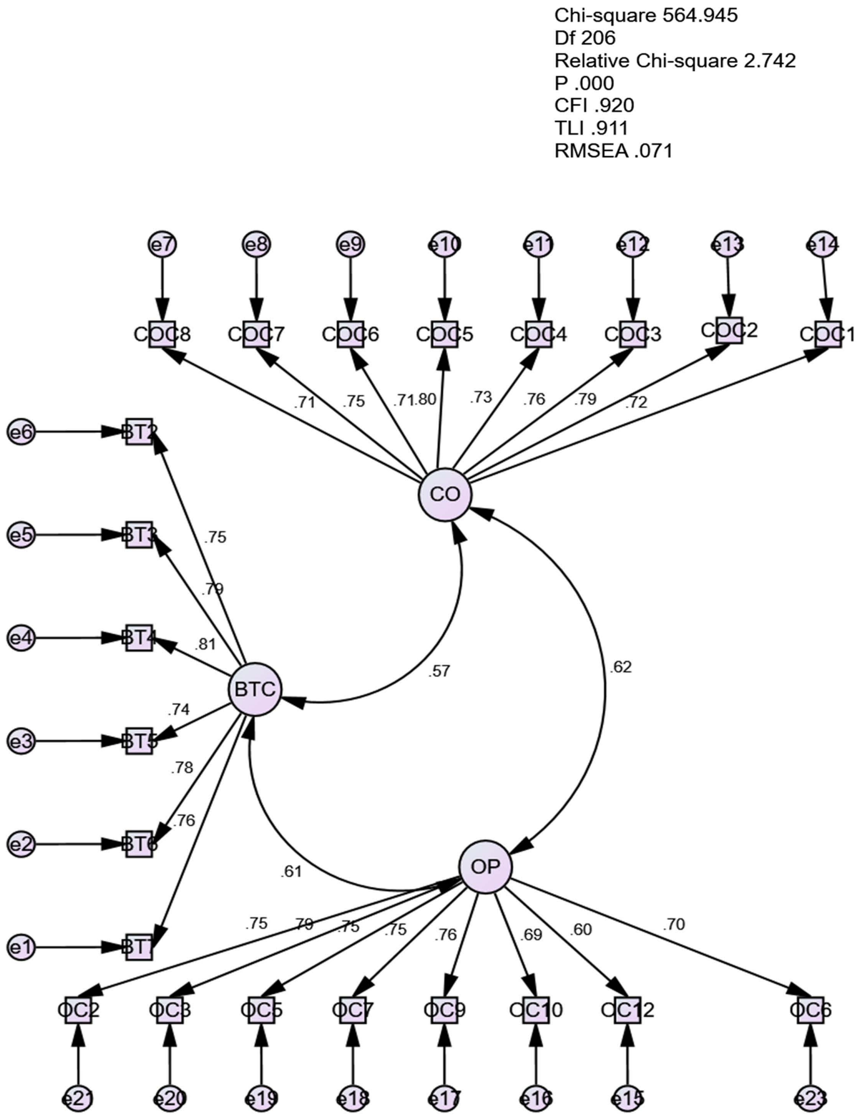

Figure 2. CFA results confirming a three-factor model of enabling competences.

Table 2. Average Variance Extracted (AVE), Composite reliability, Discriminant Validity and shared variance among the enabling competences.

	CO	OP	BTC
CO	**0.771**	0.381	0.321
OP	0.617	**0.748**	0.372
BTC	0.567	0.610	**0.878**
Composite reliability	**0.910**	**0.910**	**0.898**
Average Variance extracted (AVE)	**0.595**	**0.559**	**0.602**

correlation between that construct and each of the other constructs. In this case, the values for AVEs were larger than majority of the shared variance above the diagonal as in Table 2 above.

The values for correlations between the latent constructs (below the diagonal) also indicated that three competences are inter-related and distinct. Likewise, the respective composite reliability indices are above the threshold of 0.6. Core competences (CO) (0.910), Operational competences (OC) (0.910), and Business Transaction competences (BTC) (0.898).

In conclusion, CFA, confirms the H_1. Enabling competences of time-based manufacturing are multidimensional and distinct in nature. As indicated in objective 1, this was psychometrically achieved with reliability, convergent validity and discriminant validity and composite reliability.

