EJABM European Journal of Applied Business and Management

European Journal of Applied Business Management, 9(1), 2023, pp. 140-162 ISSN 2183-5594

Research Paper

Manufacturing flexibility and business environment uncertainty: Establishing supporting practices within manufacturing flexibility

Submitted in 06, March 2023
Accepted in 13, March 2023
Evaluated by a double-blind review system

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ABSTRACT

Purpose: There is a growing interest in the role of flexibility in manufacturing companies, especially in its relevance to managing business uncertainties. Several studies have been conducted on manufacturing flexibility, but no study has examined a possible support practice among the practices of manufacturing flexibility. This study explores that literature gap in a Sub-Saharan business environment.

Design/methodology/approach: This study adopts a cross-sectional survey approach and criterion sampling method to select and administer its research instrument to respondents of the study. The sample size was 416, and the hypotheses were tested via the structural equation model.

Findings: Study revealed that mix flexibility had a direct impact on supply uncertainty; production flexibility had a direct impact on supply uncertainty; and product flexibility had direct and indirect impact supply uncertainties. Volume flexibility is the only flexibility dimension with no impact on supply uncertainty, both directly and indirectly. In addition, product flexibility is the only practice with indirect impact on supply uncertainty.

Practical implications: Managers can adopt manufacturing flexibility to combat supply uncertainty. Funding production and product flexibility will enhance capacities in managing supply uncertainties. Managers should establishing product flexibilities prior to other forms of flexibilities. Practitioners considering implementing one dimension can employ production flexibility to limit supply uncertainty, because it has the most impact on supply uncertainty individually.

Originality/value: This study contributes to literature by uniquely examining manufacturing flexibility impact on supply uncertainty exclusively. It is also the first empirical investigation into supporting practices among manufacturing flexibility practices in any business environment.

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European Journal of Applied Business Management, 9(1), 2023, pp. 140-162 ISSN 2183-5594

Keywords: Manufacturing, Flexibility, Uncertainty, Production.

1. Introduction

The business world is a global village, and business challenges continue to grow and evolve. Competition in business has driven most businesses underground, while others adapted quickly escape extinction, in addition to this; there exist uncertainties from the demand end of supply chain which is accompanied by the risk of supply disruption. As Svensson (2002) puts it, supply chain disruption can be viewed as any scenario that cuts (unexpectedly) the flow of inputs needed for production of goods or service. This disruption could be internal (Chorpa & Sodhi, 2004) or external (Sheffi, 2001; & Cooke, 2002). Practically speaking, uncertainty in the business environment is constant, while a possible supply chain disruption is a matter of when (Skipper & Hanna, 2009), hence, firms must prepare for this possibility if they want to build responsiveness that can minimize the effect of supply disruptions.

Large firms with interdependent processes are more vulnerable in the event of supply chain disruption (Christopher & Holweg, 2011; & Durach, Glasen, & Straube, 2017), however, flexibility in manufacturing provides more capacity to responsiveness when these events /disruptions occur (Skipper & Hanna, 2009). Flexibility itself provides some form of back-up plan for organisations that are more likely to face disruption (Skipper & Hanna, 2009), even as studies are tilting towards more of proactive planning to mitigate the damage caused by supply disruptions (Paul, Sarker, and Essam 2014; Kamalahmadi and Parast 2016; Ivanov, Sokolov, Pavlov, Dolgui, & Pavlov 2016; and Ivanov, Dolgui, Sokolov, & Ivanov 2017). Manufacturing flexibility which focuses on the internal flexibilities (Duclos, Vokurka, & Lummus, 2003; Fredriksson & Wanstrom, 2015) could aid improved production pace and improved new product development pace. Manufacturing organizations operate in business environments that are highly uncertain in character, which is an offspring of the increasing rate of dynamic customer preferences/expectations, coupled with aggressive competition and technological changes (Zhang, Vonderembse, & Lim, 2003; Chang, Lin, Chen, Huang 2005; Seebacher and Winkler, 2014). The contemporary studies within manufacturing understudy manufacturing flexibility in a bid to develop capacity to improve responsiveness to uncertainties (Fayezi 2014, Scherrer-Rathje 2014, Lafou 2016; Khalaf & El-Mokadem, 2019). Studies conducted by the business continuity institute (BCI) (2013) revealed that 75 percent of manufacturing firms encountered a minimum of one disruption; where 21 percent of these affected firms recorded above a €1M loss in a single incident (Business Continuity Institute, 2013). Disturbing research results of this nature continue to drive the interest into mitigation strategies against uncertainties.

2. Literature Review

2.1 Theoretical framework: Resource Based View (RBV)

The resource-based view ideology is that any firm who exploits any opportunity, does so with the resources at their disposal. In like manner, if the firm is to fend off threats to the continuity of the firm, it must do so with its resources (Barney 1991). Resources that are valuable, rare, non-substitutable and not easily imitated by competitors are the ones every firm needs to build (Barney, 1991). Earliest mention being the strategic management journal in 1984, Birger Wernerfelt emphasized the building of capacities that could not be replicated (Wernerfelt, 1984; Kraaijenbrink, Spender, & Groen, 2010). Flexibility is often seen as a strategic resource to exploit the seemingly unnoticed opportunity that exists in the event of a disruption to an industry, because while others are in confusion, a flexible manufacturing system would be capitalising on the failings of others to gain market share. Thus, the theory is relevant to this study because while organisations may understand flexibility as a resource, implementation is always different, and the uniqueness gives the resource to exploit in times of disruption occurrence.

2.2 Conceptual framework

2.2.1 Manufacturing flexibility

While several works have studied the relevance of manufacturing flexibility to a firm's competitive advantage and performance at large (Oke, 2013; Abdelilah, Korchi, & Balambo, 2018), there is much on manufacturing flexibility undone (Jain, Jain, Chan, & Singh, 2013; Mishra, Ashok, & Ganapathy, 2014). Literature also posits that if the forgone alternative of flexibility is quality and/or cost, then it was wrongly implemented (Scherrer-Rathje *et al*., 2014), therefore, it's imperative to not only accept manufacturing flexibility, but implement it properly to avoid invaluable collateral damage to competitiveness. Manufacturing ability is creating a system to adapt to changes, because the changes are beyond your control (Chaudhuri, Boer, & Taran, 2018); however, some studies opine that it cannot be achieved via individual effort (Christopher & Towill, 2001; & Lin, Chiu, & Chu, 2006). The ability to withstand the risks posed by an uncertain environment (inclusive of threats from aggressive competitors, and disruptions), while maintaining recommendable quality and price might occur through flexibility (Seebacher & Winkler, 2014; and Khalaf & El-Mokadem, 2019).

