ISSN No:-2456-2165

The Influence of Supply Chain Flows on Improving Food Security: A Case Study of Maize Supply Chain in Zimbabwe

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Abstract:- This study explores the influence of supply chain management (SCM) flows on food security, a connection that has received less scholarly attention, particularly in developing countries. The study's primary objective is to determine whether applying SCM concepts will aid the Zimbabwean maize industry in achieving food security and poverty reduction. This study employs a quantitative research design. Survey questionnaires are used to collect data. Participants were selected from two districts in two separate climatic regions: Guruve in Mashonaland Central province (rainfall region 2) and Chiredzi in Masvingo province (rainfall region 5). SmartPLS-3 was used to test the hypotheses. The findings indicate that SCM has a significant positive influence on food security. The supply chain variables information flow, product flow, and money flow all have direct relationships and contribute significantly to enhancing food security at varied levels. Recommendations were developed, including the need to educate farmers about the importance of supply chain management through various platforms, and the government's obligation to empower farmers with information about critical supply chain variables such as lucrative commodity prices in upcoming farming seasons to encourage maximum maize acreage production and thereby continuously improve food security in the country.

Keywords:- *Food Security, Supply Chain Management, Product Flow, Money Flow, Information Flow.*

I. INTRODUCTION AND BACKGROUND

Typically, supply chain flows begin with the food producer (upstream) and cascade down the channel to the ultimate user (downstream) (Koufteros & Lu, 2017). Similarly, food security begins with the availability of food from producers (farmers) to various processing institutions and middlemen, and finally to the rest of the community's population (KPMG, 2013). When considering the route through which maize food is transported, there is a link with supply chain flows and a requirement to understand and utilise these supply chain flows as an efficient instrument for improving food security in any nation (Dani, 2015). Understanding supply chain flows is critical for food security, primarily to ensure that food is not lost between farmers and consumers. SCM flows provide seamless information to all supply chain partners and develop sustainable financial flows to ensure that food availability and access remain constant throughout the country. Fundamentally, knowing the relevance of supply chain flows enable effective management of food insecurity (Eastham, Luis, & Thelwell, 2017). Figure 1.1 illustrates typical maize supply chains in Zimbabwe. Note should be taken that maize is mostly a controlled commodity by the Grain Marketing Board of Zimbabwe (GMB) This is a parastatal which is a wing of the government hence less utilisation of the common supply chain channel which goes through producers, wholesalers and retailers, unless the wholesalers and retailers get the commodity from the GMB (Pamela, 2021). From Figure 1.1. channels 3, 4, 2 are the most utilised in that respective order. Supply chain channel 1 is still existing but on a small scale of utilisation.