The second hypothesis concerns whether time-based manufacturing practices are operationally distinct from each other in the context of Ugandan factories. To address this, the data was also first subjected to principal component analysis to determine and validate the underlying structure of time-based manufacturing. PCA was performed at instrument development phase to ascertain factory-managers' knowledge about the unique orientations of lean, agile and leagile in Uganda. Of the 30 items of time-based manufacturing generated, only 21 loaded with minimum score of 0.5 to 3 specific practice. 9 items failed to load into any practices. Meaning that they did not generate any meaning to the managers regarding lean production, agile manufacturing or leagile manufacturing. Three practices as indicated in the extant literature were extracted from the data. The PCA results are presented in **Table 1**.

To further test the validity of the subjective measures of lean production, agile manufacturing and leagile manufacturing, confirmatory factor analysis procedures were performed as recommended by Joseph, William, Barry, & Rolph [66]. Confirmatory factor analysis resulted into elimination of some items or factors explaining certain practices. After careful review of the items for each practice, a few problematic items were identified and deleted. In this case, LN2, LN3, LN7, LN9, LN10, LG7 and AG5, AG6, AG7 were respectively eliminated from lean, leagile and agile scales and statistically the elimination of some items did not affect the validity of the model but rather improved it.

Comparative fit index (CFI) was assessed and values more than 0.80 indicates a good fit. The root mean square error of approximation (RMSEA) was also calculated, and it was within the recommended range [66]. The relative chi-square was estimated. This estimates the errors present versus the number of parameters estimated. The low ratio of utmost 2 indicates a better model. The trimmed model subsequently had a CFI of 0.938, $\chi^2 = 103.145$, 62 d.f., RMSEA = 0.081, χ^2/d.f. 1.664 and without error terms that are significantly related.

The result depicted in **Figure 3** shows that the three practices; lean (Ln), agile (Ag) and leagile (Lg) are related to time-based manufacturing. Further evidence of convergent validity, average variance extracted and discriminant validity was provided through examination of standardized coefficients between observed variables and the latent constructs.

While assessing discriminant validity, the square root of the average variance extracted (AVE) is compared with the correlation of latent constructs. For this study, individual time-based manufacturing practice should explain better the variance of their own exogenous variables rather than the variance of other practices [67]. The extent to which time-based manufacturing practices are discriminant is indicated by the fact that all the square root values of AVE for each practice indicated along the diagonal in **Table 3** are more than their correlations with other practices. The AVE details for Lean, agile and leagile manufacturing practices are indicated in **Table 3** below.

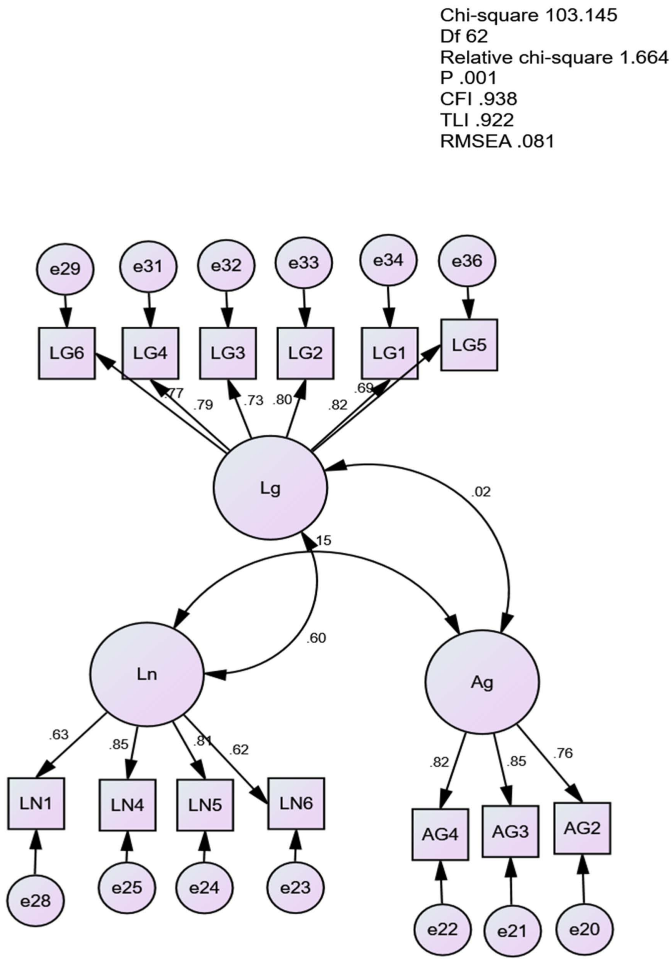

Figure 3. CFA results on three-factor model of time-based manufacturing practices.

