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Information systems flexibility and robustness of manufacturing firms in Nigeria

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Abstract
This study examined the nexus between Information systems flexibility and Robustness of manufacturing firms in South-South, Nigeria. Nine objectives and hypotheses were postulated to examine the relationship between the dimensions (IT flexibility, Process flexibility and Data flexibility) and the measures (Persistence, Structural stability and Superposition). A structured questionnaire was prepared, while Google forms was used to gather the data from the 210 respondents. Structural Equation Modelling (SEM) with the aid of Smart PLS 3.3.3, was used to examine the relationship between the dimensions of Information systems flexibility and the measures of Robustness. A total of 185 responses were collected and used for the analysis. The results show that all three dimensions of Information systems flexibility improved Robustness. The study recommends amongst others, that Management of manufacturing firms should adopt flexible information systems through strengthening of networks, relationships with stakeholders and the emphasis on information technology. This will advance the organisations options and provide the firm with various advantages in terms of information access and knowledge sharing needed for their agility within the business environment.

Keywords: information systems flexibility, IT flexibility, process flexibility, data flexibility, robustness, persistence, structural stability, superposition

1. Introduction

The last couple of decades proved to be the most volatile and unpredictable since the industrial revolution, maybe in history. Technological innovation, the globalization of production, the desire of customers for more individualized products accompanied by constantly fluctuating demand and shortening product lifecycles create ever new challenges for manufacturing companies. Businesses have frequently found themselves under pressure to decrease their operating costs and increase revenue, while enhancing organisational success and maintain their stability in the environment. Organizations that have thriven over the decades are those that are robust in their capacity to withstand the impoundable nature of the business world. A robust firm is able to withstand eventualities within the business environment.

A system is robust if it does not cause considerable loss of form or function (Agarwal, Blockley & Woodman, 2007) [3]. Robustness is the ability of a firm to maintain its functions against perturbations in an environment. Robustness quantifies a system's ability to adapt to unanticipated environmental changes. Changes in an unpredictable environment are complete surprises that cannot be properly anticipated. Often, these shifts occur in what are referred to as hypercompetitive contexts, which are characterized by constant change and high uncertainty. In hypercompetitive contexts, it is usually hard to forecast the new ideas, new concepts, new opportunities, and new dangers that constantly and regularly emerge. Robustness is always related with a complex system's ability to continue functioning in the face of shocks or disturbances (Mens *et al*. 2011). Organisations can be robust to constant changes in hypercompetitive, fast changing settings through the use of flexible information systems.

Information system flexibility is the ability of organisations to maintain control and react to constant changes in hypercompetitive, rapidly changing environments.

A flexible information system enables effective support for business activities such as procurement and customer relationship management (Nandakumar *et al*, 2014) [36]. It consists of systemic and usage flexibility, which enables the business to adapt to changing conditions, whether internal or external (Palanisamy & Sushil, 2003; Palanisamy, 2012) [41, 42].

The problem of poor robustness ability in the manufacturing sector has intensified over the years. This problem has manifested in the high liquidation of most manufacturing firms in the manufacturing industry There is ultimately no business that operates under a problem free environment. However, the challenge of poor resilience in the manufacturing sector has further manifested in the low adaptive capability of the firms and has also negatively affected their agility in responding to turbulent circumstances when they arise.

Eletu, Akhigbe and Nwuche (2021) [16] stated that between the years 2000 to 2016, up to 900 manufacturing firms liquidated in Nigeria as a result of their inability to be robust. According to Premium Times (2012), at least 800 enterprises ceased operations in Nigeria between 2009 and 2011 because of this harsh operating business environment. 50 manufacturing plants were shut down in 2016 (Ojoye, 2016) [39]. According to Nwaoguji (2019) [37], 50 manufacturing enterprises have shut down their operations since 2015 due to the Central Bank of Nigeria's decision to impose foreign exchange restrictions, the Federal Government's economic policies have made operating in Nigeria an extremely difficult task, and as a result. Further, Fagbemi (2021) [17] discovered that, since 2015, a total of 10 companies operating in the food, beverage, and tobacco industry have closed their businesses and facilities in Nigeria due to difficult business practices, especially due to stifling government policies, and they cite the disastrous impact of the COVID-19 pandemic on the country's economy.

The global supply chain has suffered severely since China, a major provider of inputs for manufacturing enterprises worldwide, has also suffered significant disruptions. Nigeria, as an example, has been hurt by these global disruptions in the supply chain. In the country, a huge number of manufacturing and service providers are facing raw material and intermediate input shortages. This will impede their capacity utilization, employment, and output, as well as making it harder to supply the domestic market with products. Manufacturing capacity is still in need of addressing, since the first quarter of 2021 saw a 6.5% decrease in importation of raw materials. This could create issues with local production and foreign exchange if firms are not resilient (Adekoya, 2021) [21]. Local manufacturers have noted that the economic recovery that's been spurred by the waning of the COVID-19 pandemic has presented certain operating difficulties (Adekoya, 2021) [21].

Even though GDP has improved, the manufacturing sector's share of GDP was under 10% in the years 2015-2018. However, its role in the GDP has steadily expanded to 11.6% in 2019 and 12.8% in 2020. In 2020, the rise was mostly due to inflation and because of a big drop in production in important industries caused by the implementation of control measures to curb the spread of the COVID-19 pandemic, which resulted in additional inflation. When compared to the investments made in other nations, the manufacturing sector has not drawn considerable investments, in part due to regulatory complexity. One major issue that has affected the Nigerian manufacturing industry is the government constantly reversing import policies, not following through on the stated goals in their policy statements, and creating regulatory glitches (Odutola, 2021) [38]. The ability to bend in the wind is critical for survival during storms. Hence this study seeks to examine the relationship between information systems flexibility and robustness in manufacturing firms in South-South, Nigeria.

