Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.7, No.4, 2016
www.iiste.org

Dynamics of Disruption Risk Management in Grain Chain in Nigeria: A Simulation Study

Kehinde Paul Adeosun Patience Ifeyinwa Opata
Department of Agricultural Economics, University of Nigeria, Nsukka

Abstract

The study focussed on disruption risks in grain chain in Nigeria. The chain consists of different stages. It includes production, processing, storage and consumption. Rice grain is an important dietary food in Nigeria, in which its sufficiency cannot be over emphasised and this is mainly consumed by households. Currently, the supply of rice is below thresholds and consumption level. Farmers, processors, wholesalers and retailers are major actors in the rice grain chain. Also governments are a vital organ in this chain in the area of policy decisions. Nigeria is currently under-supplied in rice and over the years the supply of rice by Nigerians chain actors have been fluctuating due to some prominent disruption factors associated with the chain. These factors were identified to be weather failure, natural disaster, pests and disease, political instability and infrastructural risk. This has further reduced, and caused uncertainties, in the volume supplied at different points of chain stages. This study was mainly aimed to examine the effect of disruption risks in the grain chain in Nigeria. Specifically, the research explored the actual volume currently supply from different points in the rice grain chain. The research examines the volatility that exists at different points of the chain. The average volume supplied. The results show that at production level, the output shortage is on average 6.94 mt per year. Whilst, the output shortage at processing level will on average 3.75 mt per year. There is a 90% probability that the output shortage will be greater than 5.98 mt of paddy rice and, 3.04 mt of milled rice at 5% percentile, but less than 7.82 mt of paddy rice and, 4.45 mt of milled rice at 95% percentile, in a year. These shortages fluctuate with 0.56 standard deviation at production point and 0.42 standard deviation at processing. The cost to finance the default was also simulated along with the output volume based on two strategic approaches; an increase in paddy rice production, and an increase in the import of milled rice. The average cost for the shortfalls are expected to be €3.34 billion for paddy rice production and €1.95 billion for import of milled rice in a year.

Keywords: Disruption, risk management, simulation model, grain chain, Nigeria

1. Introduction

Grain is one of the major crops grown and also form a major part of Nigeria's staple foods. Nigeria's food regime is based essentially on food grains, which provide 46% of calories and 52% of proteins consumed (Dévelopment 2010). A large part of the food grains produced is retained on the farm for subsistence due to disruption in grain chain (Ukeje 2006). There is need for dealing with disruption since grain is needed throughout the country for consumption, animal feed and in industries (Famine Early Warning Systems Network (FEWSNET) 2008).

Small holder farmers are the major producers of rice in Nigeria. They get their seeds mostly from past harvests, or they buy them from markets or sometimes from government agencies/cooperatives, especially when there is need for improved seeds. Rural assemblers get the grains from farmers for further processing and storage, and for onwards movement to the wholesalers who eventually store the grain in large quantities (Oguoma et al. 2010). The grain moves from wholesalers to industries, retailers or directly to the consumers. Although, Nigeria is one of the major producers of rice globally, what is currently produced locally is not enough to meet local consumption needs, a situation that has made Nigeria a net importer of rice (Daramola 2005). This may be as a result of disruption risk factors and low production technologies.