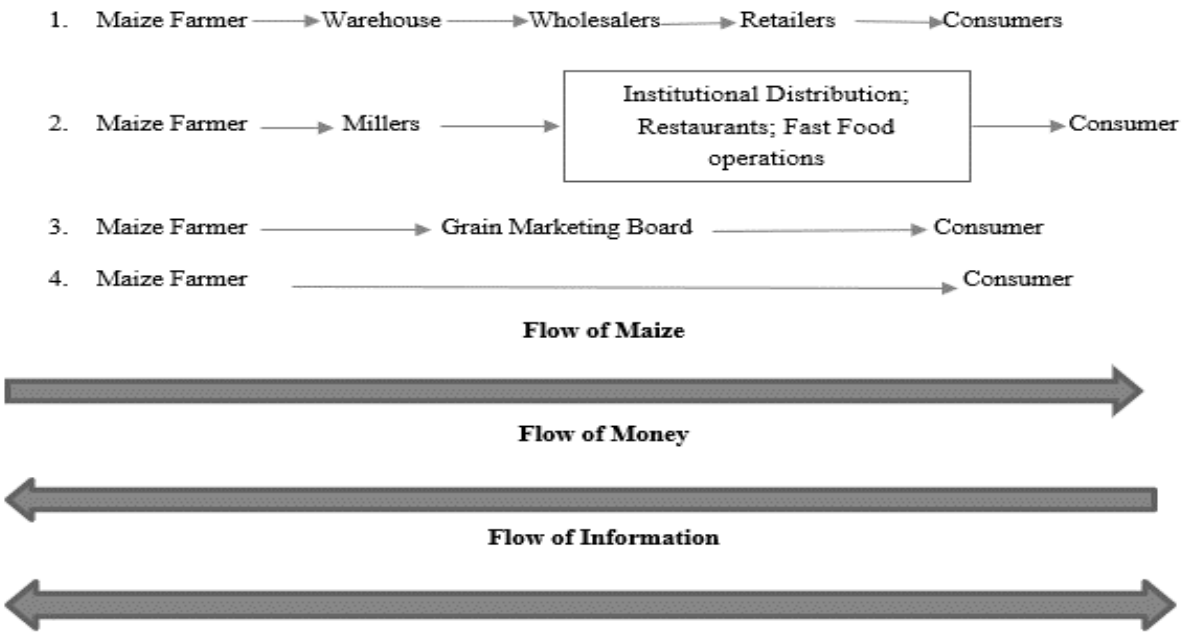

Fig1.1: Maize Supply Chains
Source: Author,2021

Maize is a grain food crop that is Zimbabwe's staple crop. Nearly 70% of Zimbabwe's population lives in rural areas and subsists on agriculture, with maize being the primary crop. Zimbabwe has seen an increase in acute hunger as a result of three years of drought, escalating hyperinflation, and COVID-19. As of April 2021, the country's food crisis was so severe that more than 1,5 million individuals received food assistance through the Lean Season Assistance program, and more than 320 thousand people received assistance through the Urban Resilience program (Nhapi, 2021). This is a clear indication that Zimbabwe's food security challenges require immediate attention. Moyo, (2000) substantiated this in Table 1.1, stating that even during normal productive seasons, more than 76% of Zimbabwe's hectarage is semi-arid to arid. This means that all of these regions (regions 3, 4, and 5) are unable to grow enough maize for domestic consumption and hence require food assistance from regions that account for less than 24% of the country's total area. Robust SCM has to be implemented to ensure that food from producing areas reach all the areas withing the 76% non-productive region (Nhapi, 2021).

Table 1.1
Description of the Natural regions of Zimbabwe

Natural Region	Area (000 ha)	Total land area (%)	Annual rainfall	Farming Systems
			(mm)	
I	613	1.56	> 1 000. Rain in all months of the year, relatively low temperatures	Appropriate for dairy farming, forestry, tea, coffee, and fruit cultivation, as well as beef and maize production.
II	7 343	18.68	700 to 1050. Rainfall confined to summer	Appropriate for intensive agriculture, with a focus on maize, tobacco, cotton, and animal rearing.
III	6 855	17.43	500 to 800. Temperatures are really high, rainfall is scarce, and the region is prone to periodic droughts and extreme mid-season dry spells.	Agriculture is carried out in a semi-intensive manner in this region. Suitably tailored for livestock production, as well as fodder and cash crop production under sound farm management.

ISSN No:-2456-2165

IV	3 010 036	33.03	450 to 650. Frequently result in droughts and extreme dry spells during the rainy season	This is a semi-extensive region. Appropriate for livestock-based agriculture systems with resistant feed crops. Forestry, wildlife management, and tourism
V	10 288	26.2	< 450. Rainfall has been inconsistent. Although the northern low veld receives more rain, the topography and soils are in poor condition to sustain any crop.	A large farming region. Suitable for cattle ranching on a large scale. Tsetse flies have overrun the Zambezi Valley. Forestry, wildlife, and tourism are three of the most suitable industries in the region.

Source: Adapted from (Moyo, 2000)

According to FAO, (2019) when a country lacks sufficient rainfall to support crop growth, it requires sufficient mechanisation and adequate water reservoirs to support agriculture in order to produce enough food to feed the entire country, while failure to do so is an automatic recipe for food insecurity and hunger. Paloviita (2017) went on to say that the few locations that consistently receive normal to above-average rainfall should produce enough food crops to feed the remainder of the world's semi-arid to arid regions. It is at this time that supply chain management becomes critical in allowing maize grain to travel from surplus areas to areas in need. To pull Zimbabwe out of the quagmire of food insecurity, proper management of supply chain flows (flow of information, flow of products, flow of money) must be employed. Upstream and downstream, producing and non-producing locations where maize food flows are referred to as producing and non-producing regions, respectively (Pamela, 2021).