1.1 Aim and Objectives of the Study

The aim of this study is to examine the relationship between information systems flexibility and robustness of manufacturing firms in South-South, Nigeria.

The specific objectives are to:

1. Investigate the relationship between IT flexibility and persistence.
2. Examine the relationship between IT flexibility and structural stability.
3. Determine the relationship between IT flexibility and superposition.
4. Investigate the relationship between process flexibility and persistence.
5. Examine the relationship between process flexibility and structural stability.
6. Determine the relationship between process flexibility and superposition.
7. Investigate the relationship between data flexibility and persistence.
8. Examine the relationship between data flexibility and structural stability.
9. Determine the relationship between data flexibility and superposition.

1.2 Research Hypotheses

The following null hypotheses are put forwards as tentative answers to the research questions:

Ho_1: There is no significant relationship between IT flexibility and persistence.

Ho_2: There is no significant relationship between IT flexibility and structural stability.

Ho_3: There is no significant relationship between IT flexibility and superposition.

Ho_4: There is no significant relationship between process flexibility and persistence.

Ho_5: There is no significant relationship between process flexibility and structural stability.

Ho_6: There is no significant relationship between process flexibility and superposition.

Ho_7: There is no significant relationship between data flexibility and persistence.

Ho_8: There is no significant relationship between data flexibility and structural stability.

Ho_9: There is no significant relationship between data flexibility and superposition.

2. Literature Review

This work is based on the dynamic capability theory (DCT). Augier and Teece (2009) [6] defined dynamic capabilities as an organisation's capacity to integrate, grow, and reconfigure internal and external skills in response to quickly changing circumstances. Dynamic capabilities refer to an organisation's ability to purposefully build, extend, or adjust its resource base (Helfat *et al*., 2007) [24], as referenced in Augier and Teece (2009) [6]. The dynamic capability framework's fundamental premise is that core capabilities should be used to adjust short-term competitive positions in order to develop longer-term competitive advantage. These authors assert that the literature on dynamic capacities evolved from (1) the resource-based view of the company and (2) the concept of "routines" in evolutionary theories of the organisation (Nelson & Winter, 1982), as referenced in Augier and Teece (2009) [6]. Thus, it serves as a bridge between the literature on economic-based strategy and evolutionary approaches to organisation. According to them, three dynamic qualities are required to face emerging challenges; organisations and their employees require the ability to rapidly acquire new knowledge and develop strategic resources; the company's new resources, such as capability, technology, and consumer input, must be incorporated; and existing strategic assets must be repurposed or redesigned. Treece's (2011) concept of dynamic capabilities essentially states that what matters for business is corporate agility; the capacity (1) to detect and shape threats, (2) to seize opportunities, and (3) to maintain competitiveness through the enhancement, combination, protection, and, when necessary, reconfiguration of the business enterprise's intangible and tangible assets.

Fink and Neumann (2009) [18] employed a resource-based view of the company and a dynamic capabilities approach to account for the competitive implications of flexibility. Inadequate flexibility might jeopardize an information system's performance by precluding its use in certain scenarios and necessitating exception handling. Additionally, insufficient flexibility might shorten a system's total life. However, excessive flexibility might jeopardize the effectiveness of an information system by limiting usability and increasing complexity (Economist, 2004) [15], necessitating greater initial investments, a longer implementation timeframe, and increased ongoing running and maintenance expenses (Soh *et al*., 2003) [46]. The flexibility of an information system to change impacts the work necessary to later add functionality, enlarge the database, enhance the user interface, and add processing power in information to unanticipated process scenarios enabling the firm to be robust (Gebauer & Lee, 2005) [20].

2.1 Operational Framework

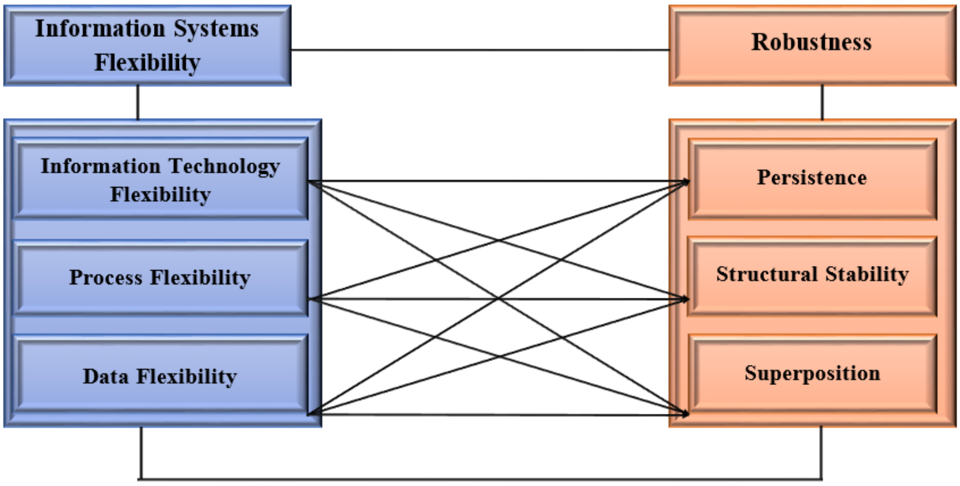


Fig 1: Operationalised by Researcher (2021)