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A review study by Jain *et al*., (2013) on manufacturing flexibility listed 12 dimensions, including machine, operation, routing, volume, expansion, mix (i.e. process), product, production, material handling, programme, market and labour. That being said, volume flexibility and mix flexibility seem to be more profound than others in the measurement of manufacturing flexibility literature (Danese *et al*., 2013; Scherrer-Rathje *et al.,* 2014; & Chaudhuri *et al.,* 2018). In addition to the most used manufacturing flexibility dimensions (mix and volume), tactical manufacturing flexibilities; i.e. product and production (Stevenson & Spring, 2007) will be added. They are very crucial to the creation of new/multiple products, as well as adding or replacing parts of the systems without incurring high costs, and they may have great impact on supply disruptions/uncertainties. This study will therefore consider volume, mix, product, and production as the parameters of manufacturing flexibility.

2.2.2 Uncertainties/disruptions in the wake of Covid 19

The risk posed by the presence of uncertainty in the business environment is a constant, and that is why decision making is given to competent hands to steer the organisation toward its goals despite these uncertainties that abound. The most appreciated decisions are those that can handle the external environment (Otley, 2016; & Arieftiara, Utama, & Wardhani, 2017). With the world at the mercy of the novel corona virus, several organisations are in constant meetings to mitigate the effect of supply chain disruptions especially on the supply end. The disruption has affected the big and small of the business world, with over 90% of the top firms said to have felt the effect of the supply chain disruption already (Zanni, 2020; Erik 2020), and prepares for even more shock waves. Uncertainty is seen as the scenario where predicting outcomes are incredibly tough due to the complex dynamic nature of the business environment (Silva & Ferreira, 2017).

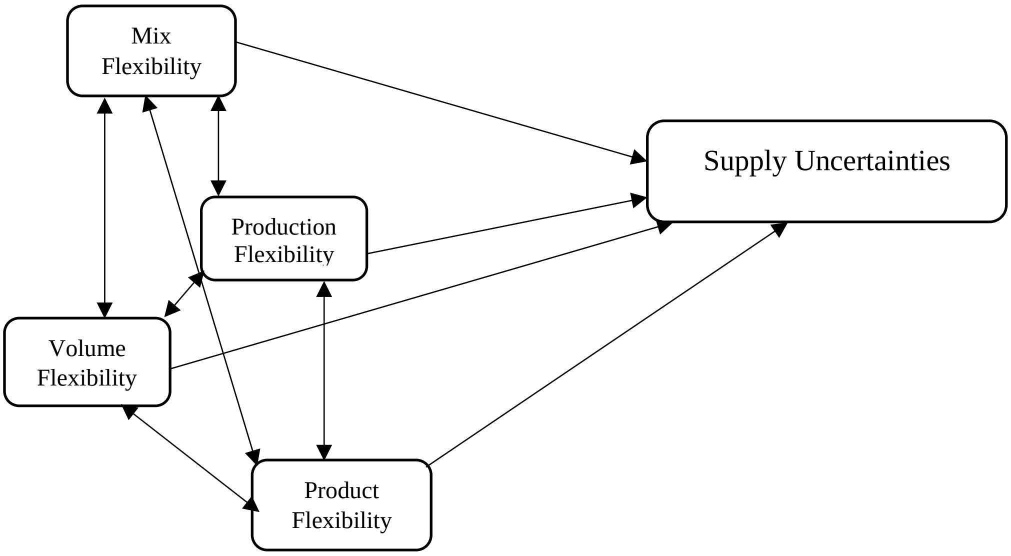
Environmental uncertainty is undeniably a major limitation to competitiveness of focal firms and their supply chain (Nagarajan, Savitskie, Ranganathan, Sen, & Alexandrov 2013). As a construct; it is pivotal to managers as they craft the way forward for firms (Sharma, Aragón-Correa, & Rueda-Manzanares, 2007; López-Gamero, Molina-Azorín, & Claver-Cortés, 2011), yet, there are insufficient studies into what could provide the upper hand to the decision-making process in the battle against uncertainty (López-Gamero *et al*., 2011; Rojo *et al.*, 2018). The corona virus first manifested in China sometime late 2019, and has caused several planning difficulties and supply chain disruptions. China being home to most of the major suppliers of manufacturing firms in Nigeria, it is greater cause for concern in the country. Before becoming a global pandemic, China had earlier (January) placed restrictions on regular trading to curb its spread (Zanni, 2020), inevitably causing the first shock waves of disruption to Nigeria and the rest of the world. Manufacturers in Nigeria were hoping this would be resolved quickly, unfortunately, the reverse was the case. However, with restrictions on trade importations as we know it for the time being, firms who were mostly reliant on the suppliers from China are left in the wind as Nigeria gradually eases its restrictions on movement and trading. This study will be examining supply uncertainty/disruption

2.2.3 Manufacturing flexibility and supply uncertainties

History has shown that a supply disruption is somewhere down the road, and cannot be wished away. Smart managers prepare the best way possible to cushion its shock wave. Toyota lost a possible $300 million plus sales to a supply disruption (fire outbreak at a supplier factory) in 1997 (Converium, 2006), BCI's study (2013) result revealed several million-dollar disruption incidents across countries and continents. All these uncertainties, growing and unstoppable; requires even more flexibility in manufacturing firms (Sanchez & Perez, 2005). As skipper and Hanna (2009) said, the event of disruption is not the focus, it is the expected magnitude of the event that's the focus, hence, the drive behind the level of investment in flexibility initiatives. While this level of supply chain disruption could not have been envisaged in most wild dreams, after all; the last time the world encountered this level of supply chain disruption was in 1968 with the Flu pandemic (CDC, 2020). Necessary investments to cushion this level of threat may not have been made. That said, investments to manage uncertainties are expected to exist, especially regarding flexibility. This peculiar time presents an invaluable window to assess the relevance of intra-firm flexibility to manufacturing systems in developing nations such as Nigeria. Afterall, the essence of flexibility was for times like these.