II. LITERATURE REVIEW

The first stage of the literature review is to create a conceptual framework for the study, which explains how variables interact. Food security, supply chain information flow, supply chain product flow, and supply chain money flow are explained in the second part of the literature study.

➢ *Conceptual Framework*

A conceptual framework developed for the study focuses on the three supply chain management flows and food security. In the framework, money flow and maize (product) flow are the predictor variables, whilst supply chain information flow becomes the mediating variable. Food security or specifically improved food security would therefore be the outcome variable as shown in figure 2.1. The framework supports that food security (availability, accessibility, and affordability of maize) is an outcome of a combination of supply chain management flows (Marambanyika, Beckedahl, & Ngetar, 2016). Essentially, supply chain information flow is an important element for all the other three variables. In order for communities to know that a certain farmer has produced excess yields, there is a need for information sharing from the farmer's point to those who are in need of the food maize. On the contrary, the farmer also requires information with regards to which specific location the maize is being demanded so that the farmer can make a stance to deliver or to inform the communities to come and get the maize. Given that sufficient information has been cascaded downstream and feedback from downstream received, then transactions may be initiated which initially require the release of money or finance in various forms to enable the farmer to release the product (Saidon, Mat Radzi, & Ab Ghani, 2015). Hence, there would be eventual maize flow from the farmers to communities demanding the maize. Having achieved this level would mean that food is now available and accessible to those who need it. Maize prices are normally stabilised when information about maize demand and farmers who are supplying it is shared across the entire supply chain system without bottlenecks. If all the necessary information flows appropriately, then competitive systems result in the maize being affordable for communities. Coherence of the three supply chain flows would then result in improved food security in each environment, such as Zimbabwe. (Mandisvika, Chirisa , & Bandauko, 2015).The conceptual framework olso depicts that to achieve food security there is need for coherent and coordinated interrelationships amongs the three flows themselves. This is what strengthens the ability of the SCM flows to effectively influence food security (Gaskin, Godfrey, & Vance, 2018).