Information Systems (IS) Flexibility

Gebauer and Schober (2006) [21] defined IS flexibility as the efficiency with which the system function is used and provided (or changed) for the purpose of providing operability, not as a tool, but as a business process, and offered a cost-efficiency metric for evaluating a given business process. A flexible information system enables effective support for business activities such as procurement and customer relationship management (Nandakumar *et al*, 2014) [36]. It consists of systemic and usage flexibility, which enables the business to adapt to changing conditions, whether internal or external (Palanisamy & Sushil, 2003; Palanisamy, 2012) [41, 42]. The information system is defined as the configurations of people, data, procedures, and technology, as well as their interactions, that are required to accomplish organisational activities (Jacome, 2007) [25]. Organisations can keep control and adapt to constant flexibility in hypercompetitive, fast changing settings through the use of flexible information systems. Theoretical studies indicate that information systems exhibit links between flexibility and efficiency comparable to those discovered for industrial systems.

Information systems are critical to an organisation's competitiveness in practically every business (Melville, Kraemer & Gurbaxani, 2004) [34]. In a commercial setting, an information system is typically thought of as being composed of numerous components: information technology components such as hardware, software, procedures, and data. A system is a collection of disparate components that work cooperatively to accomplish a common goal or purpose. As a result, an information system's components are integrated to meet certain corporate objectives and aims. Given that information systems are a critical component of determining a firm's competitiveness in an industry, these systems must be capable of adapting to any required changes in the firm's strategies and structures. It has been demonstrated that alignment of corporate strategy, organisational structures, and information systems is associated with organisational performance (Chan, Huff, Copeland & Barclay, 1997) [11]. As a result, it stands to reason that since organisations' business strategies and organisational structures are continually changing and altering in business settings, their information systems must likewise change in order to remain aligned. In such instances, information systems must be adaptable enough to change in lockstep with the businesses' strategies and structures. Prior work on information system flexibility has not taken this requirement into account when discussing information system flexibility (Byrd & Turner, 2000) [8].

Information Technology (IT) Flexibility

Byrd and Turner (2000) [8] recognized three important variables that contribute to the flexibility of information technology infrastructures: the flexibility of information technology employees, as seen by their diverse skill sets and attitudes; data and functionality integration, as enabled by an open network architecture, a plethora of interfaces with transparent access to platforms and applications, and application portability between platforms; and modularity, as facilitated by reusable software modules, vendor-independent database connectivity, and object-oriented development tools.

IT flexibility is a critical component of the organisational core competencies required to survive and succeed in rapidly changing, competitive business contexts (Byrd, Madariaga, Byrd & Mbarika, 2010) [9]. The comments imply that the concerns around IT flexibility are more about how technology is managed than about technical or architectural aspects. The initial paradigm for IS flexibility made no mention of the managerial implications of IT flexibility. A decision in point is the option that IT management must make between IT acquisition and IT development. According to managers, commercial software is chosen over in-house development for flexibility reasons. The reason for this is that commercial software has been designed from the start to be highly modifiable and thus extremely versatile. IT managers, on the other hand, believe that the IS flexibility is diminished if they are restricted from purchasing software of their choosing or pursuing a particular software solution by the global enterprise IT strategy. This is a management issue with the concept of independence. However, research indicates that when an entire organisation is evaluated, such a policy may boost flexibility in the long run (Byrd *et al*, 2010) [9]. When businesses have good IT skills, they prefer to make faster decisions in response to evolving consumer demands (Osita-Ejikeme, 2021) [40].

Process Flexibility

A simple process is easier to express and comprehend. Excessive tasks linked with a single simple task operate as a constraint on agility. Processes that are intrinsically related to operations or involve multiple business divisions should be especially adaptable. The rationale for this is that modifications to those processes have a greater influence on the organisation. Additionally, other critical factors that enhance IS flexibility in the process dimension include the mandatory alignment of processes with business rules, the mapping of policies to well-defined common processes, and the presence of a governance framework (Byrd *et al*, 2010) [9]. These criteria are all inextricably tied to the enterprise's structural characteristics. The architecture of these procedures may provide organisations facing a dynamic market environment with enhanced strategic flexibility (Byrd *et al*, 2010) [9]. According to Wagner *et al*. (2011) [50], process flexibility entails modifying the structure and behaviour of the processes involved in order to facilitate capacity reallocation and the management of anticipated environmental uncertainty in terms of risky demand.

Data Flexibility

Duncan (1995) [14] believes that critical data and core data-processing applications are an integral part of the IT foundation that enables current and future business applications. She makes a connection between infrastructure flexibility and the extent to which its resources are shareable and reusable. According to interview data, the primary data concerns affecting IS flexibility for managers are data integration, data definition, and data availability. These aspects are mentioned in passing throughout the interviews in relation to the sharable property. For instance, combining data definitions (in terms of the data required and its format) and creating naming conventions enables managers to respond quickly since they share a similar vocabulary and have access to the data required by all business units. Additionally, they view the ability to get data quickly in order to make quick decisions. The management view standards with other entities (such as other operators) as critical, owing to the high level of engagement required by the industry (e.g., to be able to share data from networks of different providers in order to calculate costs and other metrics). On the other hand, they do not believe it is necessary to enforce standards at the development level within their own information systems unit. This can be explained in part by their team structure (separate teams responsible for a particular business unit) and their extensive usage of external providers to create applications.