2.3 Conceptual model

Figure 1: Research model of the interaction among manufacturing flexibility dimensions and supply disruption/uncertainties.



Source: Own elaboration

2.4 Hypotheses development

Though manufacturing flexibility has been said to bring favourable outcomes to manufacturing firms (Oke, 2013; Mishra, 2016; Mishra, Ashok, & Ganapathy, 2017). The individual impact of its parameters has not been sufficiently tested on different aspects of organisational performance (Camison & Lopez, 2010; Alamro, Awwad, & Anouze, 2018). It is therefore important for studies to isolate the exclusive parameters of manufacturing flexibility and test their impact on different aspects of firm, in this case supply uncertainty management. This will highlight the individual impact of manufacturing flexibility practices on supply uncertainty. The study on manufacturing flexibility by Mishra (2016) revealed that its limitation of being qualitative and domiciled in India was cause for other studies to replicate its study across other geographic regions with emphasis to quantitative approach. The study implicitly asked further studies to investigate (quantitatively) the relationship and impact of manufacturing flexibility on performance dimensions. This study uniquely intends to fill that gap by empirically testing the impact of manufacturing flexibility on supply uncertainty using a Sub-Saharan nation as the focus. Therefore contribution to the research on flexibility and uncertainty from the Sub-Saharan view. Upon examination of manufacturing flexibilities and its impact on responsiveness to uncertainties, Kim, Suresh, and Kocabasoglu-Hillmer, (2013) revealed a direct impact of market flexibility on supply chain responsiveness towards supply disruptions, as well as a direct relationship among some dimensions of manufacturing flexibility. However, the study did not research multiple indirect relationships using manufacturing flexibility dimensions. After all, absence of direct impact does not necessarily mean absence of significant impact (Udofia, Adejare, Olaore,

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& Udofia, 2021). Among other concerns and recommendations of the study by Mishra *et al*., (2017), it called for empirical studies on manufacturing flexibility impact on several aspects of firms domiciled in developing nations.

Singh, Acharya, and Modgil (2020) understudied how flexibility may affect capacity for uncertainties management, they however called for other studies to investigate the flexibility impact on uncertainties in their business environment. They argued that the business environment could have different levels of uncertainty, thus, changing the dynamics in the relationship. It is important for corresponding studies on flexibility and uncertainty to be conducted from other business regions, especially, other developing nations for comparison of findings. Though Jain *et al.*, (2013) called for more empirical studies into manufacturing flexibilities and responsiveness to disruptions, Jain *et al*., (2013) comprehensive literature review suggested future research to investigate the relationships between flexibility dimensions as this will fortify the understanding of manufacturing flexibility in a holistic manner of the firm. Russell, Ruamsook, and Roso, (2022) further emphasised the need more studies in the interrelationships between the flexibility dimensions and various parameters of organisational performance. There is no study investigating inter-relationship among manufacturing flexibility dimensions when interacting with any form of uncertainty. Therefore, this study is the first to attempt the establishment of support practices within manufacturing flexibility when faced with supply uncertainties, and from Sub-Saharan Africa. From these literatures, the following hypotheses were formulated in their alternate forms.

H1: Mix flexibility has a significant direct impact on supply uncertainty
H2: Mix flexibility has a significant indirect impact on supply uncertainty
H3: Volume flexibility has a significant direct impact on supply uncertainty
H4: Volume flexibility has a significant indirect impact on supply uncertainty
H5: Production flexibility has a significant direct impact on supply uncertainty
H6: Production flexibility has a significant indirect impact on supply uncertainty
H7: Product flexibility has a significant direct impact on supply uncertainty
H8: Product flexibility has a significant indirect impact on supply uncertainty

3. Methodology

3.1 Design, population, and sample

Employing a cross sectional survey design, the population of this study is comprised of manufacturing firms that had been registered on the Nigerian Exchange Group (NGX). That is, all employees of the 38 manufacturing firms that are listed in the Nigerian

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Exchange Group, which is 19,500. The study employed a criterion sampling method, it sampled manufacturing firms who were present in all 6 geo-political regions of the country, had over 200 employees, and had been listed and doing business as at least January, 2010 in Nigeria. This resulted in 35 firms. These criteria were carefully deployed to capture firms that were big, had a national presence, and were old enough (in Nigeria) to have experienced one or more supply chain disruption, which will trigger some investment in flexibility mitigating strategies. However, after contacting all firms in the bracket to request for participation in the survey, 16 firms indicated interest. A Google form was created to capture all items on the research instrument, and was sent to all 16 firms to distribute to the Executives (Managing Directors/CEOs/COOs/Directors), Managers, Assistant managers, Coordinators, and Supervisors of specific departments, including the Operations/Production, Supply chain/Logistics, Procurement, Inventory, and Marketing in their respective firms. Provision was made for 26 employees of the interested 16 manufacturing firms (that is, a sample of 416). This is appropriate because it is higher than the minimum required sample size of 391 for the population using the Yamane formula (1967).

3.2 Research instrument

A content validation was conducted on the research instrument by two industry practitioners in operations and supply chain management and 1 senior academician in operations management. In addition, a pilot study was conducted on the instrument to ascertain its simplicity and reliability. This was done by mailing it to twenty departmental heads who filled and returned them. The Cronbach Alpha figure for the research instrument was .811, thus, acceptable being above .70 (Ghazali, 2016). The response to the items on the questionnaire were drafted to reflect the Likert scale of 1-5 representing strongly disagree – strongly agree respectively. The questionnaire was largely broken into 2 section, where the first addressed information about the demographic details of the respondent. The second section covers items that help measure the variables under investigation. The second section of twenty-five items was further broken down into two variables. That is manufacturing flexibility and supply uncertainty. Twenty items measured all four manufacturing flexibility dimensions (Mix, Volume, Production, and Product flexibility) adopted in this study, that is, five items for each flexibility dimension. While five items measured supply uncertainty.