Table 3. Average Variance Extracted (AVE), Inter-factor correlations and shared variance among the time-based manufacturing practices.

	Ln	Ag	Lg
Lean (Ln)	**0.717**	0.022	0.354
Agile (Ag)	0.149	**0.813**	0.0004
Leagile (Lg)	0.595	0.019	**0.769**
Composite reliability	**0.778**	**0.780**	**0.846**
Average Variance Extracted (AVE)	**0.515**	**0.661**	**0.592**

Internal consistence reliability between indicators of individual practices was assessed using composite reliability index. In this case, all the three measurement models are having the required composite reliability. The composite reliability indices were above 0.6. The composite reliability indices for lean, agile and leagile manufacturing practices are respectively, 0.778, 0.780 and 0.846 respectively as indicated in **Table 3** above. The results satisfactorily justify that time-based manufacturing is threefold in the context of factories in Uganda. Therefore, the second objective of the study was fulfilled.

The third hypothesis (H_3) suggested that the lean and agile initiatives build a strong leagile manufacturing system. On establishing the measurement model for individual practices of lean, agile and leagile, the path coefficients were later examined. Although the three practices are related but distinct, it is also important to assess the extent to which lean and agile initiatives facilitate successful implementation of leagile practice using structural equation model in **Figure 4**. Using the model in **Figure 4**, the extent to which lean and agile practices stimulate leagile practices is assessed. In addition, withstanding the fact that lean, agile and leagile are in progression, the indirect effect of the lean on leagile via agile manufacturing is also determined. The result revealed a sufficient model-to-data fit (χ^2 = 170.59, 100 df., TLI = 0.867, CFI = 0.902, RMSEA = 0.083, and χ^2/d.f = 1.706). In attempt to validate the structure model, items for responsiveness (FP4, FP5, FP6, FP7) were eliminated as they did not fit the model. The path analysis results indicate that lean is strongly related to leagile manufacturing compared to agile manufacturing. The standardized path coefficient for lean was positive and significant ($\beta = 0.64$, $p < 0.001$). Agile manufacturing does not significantly explain leagile manufacturing practices ($\beta = -0.109$, $p > 0.1$).

Further analyze was made on the mediating effect agile manufacturing practice. Even though not hypothesized, the results in **Table 4** indicate that agile does not exercise a partial mediation effect between lean and leagile manufacturing practices. This implies that the choice of implementation of leagile manufacturing practices is not pivotal on agile manufacturing practices. Rather, leagile manufacturing is significantly driven by establishments of lean system.

The fourth and last hypothesis (H_4) states that there a positive and significant relationship between leagile manufacturing and factory performance of small

Table 4. Standardized Beta Weights (β), CR, P-values.

Structural path	Estimate	S.E.	C.R.	P-values	Outcome
Ag ← Ln (a)	−0.109	0.163	−0.934	0.350	Not significant
Lg ← Ag (b)	0.100	0.087	1.057	0.291	Not significant
Lg ← Ln (c)	0.640	0.184	4.580	0.000	Very significant
Fp ← Lg	0.041	0.141	2.675	0.457	Not Significant
a*b	0.011				
a*b < c	Mediation does not occur				