Robustness

A system is robust if it does not cause considerable loss of form or function, and merely a single mode of vulnerability deems a system insecure (Agarwal, Blockley & Woodman, 2007) [3]. Robustness, in a broad sense, refers to the capacity to tolerate or survive external shocks, to maintain stability in the face of uncertainty (Bankes, 2010) [7]. More precisely, robustness has been defined as a system's ability to endure structural perturbations without compromising its function (Jen, 2003) [29]. In all cases, robustness refers to a complex system's ability to continue functioning in the face of functional shocks or disturbances (Mens *et al*., 2011). This emphasis on shock resistance and systemic functioning pervades the majority of robustness applications across multiple fields. The robustness of an organisation is defined as 'its capacity to preserve its fundamental pattern under changing situations while retaining its core characteristics' (Van Oss & Van Hek 2011) [49]. Robustness quantifies a system's ability to adapt to unanticipated external changes (Golden & Powell, 2000) [22].

A system is robust as long as it retains functionality, regardless of whether it enters a new steady state or whether instability actually aids the system in coping with shocks (Kitano, 2007). The term "robustness" refers to the persistence of features in systems where the perturbations are not fluctuations in external inputs or internal system parameters, but rather changes in the system's composition, topology, or fundamental assumptions about the environment in which the system operates (Jen, 2003) [29]. Thus, robustness refers to the feature of institutional arrangements that enables a system to adjust or reestablish stability following times of uncertainty and/or transformation (Capano & Woo, 2016) [10]. Robustness refers to a system's ability to adapt its behaviour to an unanticipated change in the environment's status quo or to internal system failure. Robustness is described as a multiagent system's capacity to recover from failures and exceptions. An exception can be characterized as a divergence from the "ideal" behaviour of a system (Dellarocas & Klein 2000) [12]. Recovery would subsequently entail implementing certain corrective actions to restore the system's ideal behaviour. Robustness refers to an organisation's capacity to retain operational capabilities under a variety of conditions. However, a firm's adaptability is more than the sum of its individualistic and collabourative capacities. Capacity building must also address the organisation as a whole, with managers influencing policies, procedures, systems, technologies, structures, and culture to improve their ability to adapt to or even initiate change. Robustness is concerned with the ability of systems to remain stable in the face of uncertainty. Kitano (2004) [31] defines robustness as the ability of a system to retain its functions in the face of environmental perturbations.

Persistence

Audia, Locke and Smith (2000) [5] defined persistence as a firm's proclivity to remain with previously successful methods. Taken together, persistence in this sense refers to a decision made by a firm's top management team to continue on a present path of action in the face of opposition, failures of other enterprises, and appealing alternatives. While persistence can be advantageous when the environment is stable and cause-effect relationships are well understood, persistence in the face of environmental changes such as legislative changes, competitor business failures, and technological advances can be lethal to the organisation (Audia *et al*., 2000) [5]. Systems can employ persistence to connect robustness with strategic mechanisms of robustness (Desouza & Xie, 2021).

According to Amankwah Amoah (2014) [4], strategic persistence has two primary dimensions: short- and long-term. Persistence in the short term is defined here as persistence shortly following an occurrence. This is the point at which the outside firm judges that while there may be beneficial lessons to be learned, the unchanging nature of events dictates that persistence is the prudent course of action. Long-term persistence, on the other hand, occurs when outside enterprises believe that the failure was caused by firm-specific reasons and hence provides no meaningful insight for their businesses (AmankwahAmoah, 2014) [4]. Persistence, then, requires the decision to uphold existing commitments and avoid straying from the current approach in the face of changing circumstances. Strategic persistence may simply indicate an organisation's commitment to a certain plan or course of action (Grossman & Cannella, 2006) [23].

Structural Stability

Structural stability is a word that refers to a dynamic state, a state of stability that is capable of coping with the inherent dynamics of (developing) business settings. Thus, structural stability may be defined as a scenario characterized by sustainable development, favourable social and environmental conditions, and the capability to adapt to change (European Commission, 1996). Structural stability is a fundamental feature of a dynamical system, implying that minor disturbances have no effect on the qualitative behaviour of the trajectories. Structural stability refers to a structure's resistance to unwanted movement such as sliding, collapsing, and overturning (Jamal, 2017) [27]. Stability is defined as a structure having a sufficient number of reactions to withstand perturbations without moving (Jamal, 2017) [27]. Structural stability implies that systems have a sophisticated structural design that makes them indifferent to system inputs. As a result, it is unlikely that a change in the system's input will result in major changes in the system's output, i.e. buffering (Kitano, 2004) [30]. Structural stability is primarily responsible for persistence (Desouza & Xie, 2021). When a structure is unable to change its requirements, a structural component changes, resulting in a loss of resistance to disturbances and the structure being unstable. Instability is a risk factor for failure. When a structure is subjected to a sufficiently high level of disturbance from the environment, it tends to lose its stiffness, undergo observable change, and eventually become unstable (Lui, 2020).

Superposition

In the context of robustness, superposition refers to a system's ability to respond proactively to perturbations and preserve system functionality via dynamically altering system activities in a dynamic environment (Desouza & Xie, 2021). When addressing the hyper-turbulence of an environment, superposition is distinct from adaptation. Due to the fact that the environment might change continuously during a complex process, systems can constantly adopt multiple states in order to preserve system functionality. Given the difficulty of forecasting a highly turbulent environment, the system state necessary to maintain basic functions becomes similarly difficult to forecast. Thus, the state of a robust system can be highly unknown until the environment is fixed. Thus, the state of a robust system can be in a condition of superposition. For example, consider an organisation that is continually confronted with unforeseen blackout disruptions (Desouza & Xie, 2021).