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Table 1: Measurement items

MANUFACTURING FLEXIBILITY		
Mix Flexibility (MF)		
MF1	We can produce different product types without major changeover.	(Oke, 2013)
MF2	The manufacturing system can quickly changeover to a different product mix.	(Tamayo-Torres *et al*., 2011)
MF3	The material requirements for the products produced in the plant vary greatly from one product to another.	(Tamayo-Torres *et al*., 2011)
MF4	Productivity levels are not affected by changes in product mix.	(Tamayo-Torres *et al*., 2011)
MF5	We can simultaneously produce multiple products in our production plant	(Oke, 2013)
Volume Flexibility (VF)		
VF1	The existing capacity can adjust to a large number of production volume changes	(Larso, Doolen, & Hacker, 2009)
VF2	The existing capacity can handle a high variation in volume changes	(Larso *et al*., 2009)
VF3	Capacity changes can be made quickly	(Larso *et al*., 2009)
VF4	Capacity changes can be made economically	(Larso *et al*., 2009)
VF5	Changes in capacity do not increase time delays	(Larso *et al*., 2009)
Production Flexibility (PF)		
PF1	The production system can produce several products without modification to the machines	Stevenson & Spring, 2007
PF2	The production system is designed to produce with different raw materials	Jain *et al*., 2013
PF3	The production system can easily switch production focus with minimal machine part change	Jain *et al*., 2013
PF4	We are frequently introducing new products to the market	Jain *et al*., 2013
Product Flexibility (PFL)		
PFL1	Design modifications are done with minimal cost	(Kim *et al*., 2013)
PFL2	Existing products lines are frequently modified.	(Tamayo-Torres *et al*., 2011)
PFL3	There are a large number of modified products produced each year	(Tamayo-Torres *et al*., 2011)
PFL4	The features of existing products are often modified	(Tamayo-Torres *et al*., 2011)
PFL5	Modified products can be made quickly	(Tamayo-Torres *et al*., 2011)
SUPPLY UNCERTAINTY (SU)		
SU1	We have experienced supply failures that affects production	Chaudhuri *et al*., 2018
SU2	There is a possibility of shipment operations being interrupted affecting your deliveries	Chaudhuri *et al*., 2018
SU3	There is a possibility of extended lead time at supplier’s end	Mishra *et al.*, 2017
SU4	There is uncertainty relating to change in price of raw materials	Mishra *et al.*, 2017
SU5	Uncertainty related to quality of raw material supplied	Mishra *et al.*, 2017

Source: Own elaboration

4. Results

4.1 Measurement model

Multivariate normality was tested by looking at the Mahalanobis number range for the data, which was 1.002 to 84.623. The critical value was calculated be 36.42, and all rows (22) with a Mahalanobis figure greater than the critical value were deselected. The multi collinearity was done by assessing the Tolerance and the VIF values of the data set, which revealed that both values were within range (tolerance < 0.2 and VIF < 5). The sample size of the study 491 was adequate for SEM, and positive definiteness was ensured by running an exploratory factor analysis that revealed a determinant value of 2.174, a

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Kaiser-Meyer-Olkin (KMO) value of .788, and significant value 0.000 (Lowry and Gaskin,2014).

Table 2: Construct assessment

Construct	items	Factor loading	CFI	GFI	RMR	NFI	*p*	Cronbach α	AVE	CR
Mix Flexibility (MF)	MF1	.712	.921	.920	.071	.924	.061	.724	.616	.722
	MF2	.881								
	MF3	.824								
	MF4	.771								
	MF5	.782								
Volume Flexibility (VF)	VF1	.739	.934	.913	.052	.961	.059	.702	.522	.827
	VF2	.875								
	VF3	.799								
	VF4	.813								
	VF5	.892								
Production Flexibility (PF)	PF1	.711	.907	.951	.044	.932	.049	.870	.612	.892
	PF2	.832								
	PF3	.790								
	PF4	.903								
Product Flexibility (PFL)	PFL1	.811	.948	.942	.069	.975	.154	.794	.598	.873
	PFL2	.847								
	PFL3	.793								
	PFL4	.878								
	PFL5	.729								
Supply Uncertainty (SU)	SU1	.772	.911	.933	.047	.988	.044	.731	.638	.877
	SU2	.897								
	SU3	.758								
	SU4	.884								
	SU5	.821								

Source: Field Survey (2022)

The reliability of the constructs was adequately above 0.7 (Ghazali, 2016), as seen in the Table 2 below. The model fit for the constructs were also adequate by being above 0.90. Model fit indices used were normed fit index (NFI), goodness of fit (GFI), and comparative fit index (CFI). In addition to these, the root mean square residual (RMR) was also used in assessing the model fit for the constructs, and all these were observed by conducting the confirmatory factor analysis (CFA). Table 2 also captures the result of the convergent validity test, thus, revealing values for average variance extracted (AVE) and composite reliability (CR). RMR, AVE, and CR values above 0.08, 0.5 and 0.7 respectively are adequate (Bagozzi and Yi, 1988; Hair et al., 1998). Discriminant Validity was satisfied by observing that squared correlation values of the constructs were lower the squared root AVE values the same construct (Fornell & Larcker, 1981). See Table 3 for discriminant validity.

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Table 3: Discriminant Validity - Construct squared correlation and squared root AVE values

Constructs	Mean	SD	MF	VF	PF	PFL	SU
MF	4.221	0.720	***.785***				
VF	4.511	0.523	.717**	***.723***			
PF	3.893	0.348	.686**	.718**	***.782***		
PFL	4.002	0.291	.741**	.720**	.755**	***.773***	
SU	4.986	0.316	.279**	.391**	.337*	.494**	***.799***

** ≤ .01 significant value and * ≤ .05 significant value
Bold diagonal figures are the squared root AVE values
Source: Own elaboration

4.2 Non Response Bias

To curb the possibility of non-response bias, some approaches were used. The measurement items for the research instrument was written in a simplistic form to aid understanding and mitigate any confusion that can trigger non response. Emphasis was given to who qualified as a respondent; this was to get industry practitioners that were most likely abreast with the study variables and concepts to fill the questionnaire. The comparison between first fifty and late fifty submissions was done via the paired sample t-test according to recommendations by Mishra, 2016; and Huo, Haq, & Gu, 2020 who tested for non-response bias. Results show there was no bias in this regard.