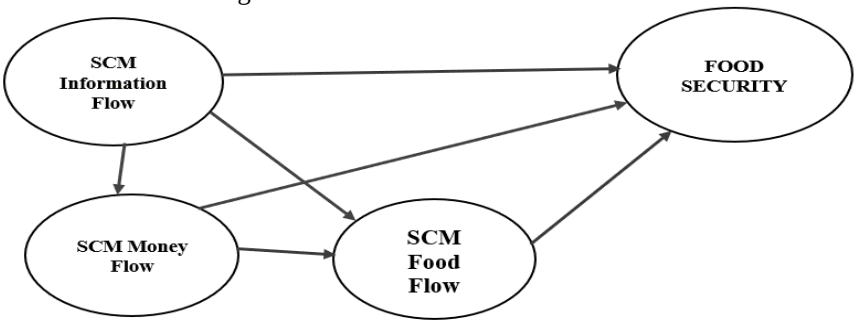

Fig 2.1: Conceptual Framework
Source: Author

➢ *Food Security*

Food has an impact on every aspect of human life. It's not just about feeling full and pleased; it's also about being connected to and a part of the community. Food is a method to bring people together and celebrate shared humanity across cultures. Food, shelter, water, and rest are the cornerstones of a healthy human, according to Maslow's hierarchy of needs (Iakovou., 2016). It is difficult to conceive of safety, community, our future, or our potential without these foundational elements in place. Food security is the most basic human requirement. We would not be able to thrive, let alone exist, without it. Food security is defined by the FAO, (2019) as a situation in which all people have physical and economic access to adequate, safe, and nutritious food to always suit their dietary needs and food choices for an active and healthy life. The four pillars of food security are availability (does food exist near me?), access (can I get food easily?), and utilisation (would this food benefit my health and well-being?) and consistency (Will there be food next day, next week or next month?) (FAO, 2019). Food security happens when any one of these components is met (Mandisvika , et al,. 2015). Food security, as seen in Figure 2.2, is defined as the availability, accessibility, and utilisation or consumption of sufficient food (Smith, 2013). Food production is a source of food availability (Koufteros & Lu, 2017). Food availability is contingent on adequate food production. Without food production, clearly, food will not be available. Food availability can be defined as providing enough food to meet people's food demands in their immediate surroundings, such as a village or a state (Smith, 2013). People, on the other hand, will not be able to eat enough food unless it is available and consumable. People must have access to and consume food in order to be food secure. Food is available to anyone with sufficient income to purchase it, and it is physically accessible (e.g., foods are sold in nearby local marketplaces) (Mandisvika, et al,. 2015). The final aspect must be achieved by people and families using or consuming the product. Even though food is available and accessible, many continue to be food insecure. In most places of the world, supply networks can assist in achieving food security (Iakovou., 2016). Food consumption, the third pillar of food security, is more dependent on people's choices to eat or not eat, and their choices are influenced by their perceptions of food need, regardless of food availability and access. There is not much supply chains can do in this situation. (Regmi & Meade, 2013) Agricultural supply chains, on the other hand, can help with both the first (food availability) and second (food access) pillars of food security (Iakovou., 2016). Food may be made available by creating foods, and this can be done even more efficiently by minimizing food losses, discarding already produced foods, and avoiding the development of undesirable foods (Paloviita, 2017). Because of the detrimental effects of climate change and other human influences, nations, and communities' ability to produce food has been harmed, putting all aspects of food security at risk. In order to thrive and ensure food security in such a situation, proper management of current food reserves through supply chain management is required, as well as no leakage in terms of the supply chain's three flows (Lipton & Saghai, 2017).

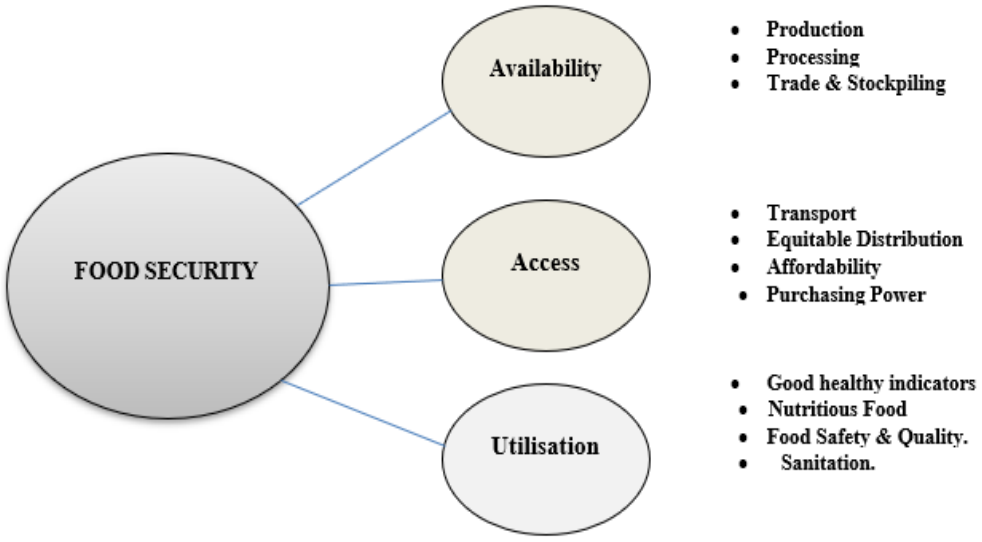

Fig 2.2: Food Security Pillars
Source: (Smith, 2013)