To achieve organisational robustness, the organisation must be nimble in its approach to outsourcing in order to adapt to varying degrees of blackout disruption. Given the frequent changes in outsourcing strategies, the company's operations are highly uncertain; as a result, the organisation employs a superposition technique to create organisational robustness (Desouza & Xie, 2021) [13]. Organisations must employ the superposition method to create cognitive robustness in such an environment. Organisations must be able to reuse, innovate, and reorient their constituents (resources, processes, capabilities, and assets).

Relationship between Information Systems Flexibility and Robustness

In an era of rapid technological advancements and volatile global markets, information systems flexibility is becoming increasingly vital (Stohr & Muehlen 2008) [47]. In a flexible information system, the system can adjust or reconfigure itself in response to environmental feedback (Mahinda & Whitworth, 2004) [33]. If an information system can forecast a future environment change using system logs or data, users or programmers can alter it to accommodate such changes (Mahinda & Whitworth, 2004) [33]. Gebauer and Schober (2005) [20] conclude that the focus of information system management should be on the flexibility to change the information system to support processes with a high degree of uncertainty, whereas situations with a low degree of uncertainty require a focus on the flexibility to use the information system. The capacity for respond proactively is determined by the flexibility of an organisation's information systems (Gebauer & Schober, 2006) [21].

Seo and La Paz (2008) [45] identified numerous explanations for the detrimental effects of information technology flexibility on organisational robustness, including the massive accumulation of data and the inflexibility of information technology. Organisations must be capable of repurposing, innovating, and reorienting organisational components (resources, processes, capabilities, and assets) in unique ways. In this setting, information technology may have a greater impact on organisational robustness (Desouza & Xie, 2021) [13]. If a system is incapable of prediction but is easily changeable, it can be modified to fit the occurrences, even if they were unanticipated (Mahinda & Whitworth, 2004) [33]. Organisations are increasingly relying on information technologies, knowledge management procedures, and communication technologies to increase their robustness (Sambamurthy *et al.*, 2003) [44]. According to Tomomitsu and Moraes (2021) [48], IT flexibility has an effect on organisational robustness.

The capability of an organisation to respond more quickly and wisely to perceived signals can be based through IS flexibility (Desouza & Xie, 2021) [13]. The flexibility of information systems can significantly improve organisational communications. Thus, executives can make and implement decisions quickly. For instance, in the traditional model, numerous administrative tasks must be completed before executives approve change ideas. With an information system in place and business processes digitalized, change proposals may be authorized and implemented considerably more quickly. Additionally, information systems may do data analytics and improve organisational expertise, enabling executives to make more informed decisions in response to perceived signals. For example, there has been a recent surge in interest in leveraging big data analysis in information systems, which has the potential to significantly improve knowledge generation and decision making (Abbasi, Sarker & Chiang, 2016) [1]. Additionally, Jacome, Byrd and Byrd (2011) [26] stated that IT flexibility enables a system's robustness. Organisations must employ the superposition method to create cognitive robustness in such an environment (Seo & La Paz, 2008) [45].

The three functional mechanisms of robustness can be used to describe the effects of IS flexibility on organisational robustness. Because ISs are well-structured components of organisations, they can contribute to structural stability. IS is capable of absorbing errors, ensuring that organisational processes remain undisturbed. The use of information technology (IT) can assist organisations in rapidly identifying and addressing risks, prior to the occurrence of catastrophic consequences. For example, Nan and Lu (2014) demonstrate that businesses may efficiently manage an earthquake-induced organisational crisis by utilizing information from digital platforms. Additionally, IT flexibility can have a beneficial effect on an organisation's robustness (Desouza & Xie, 2021) [13].

3. Method

In order to conduct the study, the research sample consisting of two hundred and ten (210) managers and supervisors. The data for this research was gotten from an online survey. Google forms was used to gather the data from the respondents. A link was sent to the respondents of which questionnaire information was displayed for them to answer. Structural Equation Modelling (SEM) with the aid of Smart PLS 3.3.3, was used to examine the relationship between the dimensions of Information Systems Flexibility and the measures of Robustness.

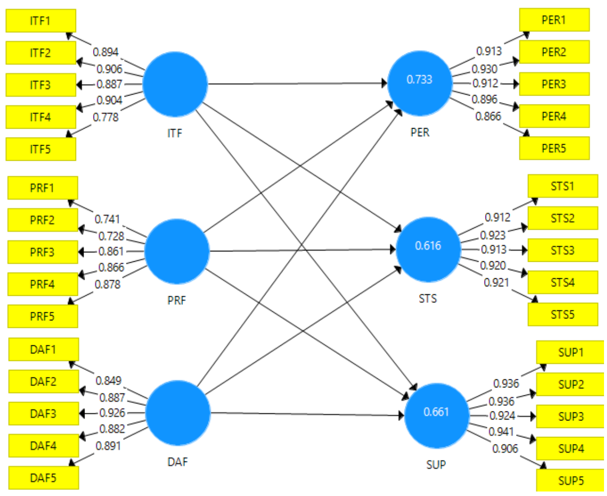
4. Data Presentation and Discussion

185 respondents, accounting for 88% of the sample size, filled the form and these filled copies were used for the analysis.