4.3 Common Method Bias

Questionnaire responses are prone to the risk of common method bias (Podsakoff & Organ, 1986). Thus, using the Harman's approach of one-factor test, common method bias (CMB) was assessed. One-factor test revealed that 22.21% of the total variance was explained. It is accepted because the explained variance is beneath the 50% threshold (Podsakoff & Organ, 1986). Studies like Ketokivi & Schroeder (2004) faults the efficacy of the Harman's test, thus, it makes a strong case for supporting the Harman's test with another test. The correlation marker variable technique (Lindell & Whitney, 2001) was employed to support the Harman's test. In applying the correlation marker variable technique, the construct with the lowest positive correlation value was used to moderate other major construct correlations. CMB was not a concern in the study's data.

Table 4: Respondents' Demographic

		Frequency	Valid Percent	Cumulative %
Gender	Male	182	83.5	83.5
	Female	36	16.5	100
	Total	218	100	
Age	20-30	4	1.8	1.8
	31-40	107	49.1	50.9
	41-50	73	33.5	84.4
	Above 50	34	15.6	100
	Total	218	100	

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Department	Operations/Production	96	44.03	44.03
	Supply chain/Logistics	31	14.22	58.25
	Procurement	22	10.10	68.35
	Inventory	14	06.42	74.77
	Marketing	55	25.23	100
	Total	218	100	
Qualification	National Diploma (ND)	62	28.44	28.44
	Bachelors/Higher National Diploma	123	56.42	84.86
	Postgraduate	33	15.14	100
	Total	218	100	
Manufacturing industry	Cement	22	10.10	10.10
	Food, Beverages and Tobacco	101	46.33	56.43
	Textile, Apparel and footwear	23	10.55	66.98
	Pulp paper and paper products	31	14.22	81.2
	Motor vehicles and assembly	17	07.80	89
	Pharmaceuticals	24	11	100
	Total	218	100	

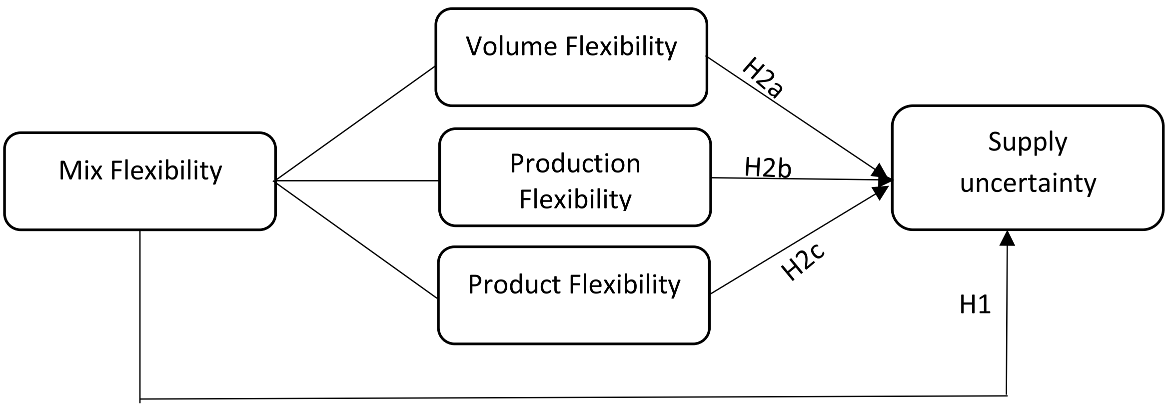
Source: Field Survey (2022)

4.4 Hypotheses testing

The study had eight (8) hypotheses, four (4) direct relationships and four (4) indirect relationships. For emphasis on establishing the manufacturing flexibility dimension that could serve the rest dimensions as an enabler, the hypotheses test was executed with focus on each manufacturing flexibility dimension exclusively.

Hypotheses 1 and 2 focuses on the direct and the indirect relationship between mix flexibility and supply uncertainty. For indirect relationship test of mix flexibility on supply uncertainty through volume, production and product flexibility, bootstrapping was pegged at 2000, and the model fitness were within acceptable ranges X^2/df = 3.223, CFI = 0.942, GFI = .911, NNFI = .891, IFI = .947, RMR = .016, RMSEA.067.

Figure 2: Conceptual model of the relationships between mix flexibility and supply uncertainty



Source: Own elaboration

Table 5: Hypotheses 1 and 2 result

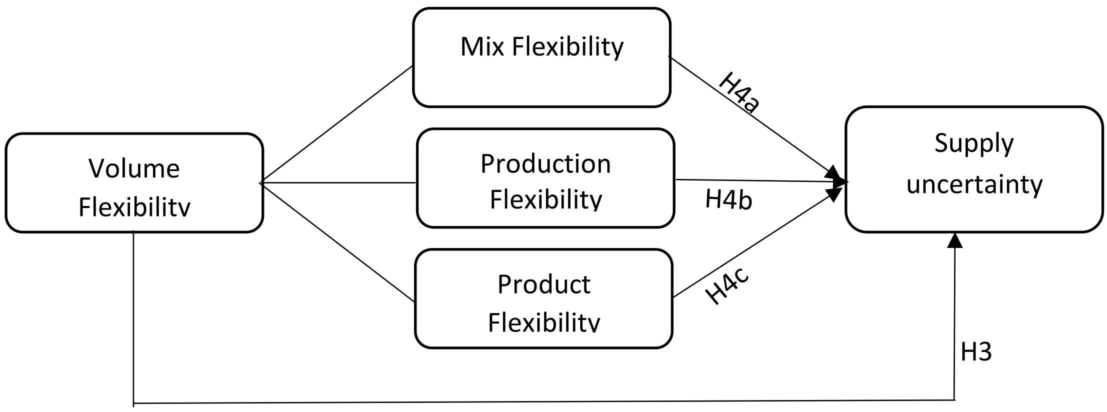
Hypothesis	Path	Standardised Coefficient	Lower Bound	Upper bound	*p*-value	*t*-values	Result
H1	MF ⟶ SU	.211			0.012	2.781	Supported
H2a	MF → VF → SU	.412	-0.011	0.002	0.027	1.511	Unsupported
H2b	MF → PF → SU	.011	-0.082	0.271	0.631	1.572	Unsupported
H2c	MF → PFL → SU	.113	-0.211	0.114	0.801	1.021	Unsupported

Source: Researcher (2022).