➢ *Supply Chain Flows and Food Security*

Supply chains can help increase food availability (supply) in a variety of ways, including by producing food with effective and efficient technology (such as irrigation, seed culture, crop harvesting and crop maintenance), providing harvest and post-harvest handling technologies that reduce food losses, and giving information on the right products and requirements needed by the market (Mandisvika , et al,. 2015). Supply chains help people get food in two ways: directly by raising their income so they can buy it, and indirectly by providing physical access to food sources where people can get it. People can earn more money because supply chains generate jobs and income for chain participants and workers then people have enough money to buy food (Marambanyika, Beckedahl , & Ngetar, 2016). In most regions of the world, around a third (1.3 billion tons) of

total food production is lost or squandered, both in rich and developing countries (Nhapi, 2021). Food loss and waste vary by geography, product type, and supply chain stage. Food loss or waste happens throughout the supply chain, from agricultural production to ultimate consumption, particularly during food preparation and delivery (Paloviita, 2017). According to a FAO report (2019), food loss and waste have not decreased significantly. Food loss (excluding food waste) is estimated to be roughly 14% of total food loss, with the post-harvest stage excluding the stages of food retailing and consumption. As a result, numerous efforts must be done to prevent food loss and wastage. One of the report's main points is the significance of integrating agricultural supply chain management, starting with gathering enough and accurate data on where food loss and waste occur in supply chains and across. Implementing high-efficiency and-effective supply chains will minimize or eliminate food waste, partially or completely, based on how effective and efficient the supply chain's functioning is. Food supply is allocated as an element of food security because of the reduced or avoided food waste. As a result, supply chains can play a bigger role in ensuring food security (Nhapi, 2021). The product flow involves the transportation of food from a producer to a customer, as well as any consumer returns or service requirements. Cash, credit terms, payment schedules, and consignment arrangements make up the financial flow. Product fact sheets, orders, timetables, and delivery status updates are all part of the information flow (Koufteros & Lu , 2017). Supply chain management flows are discussed in detail in the next sub-topics.

- *The Flow of Products (maize)*

The flow of products and materials from supplier to consumer, as well as dealing with customer service demands such as input raw materials or consumables, or services such as housekeeping, are all part of product flow. Returns and rejections are also part of the product flow (Reverse Flow). There will typically be a supplier, manufacturer, distributor, wholesaler, retailer, and consumer in a typical circumstance. The customer could even be a company's own internal customer. Food products are the most delicate goods on the market, since they are vulnerable to dangers such as improper storage, incorrect temperature levels, poor ventilation, light, humidity, and other quality and safety-related concerns (Smith, 2013). Similarly, products become perishable if they are not properly stored. As a result, every storage room must have control systems that can indicate temperature levels at any time. Farmers, producers, wholesalers, retailers, and transporters are all part of the food supply chain and are thus responsible to ensure that particular food products, such as maize, are handled properly (Dani, 2015). The following hypothetical proposal was constructed to demonstrate the importance of supply chain product flow on food security.

H1 *SCM management product flow has a significant influence on food security*.

- *The Flow of Information*

To preserve food quality in the supply chain, the flow of information among participants, as well as product management, is critical (KPMG, 2013). The food supply chain refers to all the operations that characterize the flow of food from the farm (field) to the tables of customers (production, distribution, sales, and consumption) (Lipton & Saghai, 2017). Every action in the supply chain necessitates the use of human or natural resources, and if one section of the chain is jeopardized, the entire chain suffers. It is critical that participants appreciate aspects of a product, its origin, regulatory standards, and the temperature sensibility set by producers and experts in that industry to avoid the chain collapsing or the products perishing (Paloviita, 2017). Distributors play an important role in this, as they are required to maintain product traceability at all times, which is ensured by sophisticated informational technology for temperature monitoring (Mangan & Lalwani, 2016). In terms of supply chain information flow, the following hypothesis has been established:

H2 *SCM information flow has a significant influence on food security.*

- *The Flow of Money (Finances)*

Money flow is a compensation to be paid for raw materials and products and thus it facilitates material flow. Usually, money flow is behind product flow. (Paloviita, 2017).In addition, substantial money is involved in logistics chain. Money is tied up in the goods maintained in warehouses and intermediate terminals. Also, considerable capital is tied up in the maize product being transported. Transport and storage costs themselves are a major cost factor. In addition, packing maize and planning logistics chain, implementation and management come at different costs. The major logistical costs with regards to the flow of maize from producers to the final consumer are given below (Aneesh, 2017):

- ✓ Transport Costs
- ✓ Storage Costs
- ✓ Administration Costs
- ✓ Packing Costs And
- ✓ Capital Costs.