Model Specification for Structural Equation Modelling (SEM)

The model under this section contains the outer model and inner model which reflect the conceptual framework. The outer model shows how the constructs are linked to their indicators, while the inner model demonstrates the structural interconnections between the constructs. The exogenous variable is Information Systems flexibility which has IT flexibility, Process flexibility and Data flexibility, Human Resource flexibility as its dimensions. The endogenous variable is Robustness and it is decomposed into Persistence, Structural Stability and Superposition.

Note: ITF = IT Flexibility, PRF = Process Flexibility, DAF= Data Flexibility, PER = Persistence, STS = Structural Stability, SUP = Superposition



***Source*:** Smart PLS 3.3.3

Fig 2: Output for Outer Loadings of Indicators

All indicators for the dimensions and the measures satisfied the threshold condition of 0.70.

Reliability Test

The values of standardized factor loadings, indicator reliability, internal consistency reliability (composite reliability, reliability coefficients, Cronbach alpha) and convergent validity (Average Variance Extracted) are shown in Table 1 as initial SEM assessment of measurement (outer) models.

Table 1: Test of Reliability

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
DAF	0.932	0.935	0.949	0.788
ITF	0.923	0.933	0.942	0.766
PER	0.944	0.947	0.957	0.817
PRF	0.875	0.895	0.909	0.668
STS	0.953	0.954	0.964	0.842
SUP	0.960	0.961	0.969	0.863

Note: ITF = IT Flexibility, PRF = Process Flexibility, DAF= Data Flexibility, PER = Persistence, STS = Structural Stability, SUP = Superposition

Source: SmartPLS 3.3.3 output on Research Data, 2021

Both the reliability coefficients of the latent variables and their corresponding Cronbach's alpha values exceeded the 0.7 threshold. Consequently, the results verify that the extracted variables are consistent in explaining the variances that constitute them.

Validity

Analysis on discriminant (divergent) validity reveals the magnitude of empirical difference between a construct and other constructs. Each latent variable shares more variance with its own block of indicators than with another latent variable representing a different block of indicators.

Table 2: Test of Validity

	DAF	ITF	PER	PRF	STS	SUP
DAF	0.887					
ITF	0.298	0.875				
PER	0.247	0.176	0.904			
PRF	0.424	0.277	0.206	0.817		
STS	0.382	0.397	0.214	0.360	0.918	
SUP	0.104	0.336	0.541	0.163	0.568	0.929

Note: ITF = IT Flexibility, PRF = Process Flexibility, DAF= Data Flexibility, PER = Persistence, STS = Structural Stability, SUP = Superposition

Source: Smart PLS 3.3.3 Output on Research Data, 2021

Result on validity concerning the study constructs is shown in table 2. The table reveals that all the diagonal figures (square roots of the Average Variances Extracted) are higher than 0.7; and are far greater than the off-diagonal figures (correlations between the constructs), thus confirming that each construct is distinct from any other one. Therefore, the second model endorsed discriminant validity for all the constructs.

Test of Hypotheses

In order to test the bivariate hypotheses via the SEM, the bootstrap method was applied. Path coefficients (β values) of .10 to 0.29, .30 to .49 and .50 to 1.0 are weak, moderate and strong correlations, respectively. Also, for a two tailed test, *t* values greater than 1.96 are significant, while *t* values less than 1.96 are non-significant. Furthermore, hypotheses with *p*-values less than 0.05 level of significance were rejected, while those above 0.05 were accepted.

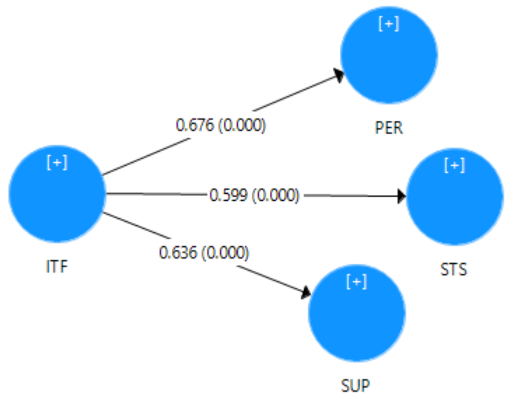
Test of Hypotheses 1-3

IT flexibility (ITF) and Robustness (PER, STS, SUP)

Ho$_1$: There is no significant relationship between IT flexibility and persistence.

Ho$_2$: There is no significant relationship between IT flexibility and structural stability.

Ho$_3$: There is no significant relationship between IT flexibility and Superposition.



Source: SmartPLS 3.3.3 Output on Research Data, 2021

Fig 2: Specific Path Model of Latent Variables of ITF and ROB (PER, STS, SUP)

The path relationship analysis presented in figure 2 indicate that there are positive and significant paths between IT flexibility and persistence (β = 0.676, p = 0.000), IT flexibility and structural stability (β = 0.599, p = 0.000), and IT flexibility and Superposition (β = 0.636, p = 0.000). Therefore, H_{O1}, H_{O2} and H_{O3} were rejected.

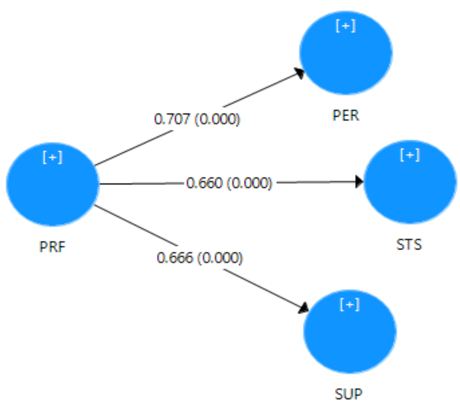
Test of Hypotheses 4-6

Process flexibility (PRF) and Robustness (PER, STS, SUP)

Ho$_4$: There is no significant relationship between process flexibility and persistence.