The table shows that mix flexibility had a direct effect on supply uncertainty, and the relationship was both positive (.211) and significant (0.012). However, considering the indirect impact of mix flexibility on supply uncertainty, it reveals that mix flexibility had no indirect impact on supply uncertainty when other flexibility dimensions was the mediator in the relationship. This means both volume flexibility, production flexibility, and product flexibility could not effectively mediate the relationship between mix flexibility and supply uncertainty. It is thus acceptable to say that mix flexibility does not significantly impact supply uncertainty indirectly in this model.

Hypotheses 3 and 4 examines how volume flexibility directly and indirectly impacts supply uncertainty.

Figure 3: Conceptual model of the relationships between volume flexibility and supply uncertainty



Source: Own elaboration

Table 6: Hypotheses 3 and 4 result

Hypothesis	Path	Standardised Coefficient	Lower Bound	Upper bound	*p*-value	*t*-values	Result
H3	VF ⟶ SU	.075			0.120	1.631	Unsupported
H4a	VF → MF → SU	.012	-0.452	0.003	0.271	1.032	Unsupported

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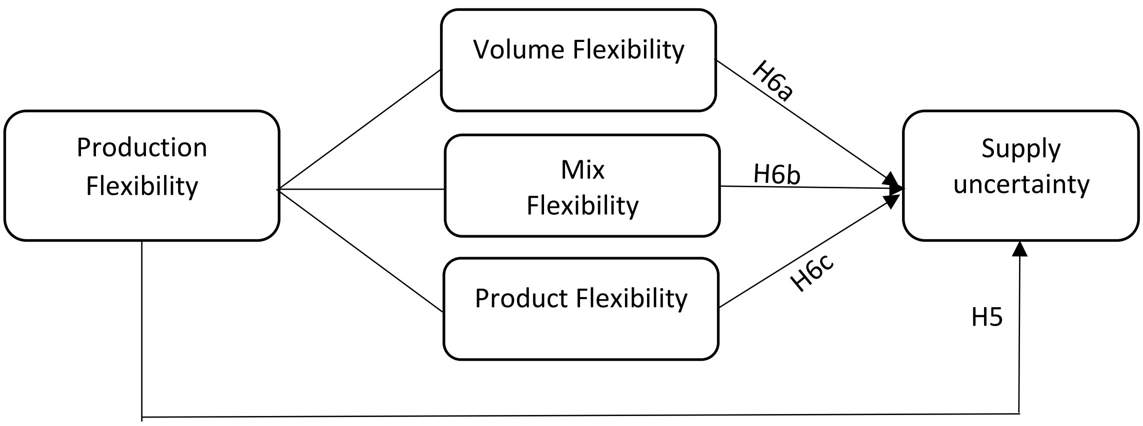
H4b	VF→ PF → SU	.256	-0.144	0.009	0.132	0.543	Unsupported
H4c	VF→ PFL →SU	.202	-0.131	0.230	0.311	1.917	Unsupported

Source: Researcher (2022).

Hypothesis 3 investigated volume flexibility and supply uncertainty. The result show that volume flexibility had no predicting capacity in supply uncertainty. The test of relationship proved that volume flexibility does not significantly impact the supply uncertainty in an organisation. The result (coefficient = .075, t-values = 1.633, and p = .120) display positive and insignificant direct relationship between volume flexibility and supply uncertainty. The result also show that volume flexibility had no significant indirect relationship with supply uncertainty (Hypothesis 4). Test for its indirect relationship with supply uncertainty through mix flexibility (coefficient = .012, t-values = 1.032, and p = .271) proved positive and insignificant. Volume flexibility indirect relationship with supply uncertainty through production flexibility (coefficient = .256, t-values = 0.543, and p = .311) resulted in an insignificant impact. And finally, indirect relationship test between volume flexibility and supply uncertainty through product flexibility was insignificant, as seen in the result coefficient = .202, t-values = 1.917, and p = .311). The t-values for all hypotheses was also below the threshold of 1.96, supporting the insignificance of the relationship between the volume flexibility and supply uncertainty.

Hypotheses 5 and 6 examines how production flexibility directly and indirectly impacts supply uncertainty.

Figure 4: Conceptual model of the relationships between production flexibility and supply uncertainty



Source: Own elaboration

Table 7: Hypotheses 5 and 6 result

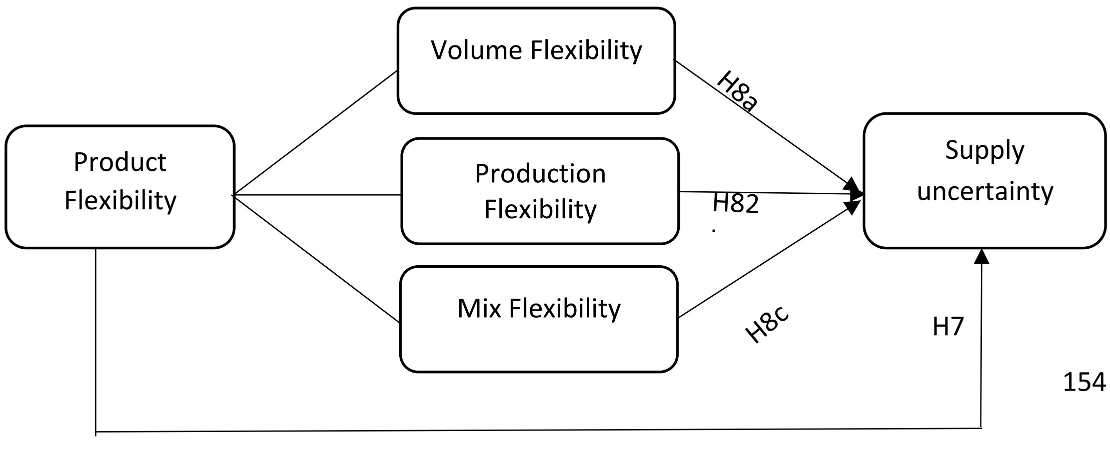
Hypothesis	Path	Standardised Coefficient	Lower Bound	Upper bound	*p*-value	*t*-values	Result
H5	PF → SU	-.163			0.004	3.182	supported
H6a	PF → VF → SU	.009	-0.032	0.213	0.160	1.114	Unsupported
H6b	PF → MF → SU	.015	-0.332	0.102	0.273	1.001	Unsupported
H6c	PF→ PFL→ SU	.010	-0.091	0.302	0.111	1.729	Unsupported

Source: Researcher (2022)