In a supply chain, money flow moves from the ultimate consumer of the product back through the chain to the producer or farmer (Dani, 2015). Money flow moves in an opposite direction with product flow since those who are supplied with the product are the ones who pay the supplier hence the opposite flow motion. Great opportunities and challenges therefore lie ahead in managing financial flows in food supply chains. The integrated management of this flow is a key SCM activity, and one which has a direct impact on the cash flow position and improvement of relations across the entire supply chain stakeholders (Pamela, 2021). Hypothesis H3 has been developed to propose the influence of SCM information flow on food security.

H3 *SCM money flow has a significant influence on food security.*

Further hypotheses were developed to show inter-relationships amongst all the four variables, these include:

H4 *SCM information flow has a significant influence on SCM Product flow (PF).*

H5 *SCM money flow (MF) has a significant influence on SCM Product flow (PF).*

H6 *SCM information flow has a significant influence on SCM money flow (MF).*

➢ *Objectives*

- To establish the influence of SCM flows on maize food security Zimbabwe's.
- To analyse interrelationships between SCM flows on improving food security.

III. METHODOLOGY

A cross-sectional study was done in Zimbabwe's Mashonaland Central (Guruve district) and Masvingo provinces (Chiredzi district) among a mix of small-holder and medium-sized maize farmers. These two provinces were conveniently chosen to represent Zimbabwe's most productive and least productive maize regions. Systematic random sampling was used to collect data from individuals who produce surplus (upstream) and those who require food assistance practically every season (downstream) from the two provinces. During the questionnaire administration, the questions were translated into the local languages to allow flexibility with a mix of literate and those challenged by some english concepts, such as supply chain management. A total of 150 questionnaires (75 from Mashonaland Central and 75 from Masvingo) were sent out to the field, with maize farmers, maize traders, and consumers from Mashonaland Central and Masvingo provinces. Because of the study's sophisticated model, the researchers used the Smart-PLS 3 data analysis tool to assess the reliability, validity, and hypothesis testing (Sarstedt & Cheah, 2019). Food Security (FS) and three supply chain management flows, Product Flow (PF), Money Flow (MF), and Information Flow (IF), are among the constructs used in the study (IF). Food security was graded on a three-item scale, product flow was graded on a four-item scale, money flow was graded on a five-item scale, and information flow was graded on a three-item scale (Oluwatayo & Rachoene, 2017). Money flow (MF) has also been employed as a moderator between food security and product flow whilst information flow being mediator between money flow and product flow (Sazzad, 2014). These constructs, along with relationships, have been highlighted in Fig. 1.

IV. RESULTS AND DISCUSSION

➢ *Results*

Initially, 150 questionnaires were distributed. Of those, 89 were returned, reflecting a response rate of 59%. In general, the acreage for maize growing ranged from as little as 0.3 acres to 35 acres. Sixty-seven percent of the respondents were male, and the remainder were female. The most represented age range was 41 to 50 years old at 37% and the least represented was 61 and above at only 6%. About 96% of the respondents indicated that they had basic education (at least completed primary education). The study's outcomes section includes an assessment of the measuring model and an assessment of the structural model. The assessment of measurement model entails determining convergent and discriminant validity, whereas the assessment of structural models entails testing hypotheses. These are discussed below in section 5.2 and 5.3.

➢ *Reliability and Validity of Findings*

The reliability of variables was tested using Cronbach's Alpha, rho_A and Composite Reliability (CR). Initially, the overall sample was assessed and items having factor loadings that were smaller than 0.600 were discarded. Factor loadings results for the remaining items are presented in Table 5.1 for the overall sample and for each latent variable. Cronbach's Alpha, rho_A and Composite Reliability were higher than the recommended value of 0.700. The Average Variance Extracted (AVE) were above 0.5 which supports that there is convergent validity (Table 5.2).