Ho$_5$: There is no significant relationship between process flexibility and structural stability.

Ho$_6$: There is no significant relationship between process flexibility and Superposition.



Source: Smart PLS 3.3.3 Output on Research Data, 2021

Fig 3: Specific Path Model of Latent Variables of PRF and ROB (PER, STS, SUP)

The path relationship analysis presented in figure 3 indicate that there are positive and significant paths between process flexibility and persistence (β = 0.707, p = 0.000), process flexibility and structural stability (β = 0.660, p = 0.000), and process flexibility and Superposition (β = 0.666, p = 0.000). Therefore, H_{O4}, H_{O5} and H_{O6} were rejected.

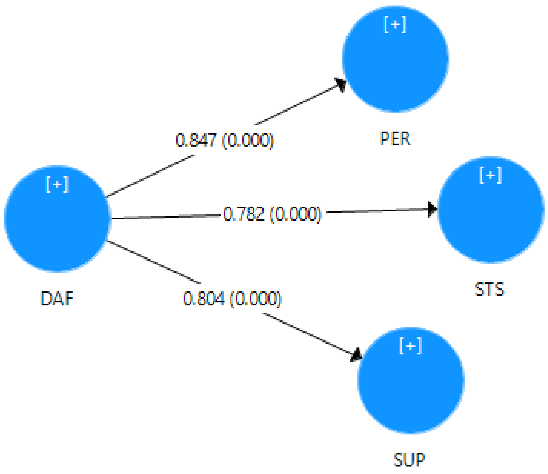
Test of Hypotheses 7-9

Data flexibility (DAF) and Robustness (PER, STS, SUP)

H_{O7}: There is no significant relationship between data flexibility and persistence.

H_{O8}: There is no significant relationship between data flexibility and structural stability.

H_{O9}: There is no significant relationship between data flexibility and Superposition.



Source: *Smart PLS 3.3.3 Output on Research Data, 2021*

Fig 4: Specific Path Model of Latent Variables of DAF and ROB (PER, STS, SUP)

The path relationship analysis presented in figure 4 indicate that there are positive and significant paths between data flexibility and persistence (β = 0.847, p = 0.000), data flexibility and structural stability (β = 0.782, p = 0.000), and data flexibility and Superposition (β = 0.804, p = 0.000). Therefore, H_{O7}, H_{O8} and H_{O9} were rejected.

Table 3: Results of Hypotheses Testing

Null Hypothesis	Path (Relationship)	Path Coefficient (β)	T Statistics (t)	P Values (p)	Predictive Accuracy (R^2)	Level of Relationship	Decision on Hypothesis
H_{O1}	ITF -> PER	0.676	13.765	0.000	0.456	Substantial, Positive and Significant	Rejected
H_{O2}	ITF -> STS	0.599	10.175	0.000	0.359	Substantial, Positive and Significant	Rejected
H_{O3}	ITF -> SUP	0.636	10.885	0.000	0.405	Substantial, Positive and Significant	Rejected
H_{O4}	PRF -> PER	0.707	13.936	0.000	0.500	Substantial, Positive and Significant	Rejected
H_{O5}	PRF -> STS	0.660	10.041	0.000	0.433	Substantial, Positive and Significant	Rejected
H_{O6}	PRF -> SUP	0.666	10.612	0.000	0.440	Substantial, Positive and Significant	Rejected
H_{O7}	DAF -> PER	0.847	32.722	0.000	0.717	Substantial, Positive and Significant	Rejected
H_{O8}	DAF -> STS	0.782	17.171	0.000	0.611	Weak, Positive and Significant	Rejected
H_{O9}	DAF -> SUP	0.804	18.110	0.000	0.647	Weak, Positive and Significant	Rejected
Note: ITF = IT Flexibility, PRF = Process Flexibility, DAF= Data Flexibility, PER = Persistence, STS = Structural Stability, SUP = Superposition							

Source: Output on Research Data, 2021

Discussion of Findings

IT flexibility and Persistence

The results on IT flexibility and persistence show that β = 0.676, p = 0.000, R^2= 0.456. This shows that IT flexibility has a positive, substantial and significant relationship with persistence. An increase in IT flexibility will lead to an increase in persistence. The coefficient of determination (R^2= 0.456) implies that a unit change in IT flexibility will account for up to 45.6% total variation in persistence. Hence, IT flexibility is important if a firm desires to be persistent. This finding is supported by Gebauer and Schober (2005) [20] who concluded that the focus of information system management should be on the flexibility to change the information system to support processes with a high degree of uncertainty, whereas situations with a low degree of uncertainty require a focus on the flexibility to use the information system.

IT flexibility and Structural stability

The results on IT flexibility and structural stability show that β = 0.599, p = 0.000, R^2= 0.359. This shows that IT flexibility has a positive, substantial and significant relationship with structural stability. An increase in IT flexibility will lead to an increase in structural stability. The coefficient of determination (R^2= 0.359) implies that a unit change in IT flexibility will account for up to 35.9% total variation in structural stability. Hence, IT flexibility is important for a firm to be structurally stable. This finding is in congruence with that of Mahinda and Whitworth (2004) [33] who asserted that in a flexible information system, the system can adjust or reconfigure itself in response to environmental feedback.