Hypothesis 5 investigated production flexibility and supply uncertainty. The result show that production flexibility had a significant effect on supply uncertainty. The test of relationship proved that production flexibility significantly affects the supply uncertainty in an organisation. The result (coefficient = -.163, t-values = 3.182, and p = .004) displays a negative and significant direct relationship between production flexibility and supply uncertainty. The result also show that production flexibility had no significant indirect relationship with supply uncertainty. Test for its indirect relationship with supply uncertainty through volume flexibility (coefficient = .009, t-values = 1.114, and p = .160) proved positive and insignificant. Production flexibility indirect relationship with supply uncertainty through mix flexibility (coefficient = .015, t-values = 1.001, and p = .273) resulted in an insignificant impact. And finally, indirect relationship test between production flexibility and supply uncertainty through product flexibility was insignificant, as revealed by the result (coefficient = .010, t-values = 1.729, and p = .111). The t-values for all indirect hypotheses were below the threshold of 1.96, supporting the insignificant indirect relationship between the production flexibility and supply uncertainty.

Hypotheses 7 and 8 examines how product flexibility directly and indirectly impacts supply uncertainty.

Figure 5: Conceptual model of the relationships between product flexibility and supply uncertainty



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Source: Own elaboration

Table 8: Hypotheses 7 and 8 result

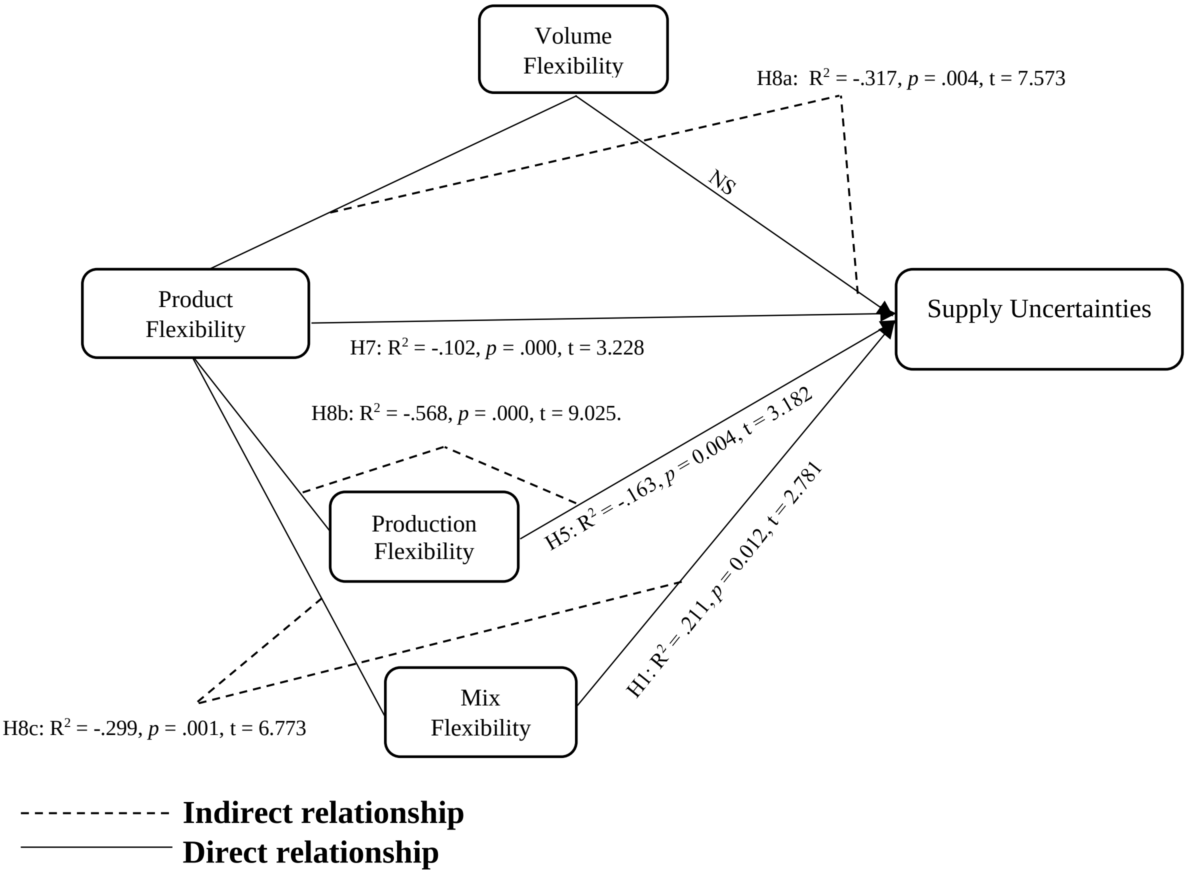
Hypothesis	Path	Standardised Coefficient	Lower Bound	Upper bound	*p*-value	*t*-values	Result
H7	PFL → SU	-.102			0.000	3.228	Supported
H8a	PFL →VF →SU	-.317	-0.173	-0.122	0.004	7.573	Supported
H8b	PFL →PF → SU	-.568	0.002	0.322	0.000	9.025	Supported
H8c	PFL→ MF→ SU	-.299	-0.011	-0.002	0.001	6.773	Supported

Source: Researcher (2022)

Hypothesis 7 examined the direct effect of product flexibility on supply uncertainty. The result show that product flexibility had a significant effect on supply uncertainty. The relationship between both variables proved negative and significant. This was evident in the relationship test results (coefficient = -.102, t-values = 3.228, and p = .000), which ensured the hypothesis 7 was retained. Hypothesis 8 assessed the indirect relationship between product flexibility and supply uncertainty. This hypothesis was tested by examining the indirect relationship between product flexibility and supply uncertainty through volume flexibility, production flexibility, and mix flexibility. Testing product flexibility and supply uncertainty indirect relationship through volume flexibility revealed that product flexibility had a significant negative impact on supply uncertainty. This was revealed by the result (coefficient = -.317, t-values = 7.573, and p = .004) of the test. Indirect relationship between product flexibility and supply uncertainty through production flexibility proved significant and negative (coefficient = -.568, t-values = 9.025, and p = .000). The test on indirect relationship between product flexibility and supply uncertainty through mix flexibility was significant, as revealed by the result (coefficient = -.299, t-values = 6.773, and p = .001). The t-values for all indirect hypotheses were well above 1.96, this lends credence to the significant indirect relationship between the product flexibility and supply uncertainty. The result of the indirect tests leads to the retaining of hypothesis 8.