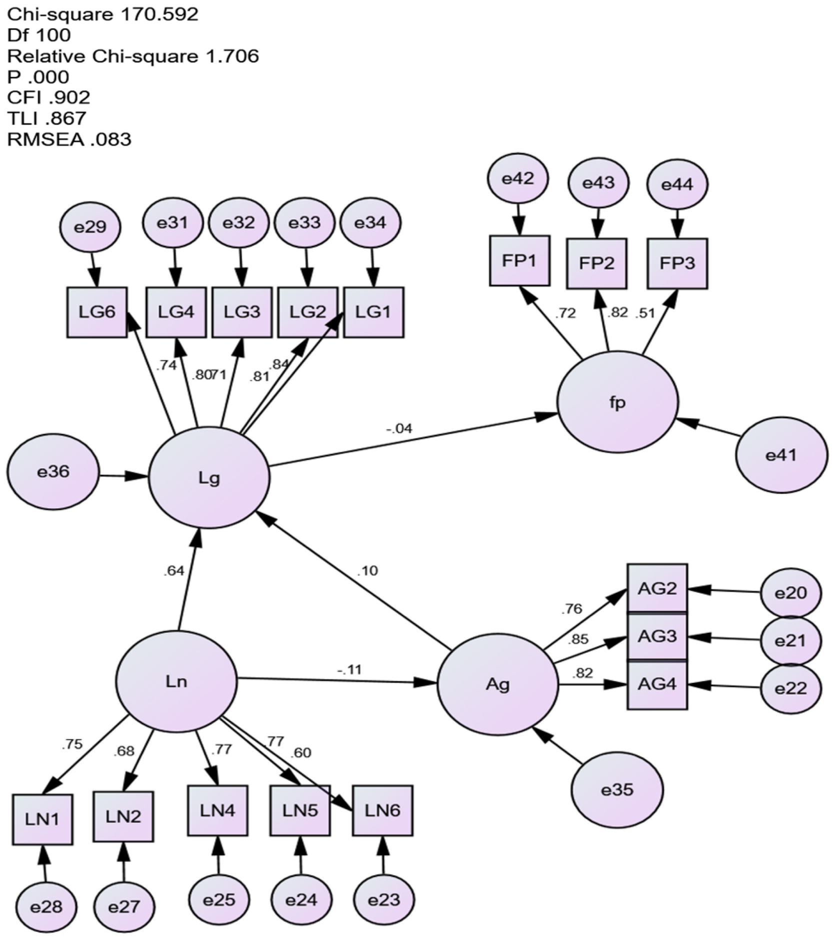

Figure 4. Leagile manufacturing model and its predictability on factory performance.

and medium factories in Uganda. H_4 is not supported by the data since the path to performance is not significant with P-value of 0.457. The standardized path coefficient is −0.041. Thus, performance of small and medium factories in Uganda is negatively associated with leagile manufacturing practices. Even though result show insignificant association, a negative element should not be ignored. The implication is that when factories concentrate on adopting leagile manufacturing practices, they are likely to loss out in terms of performance.

Discussion of Results

In the study, the underlying competences that uniquely enable adoption of time-based manufacturing practices in the contest of Uganda are investigated. The competences were threefold and distinct. The affirmative action was taken and the discriminating constructs were developed based on first objective. The core, operational and business transactions competences manifested different capabilities among small and medium factories in Uganda. PCA and CFA were used to validate the multi-dimensionality of factory competences in context of Uganda. The confirmed competence-constructs presented in the model, provide the common denominator for factories in Uganda in establishing appropriate time-based manufacturing practice. Although competences are different and distinct, the findings indicate that there are strong alignments with lean, agile and leagile processes. In particular, core competences are aligned with lean manufacturing practice, operational competences aligned with agile manufacturing practice, while business transaction competences aligned with leagile manufacturing practice.

In the case of lean, it is important to note that lean is built on high level of learning, communication standard procedure, ties and alliances, to fulfil customer expectations at low cost. Yet such competences are intangible resources that are not easily imitated. This is in line with Rajesh, Suresh, & Deshmukh [9] who argued that core competences stimulate high level of leanness. Again, the view of Wong and Aspinwall [68] is that the foundation of factories' competence shifted from physical and tangible resources to knowledge. The implication is that when factories in Uganda emphasize knowledge transfers and sharing with large-scale manufacturers, they are likely to adopt lean principles successfully. In addition, partnerships with government agencies and other organization seems to build strong foundation for the implementation of lean principles. These efforts should also aim at intensifying the intellectual work force through cross-training to enable them understand a number of processes in manufacturing industry.

On the other hand, operational competences were constructed based on information technology and organizational culture. This is in line with the fact that, the global manufacturing model indicates that successful agile system is based on integration of IT, knowledge management and organization culture [69]. The affirmed measurement scale for operational competences allows factories to boost their strength through agility. In Uganda, the collaborative nature of the partners in manufacturing equips them to serve the customer expeditiously. This however, can continue to boost their operations if all stake holders have full understanding of the factory systems and processes as emphasized by Abraham, Y Nahm; Mark, A Vonderembse; Xenophon, A Koufteros [11].

Lastly, business transaction competences were confirmed as unique enablers of leagile manufacturing. The discriminating nature of the measurement scale reveals that central principle in adopting leagile manufacturing lies in internalization and short-term contracts. These principles form the nerve center of entire factory by eliminating the trade-offs between lean and agile. Therefore, the factories in Uganda should emphasize short-term contracts and business engagements, internal sourcing and establishment of appropriate communication channels to tap into resources and leverage them to create a leagile system. This is in line with Klaus, Ram, & Rajneesh [70] argument that internalization and information sharing stimulate distinctive identity and thus reconciles conflicting forces within the system.