Table 5.1: Factor Loadings

	Food Security	**SCM Information Flow**	**SCM Money Flow**	**SCM Product Flow**
FS1	0.832			
FS2	0.891			
FS3	0.950			
IF1		0.890		
IF2		0.818		
IF3		0.642		
MF1			0.923	
MF2			0.867	
MF3			0.905	
MF4			0.841	
MF5			0.752	
PF1				0.637
PF2				0.777
PF3				0.869
PF4				0.770

Source: Data Analysis

Table 5.2
Construct Reliability and Validity

	Cronbach's Alpha	**rho_A**	**Composite Reliability**	**Average Variance Extracted (AVE)**
FOOD SECURITY	0.871	0.872	0.922	0.797
SCM INFORMATION FLOW	0.711	0.731	0.841	0.643
SCM MONEY FLOW	0.910	0.915	0.934	0.739
SCM PRODUCT FLOW	0.775	0.826	0.850	0.589

Source: Data Analysis

Discriminant Validity

Secondly, the current study also shows the measurement model assessment by using discriminant validity that is about the correlation among variables. Discriminant validity was

assessed through cross-loadings as shown in Table 5.3. It is observed that all the factor loadings are greater than their cross-loadings, which is a sign of discriminant validity. Discriminant validity was also tested using the criterion suggested by Fornell & Larcker and the Heterotrait-Monotrait Method (HTMT). The results of both tests are reported in Table 5.4. The figures highlighted that the Heterotrait Monotrait (HTMT) ratios are not more than 0.90. which is evidence of correlation among variables and valid discriminant validity as postulated by (Gaskin , Godfrey , & Vance, 2018).

Table 5.3
Cross Loadings

	FOOD SECURITY	SCM INFORMATION FLOW	SCM MONEY FLOW	SCM PRODUCT FLOW
FS1	**0.832**	0.474	-0.800	0.576
FS2	**0.891**	0.590	-0.297	0.377
FS3	**0.950**	0.470	-0.455	0.431
IF1	0.548	**0.890**	-0.376	0.574
IF2	0.396	**0.818**	-0.150	0.426
IF3	0.594	**0.642**	-0.503	0.445
MF1	-0.341	-0.337	**0.923**	-0.770
MF2	-0.418	-0.449	**0.867**	-0.830
MF3	-0.346	-0.291	**0.905**	-0.731
MF4	-0.751	-0.542	**0.841**	-0.653
MF5	-0.695	-0.376	**0.752**	-0.468
PF1	0.298	0.524	-0.392	**0.637**
PF2	0.647	0.508	-0.838	**0.777**
PF3	0.295	0.370	-0.613	**0.869**
PF4	0.225	0.249	-0.466	**0.770**

Source: Data Analysis

Table 5.4
HTMT

	FOOD SECURITY	SCM INFORMATION FLOW	SCM MONEY FLOW	SCM PRODUCT FLOW
FOOD SECURITY				
SCM INFORMATION FLOW	**0.850**			
SCM MONEY FLOW	**0.643**	**0.551**		
SCM PRODUCT FLOW	**0.569**	**0.825**	**0.889**	

Source: Data Analysis

5.3 Hypotheses Testing

Finally, the structural model assessment has been executed by using path analysis, and the results show that supply chain information flow (IF) and supply chain money flow (MF) have direct relationships with Food Security (FS) whilst supply chain product flow has a relationship with FS directly and indirectly through MF which is a moderating factor. These relationships are proven with T-statistic above 1.96 and P values below 0.05 (Table 5.5 and Figure 5.1) which is an indicator that indeed there is a relationship between the variables. In this regard hypotheses H1, H2, H3, and interrelationships hypotheses H4, H5 and H6 were all accepted. This basically means that all the relationships support the significance of supply chain management flows on improving food security.

Table 5.5
Paths Coefficients

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Decision
SCM INFORMATION FLOW -> FOOD SECURITY	0.563	0.537	0.218	2.2585	0.010	Accept Hypothesis
SCM INFORMATION FLOW -> SCM MONEY FLOW	-0.544	-0.582	0.139	3.908	0.000	Accept Hypothesis
SCM INFORMATION FLOW -> SCM PRODUCT FLOW	0.292	0.264	0.088	3.336	0.001	Accept Hypothesis