4.5 Discussion of findings

Figure 6: Significant relationships between manufacturing flexibility practices and supply uncertainty



Source: Own elaboration

Mix flexibility had a direct effect on supply uncertainty and the relationship was positive and significant. However, considering the indirect impact of mix flexibility on supply uncertainty, it reveals that mix flexibility had no indirect impact on supply uncertainty when other flexibility dimensions was the mediator in the relationship. This means that the higher the mix flexibility, the higher the supply uncertainty. Such relationship is not expected, as literature opines that flexibility creates capacity to manage or reduce the uncertainties businesses face (Mishra, 2016). Volume flexibility had no significant relationship (either direct or indirect) with supply uncertainty. Production flexibility and supply uncertainty relationships test showed that production flexibility had a significant direct and insignificant indirect effect on supply uncertainty. In direct relationship, production flexibility had a significant relationship that was also negative. Implying that the more production flexibility found in a manufacturing system, the lesser the supply uncertainties for such systems. Aligning with studies like Mishra (2016) and Singh *et al.*, (2020) who found that flexibilities capacities were good investments in moderating uncertainties impact on the firm.

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The direct effect of product flexibility on supply uncertainty reveal that product flexibility had a significant and negative effect on supply uncertainty. Indirect relationships between product flexibility and supply uncertainty proved all negative and significant too. This hypothesis was tested by examining the indirect relationship between product flexibility and supply uncertainty through volume flexibility, production flexibility, and mix flexibility. All of the indirect relationships showed that they were significantly negative and the indirect effects were all higher than the direct relationship between product flexibility and supply uncertainties. This study finding is in tandem with Jangga, Ali, Ismail, and Sahari, (2015) who conducted their study that revealed a relationship between flexibility and uncertainty. The study posit that the presence of flexibility improved the performance of firm in the face of uncertainty in the business environment. The finding of this study is very significant to the body of literature of flexibility in manufacturing firms, as it uniquely establishes that product flexibility, production flexibility and mix flexibility are the manufacturing flexibility dimension that can significantly influence supply uncertainty. However, only product flexibility and production flexibility have the capability to influence supply uncertainty in the direction that is desired for the firm. The analysis from this study also produces another major contribution to the manufacturing flexibility literature by empirically supporting the notion that among all the dimensions of manufacturing flexibility, product flexibility is the only dimension with the capacity to act as a supporting practice to all other practices within manufacturing flexibility in their relationship with supply uncertainty.

5. Discussion and Conclusion

The study focused on examining the relationship between manufacturing flexibility and supply uncertainty. From the findings of the study, the all dimensions of manufacturing flexibility did not affect supply uncertainty. The study proves that production flexibility, product flexibility, and mix flexibility affects supply uncertainty. However, the relationship between production flexibility and supply uncertainty and product flexibility and supply uncertainty proved significant and negative. This implies that the higher the production flexibility and product flexibility, the lower the uncertainties. The relationship between mix flexibility and supply uncertainty proved significant and positive, which is contrary to the desired result of limiting uncertainties from the supply end. The finding also prove that volume flexibility did not affect supply uncertainty significantly. On the supporting capacity roles within manufacturing flexibility dimensions, all dimensions of manufacturing flexibility were unable to act as support except product flexibility.

5.1 Theoretical implications

This study contributes to the existing literature of flexibility in manufacturing firms in several ways. Firstly, the study empirically tests the relationship between manufacturing flexibility and supply uncertainty in a Sub-Saharan developing nation. There is little or no empirical research in the context of manufacturing flexibility and supply uncertainty relationships, both from developed and developing nations. This responds to calls from Alamro *et al*., (2018) and Singh *et al*., (2020) for more empirical studies on flexibility and uncertainty from regions with less empirical studies, especially developing nations. The study toes the line of findings from Singh *et al*., (2020) and Russell *et al*., (2022) whose results show that flexibility has the potential to mitigate uncertainties in business environment.

Secondly, the study empirically establishes that not all dimensions within manufacturing flexibility influences supply uncertainty. As well as revealing that only production flexibility and product flexibility influences supply uncertainty in the direction the managers would wish. This gap was established by Alamro *et al*., (2018) for future studies to exploit in their business environment. The finding contributes significantly to this literature gap by explicitly identifying the manufacturing flexibility dimensions (production and product flexibility) that actually reduce the uncertainties in the business environment.

Finally, the study addresses the literature gap established by Russell *et al*., (2022), asking for data analysis to go beyond just establishing relationships between flexibility and other variable. They called for establishment of interrelationships between the flexibility dimensions. Citing that empirical studies have not addressed such issues. This study fills that literature gap by establishing that product flexibility has the capacity to act as a support practise to other forms of manufacturing flexibility practices.

5.2 Practical implications

The study findings present interesting considerations for the managers of manufacturing systems. In this era of very high uncertainty, the study present veritable paths to managing and reducing the uncertainties imbedded in supply. The study establishes that managers can adopt manufacturing flexibility as a reliable strategy to combat supply uncertainty. Specifically, production and product flexibility must be heavily funded by top management to enhance their capacities to manage uncertainties in supply. The study results also emphasise the need to establish product flexibilities first as a supporting strategy to the establishment of mix, volume, and production flexibilities. This is

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amplified by the fact that product flexibility acted as a supporting dimension to other dimensions within manufacturing flexibility. It is also supported by the fact that all dimensions that had a significant impact on supply uncertainty had more impact when moderating the relationship between product flexibility and supply uncertainty. Practitioners considering implementing one dimension due to certain constrains can employ production flexibility to limit supply uncertainty. This is because production flexibility had the most impact on supply uncertainty individually.

5.3 Limitations and suggestions for further studies

Limitations include the fact that a prior assessment was not carried out on their manufacturing systems to ascertain if they are truly flexible in manufacturing. Further studies could first off investigate the selected firms to know if they have implemented manufacturing flexibility to truly capture only firms with manufacturing flexible systems. Secondly, the analysis of this study was done without industry specificity, this would reveal more on the implementation of manufacturing flexibility as regards to industry and which manufacturing flexibility dimension is most relevant to specific industries.

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