IT flexibility and Superposition

The results on IT flexibility and superposition show that β = 0.636, p = 0.000, R^2= 0.405. This shows that IT flexibility has a positive, substantial and significant relationship with superposition. An increase in IT flexibility will lead to an increase in superposition. The coefficient of determination (R^2= 0.405) implies that a unit change in IT flexibility will account for up to 405% total variation in superposition. Hence, IT flexibility is important in a firm's quest for superposition. This finding concurs the work of Jacome, Byrd and Byrd (2011) [26] who stated that IT flexibility enables a system's robustness. Organisations must employ the superposition method to create cognitive robustness in such an environment (Seo & La Paz, 2008) [45].

Process flexibility and Persistence

The results on process flexibility and persistence show that β = 0.707, p = 0.000, R^2= 0.500. This shows that process flexibility has a positive, substantial and significant relationship with persistence. An increase in process flexibility will lead to an increase in persistence. The coefficient of determination (R^2= 0.500) implies that a unit change in process flexibility will account for up to 50.0% total variation in persistence. Hence, process flexibility is important if a firm desires to be persistent. This finding is supported by Gebauer and Schober (2006) [21] who opined that the capacity to respond proactively is determined by the flexibility of an organisation's information systems.

Process flexibility and Structural stability

The results on process flexibility and structural stability show that β = 0.660, p = 0.000, R^2= 0.433. This shows that process flexibility has a positive, substantial and significant relationship with structural stability. An increase in process flexibility will lead to an increase in structural stability. The coefficient of determination (R^2= 0.433) implies that a unit change in process flexibility will account for up to 43.3% total variation in structural stability. Hence, process flexibility is important for a firm to be structurally stable. This finding is in congruence with that of Mahinda and Whitworth (2004) [33], that if an information system can forecast a future environment change using system logs or data, users or programmers can alter it to accommodate such changes.

Process flexibility and Superposition

The results on process flexibility and superposition show that β = 0.666, p = 0.000, R^2= 0.440. This shows that process flexibility has a positive, substantial and significant relationship with superposition. An increase in process flexibility will lead to an increase in superposition. The coefficient of determination (R^2= 0.440) implies that a unit change in process flexibility will account for up to 44.0% total variation in superposition. Hence, process flexibility is important in a firm's quest for superposition. This finding concurs the work of Tomomitsu and Moraes (2021) [48] that process flexibility has an effect on organisational robustness. Organisations are increasingly relying on information technologies, knowledge management procedures, and communication technologies to increase their robustness (Sambamurthy *et al*., 2003) [44].

Data flexibility and Persistence

The results on data flexibility and persistence show that β = 0.847, p = 0.000, R^2= 0.717. This shows that data flexibility has a positive, substantial and significant relationship with persistence. An increase in data flexibility will lead to an increase in persistence. The coefficient of determination (R^2= 0.717) implies that a unit change in data flexibility will account for up to 71.1% total variation in persistence. Hence, data flexibility is important if a firm desires to be persistent. This finding is supported by Gebauer and Schober (2005) [20] who concluded that the focus of information system management should be on the flexibility to change the information system to support processes with a high degree of uncertainty. If an information system can forecast a future environment change using system logs or data, users or programmers can alter it to accommodate such changes (Mahinda & Whitworth, 2004) [33].

Data flexibility and Structural stability

The results on data flexibility and structural stability show that β = 0.782, p = 0.000, R^2= 0.611. This shows that data flexibility has a positive, moderate and significant relationship with structural stability. An increase in data flexibility will lead to an increase in structural stability. The coefficient of determination (R^2= 0.611) implies that a unit change in data flexibility will account for up to 61.1% total variation in structural stability. Hence, data flexibility is important for a firm to be structurally stable. This finding is in congruence with that of Javanmardi *et al* (2011) [28] who found a significant relationship between ICT and organisational structural stability. Sambamurthy *et al*. (2003) [44] pointed that organisations are increasingly relying on information technologies, knowledge management procedures, and communication technologies to increase their structural stability.

Data flexibility and Superposition

The results on data flexibility and superposition show that β = 0.804, p = 0.000, R^2= 0.647. This shows that data flexibility has a positive, weak and significant relationship with superposition. An increase in data flexibility will lead to an increase in superposition. The coefficient of determination (R^2= 0.647) implies that a unit change in data flexibility will account for up to 64.7% total variation in superposition. Hence, data flexibility is important in a firm's quest for superposition. This finding concurs the work of Jacome, Byrd and Byrd (2011) [26] who stated that IT flexibility enables a system's superposition. The capability of an organisation to respond more quickly and wisely to perceived signals can be based through IS flexibility (Desouza & Xie, 2021) [13]. Nan and Lu (2014) demonstrate that businesses may efficiently manage an earthquake-induced organisational crisis by utilizing information from digital platforms.

5. Conclusions and Recommendations

This research shows that all three dimensions of information systems flexibility included in the model improved the measures of robustness. The result also posited that there is a significant and positive relationship between information systems flexibility and robustness. The following recommendations are made:

1. Management of manufacturing firms should adopt flexible information systems through strengthening of networks, relationships with stakeholders and the

emphasis on information technology. This will advance the organisations options and provide the firm with various advantages in terms of information access and knowledge sharing needed for their agility within the business environment.

2. Manufacturing firms managers should look out for flexible information technologies, knowledge management procedures, and communication technologies in order to boost their agility.
3. Management of manufacturing firms should adopt flexible information systems as this would assist the firm in rapidly identifying and addressing risks, prior to the occurrence of catastrophic consequences.

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