ISSN No:-2456-2165

SCM MONEY FLOW -> FOOD SECURITY	-0.719	-0.710	0.248	2.895	0.004	Accept Hypothesis
SCM MONEY FLOW -> SCM PRODUCT FLOW	-0.678	-0.695	0.059	11.567	0.000	Accept Hypothesis
SCM PRODUCT FLOW -> FOOD SECURITY	-0.426	-0.409	0.128	3.328	0.001	Accept Hypothesis

Source: Data Analysis

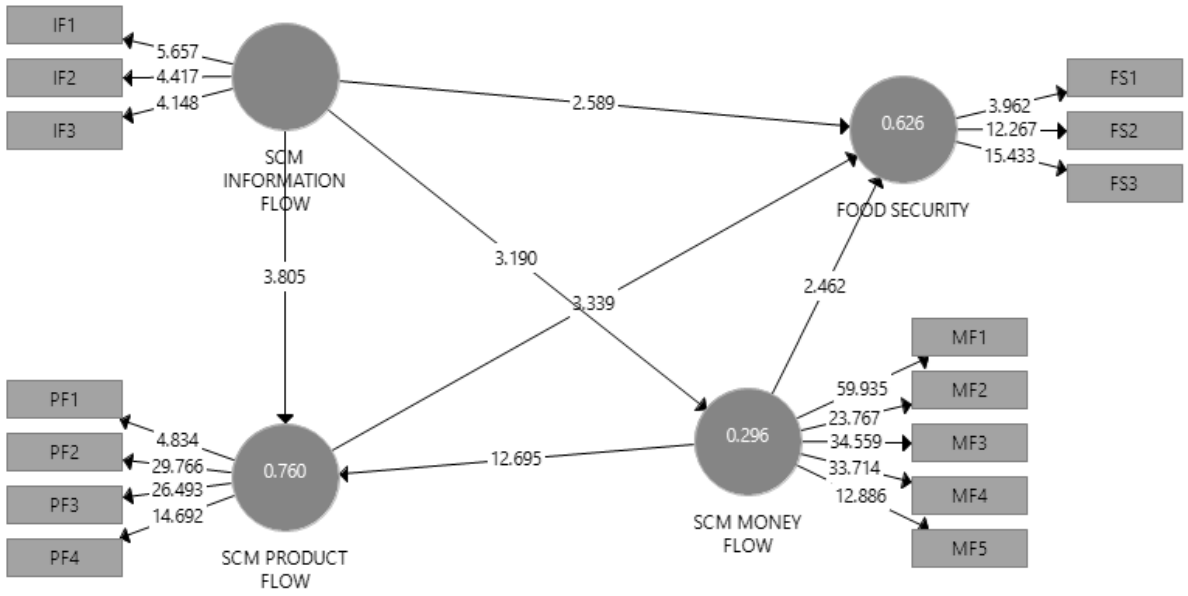

Fig 5.1: Structural Model
Source: Data Analysis

V. CONCLUSION

The results of the study revealed that supply chain flows are important in achieving food security. All three flows are important for achieving food security. These results are in line with the previous studies by Sazzad, (2014) which reveal that if supply chain management is implemented and executed efficiently, it is likely to help reduce food insecurity in any case. These results are also in line with past studies by Eastham, et al., (2017) which prove the importance of supply chain management in improving food security. These results are supported by past studies by Oluwatayo & Rachoene, (2017) which show the great contribution of supply chain management to improving food security at a national level. Moreover, study results have indicated that information flow has a mediating effect on money flow and product flow in the road to achieving food security. These results agree with the results of past studies by Aneesh, (2017) which indicated that money flow has a mediating role between product flow and food security. The study sheds light on the crucial role of money flow in guaranteeing the flow of the product (maize) from farmers to all supply chain partners up until it gets to the end user. Indirectly, the study indicates that supply chain management is crucial to ensure effective post-harvest of maize to enhance sustainable food security in Zimbabwe. Given the results of this study, there is a need to educate farmers and their supply chain partners through various platforms on the importance of supply chain management. The government needs to empower farmers with information regarding pertinent supply chain variables pertinent to maize farming, distribution, pricing, climate and rainfall patterns to encourage maximum production of maize and improve food security in the nation (Paloviita, 2017; Pamela, 2021).

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