The second objective sought to establish whether time-based manufacturing practices of lean, agile and leagile are distinct concepts in context of Uganda. The results were affirmative. The PCA and CFA confirmed the multi-dimensional nature of three factor structure in the context of Uganda. In addition, internal consistence and composite reliability were adequate. This confirmed that the lean, agile and leagile practices are distinct but related. The relationship between observed variables and their respective latent constructs was further confirmed with convergent and average variance extracted score that were within the accepted rages. This could mean that time-based manufacturing practices of lean, agile and leagile are related but with different emphases.

The third objective aimed at determining the extent to which lean and agile manufacturing practices contribute to the establishment of a leagile manufacturing system. This claim was partially supported in the context of Uganda. On satisfying data-to-fit adequacy and validity requirement of the model, the result revealed that only lean practice predicts leagile practices. Even though lean and agile share some commonalities as connoted by Rajesh & Charlene [71], the revelation from this study indicates that their strength of influence upon establishment of leagile manufacturing practice differ. The results are contrary to the theoretical connotation on leagile system where lean and agile are perceived as mutually supportive paradigms [13] [14]. The implication is that for factories in Uganda to embrace both lean and agile systems, all the partners in the supply chain have to be included in the entire process. In this case, the integrated supply chain would remove all the boundaries to allow smooth flow of materials, resources and information. The result further discloses that adoption of leagile system is grounded in value stream that aim at eliminating waste without considering customer service. Though it may sound peculiar, it is also important to know that leanness is over-arching concept that is compatible with any production system. This is in agreement with Katayama & Bennett [72]. Withstanding the finding of current research, and the fact that lean and agile easily operate at different echelons in a supply chain [18], factories implementing leagile systems should emphasize more of leanness than agility and leagility.

In addition, mediated effect of agile to leagile was found to be statistically insignificant even though data-to-fit indices were within acceptable ranges. By including agile manufacturing factor and examining its indirect involvement in stimulating leagile practices, the mediation impact was not significant. The results revealed no improvement in the standardized coefficient of agile on leagile practice. This is contrary to the progressive nature of time-based manufacturing practices as connoted by Mattias & Jan [18] and Nagaaba & Ayebale [2]. This theoretical connotation is not supported probably due to the fact that lean stimulate any production strategy. In addition, from the linear phase of organizational development, Lean and agile are considered as primary strategies yet agile is considered occasionally due to certain circumstances [6]. Therefore, small and medium factories with in Uganda should first instill lean practices of manufacturing and other practices later as they grow.

The fourth and last objective aimed at determining the predictive power of leagile manufacturing practice on factory performance. The data did not support this assertion significantly. The structural equation modeling revealed that leagile manufacturing practice is not a predictor of factory performance in this context. The model allows small and medium factories to adopt leagile manufacturing, but the empirical findings do not support them if they are to reduce cost of conversion. This is in line with the finding of Nagaaba [5] which indicated that leagile manufacturing does not influence the level of firm's performance in developing countries. The surprising results could probably be due to the measurement model of factory performance that does not realm with key aspects of leagile manufacturing which include independence of units, delayed production and coordinated flow of components. In addition, as small and medium factories delay production until orders are placed, the delays may come with other storage related costs. Perhaps, the development of a coordinated flow of components as emphasized in a leagile system seems not to generate any benefit to the factories. This is probably due seasonality in agro processing factories whose major raw material are agricultural. The fact that agriculture still forms backbone of Uganda's production economy, over reliance of small and medium factories on agriculture inputs is not a surprise.

6. Conclusion and Recommendation

The main objective of this paper was to assess the competences that enable time-based manufacturing practices and the impact of leagile practice on factory performance. Findings indicate that each of the practice (lean, agile and leagile) was enabled by its unique competences in the context of Uganda. In addition, even though lean, agile and leagile practice blend similar attributes, they offer different manufacturing capabilities. In this case, efforts were rendered to critically validate the multi-dimensional nature of competences and time-based manufacturing practices. In all cases, the data-to-fit indices were within the acceptable range rendering the measurement model reliable and adequate. Further attempt was made to determine the mediating role of agile between lean and leagile. The results did not support the assertion. The predictive power of leagile manufacturing practice on factory performance was determined although was not supported by the data. This implied that the leagile model can probably apply in a particular category of industry. Particularly when large factories employ principles of leagile manufacturing, they would benefit more than the small and medium factories. The insignificant path index for leagile on factory performance indicates that managers of factories in Uganda should invest much in implementing other time-based manufacturing practices of lean and agile other than leagile. Probably future studies would focus on the contribution of other time-based manufacturing practices in fostering factory performance.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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