Rice commodity flow is the movement of rice volume from one stage to another such as production to consumption. This flow contributes significantly to rural economic growth and poverty reduction in developing nations (Dorward et al. 2008; Greig 2009; Kostov & Davidova 2013; Zanello 2012). Yet several factors disrupt the flow in the fast-paced market environment. This raises a pertinent puzzle regarding what may be required to spark increase market flow (Gabre-Madhin 2006; Barret 2008; Dorward et al. 2008). Several studies associated grain flow to institutional constraint (Gabre-Madhin 2006; Baltenweck & Stall 2007). Other studies attributed disruption in the flow to certain factors such as erratic rainfall, high humidity, droughts, pests and disease epidemics along any rice chain(Lire et al. 2000). These factors reduce the volume of the rice as they flow from one stage to another, thereby causing shortages in terms of quantity. Risk in agricultural food production is defined as an uncertainty (i.e. imperfect knowledge or predictability) because of randomness(Aker 2010). It is regarded as the probability of losses resulting from incomplete control over the processes with which farmers are concerned (Organization for Economic Cooperation and Development (OECD) 2000). Weather factors are essential in rice production. Rice production in Nigeria is still predominantly rain-fed (International Food Policy Research Institute (IFPRI) 2009). Rainfall which increases grain moisture content is a key issue during and after harvest. Smallholder farmers rely on sun drying to ensure that grains are well dried before storage. If unfavourable weather conditions prevent grains from drying sufficiently, then losses will be high. Also, pest and disease affect the grain during storage if they are not stored properly.

Nigeria's production and consumption of rice have increased significantly since independence in 1960 (Federal Ministry of Agriculture and Rural Development (FMARD) 2006). However, the production increase has been insufficient to match consumption demands, despite the availability of a vast area of fertile and cultivable land (Akande, 2003). Limited supply has often led to large scale importation of food, especially rice, which is one of the major staple foods consumed by the Nigerian population (Ogunbiyi 2011). The Nigerian government has recently banned the importation of rice in order to encourage local production.

Grain availability is low in Nigeria due to a combination of low productivity and postharvest losses (Babalola 2003; International Food Policy Research Institute (IFPRI) 2009; Agwu et al. 2012). Also, Climate factors such as rainfall, temperature and humidity are key determinants of grain production and grain losses (Peel et al. 2007). Climate variability is likely to increase post-harvest losses due to the combination of changes in various climatic variables, which may increase in the number of pests and diseases which attack stored grain, as well as it creating an environment for new insect pests to flourish (Paterson & Lima 2010; Deffenbaugh et al. 2008). Weather instability exposes rice production to uncertainty, such that it may bring output fluctuations. For instance, if rainfall is inadequate or untimely, plants dry up and yields are in jeopardy. If rainfall is inadequate at the beginning of the rainy season, seeds dry up and the harvest is likely to be poor (IITA (International Institutes of Tropical Agriculture) 2007). If something is not done with the management of irregularities of disruption risk, it poses a great danger to the food security of Nigeria. This has further seriously reduced the supply of rice and domestic agriculture remains underdeveloped. As a consequence, the country continues to depend on imports to meet domestic demand for food to feed its 170 million people. Climatic factors are believed to be the strongest elements influencing high fluctuations in crop yield and, ultimately, food supply (Odozi 2014), with the problem of inadequate storage facilities and, post-harvest inefficiencies potentially leading to serious food shortage.

Risk in the grain chain is not only associated with production stage alone but is also present in other stages in the chain such as processing, storage and government policy. This negatively affects farmers, processors, and wholesalers decision's on their production activities, processing and the volume of storage. This may reduce the quantity supplied, thereby reducing the revenue of each actor in the chain. Similar studies have been conducted in Ghana on agricultural supply chain risk identification by (Yeboah et al. 2014) and in Thailand on uncertainty factors affecting the sustainable supply of rice production by (Thongrattana 2012). However, this study examined the effect of disruption risk variables on the volume of rice supplied at the level of production, processing and storage in the rice chain in Nigeria. This may help farmers, processors and wholesalers in Nigeria to make better strategic risk prevention decisions on production, processing and storage practice techniques. Furthermore, it may help governments to review and improve grain importation policy and improve support for grain farmers, and adopt better strategies to dissipate shortages.

This study will focus on rice as an example of major grains in Nigeria. The choice for rice in this study is related to its unique adaptability to diverse climatic conditions and its differential utilities in food and nutrition choices of consumers in Nigerians. In addition, rice is one of the grains chosen for the Presidential Initiative Agenda (PIA) and the Agricultural Transformation Agenda (ATA) of the Nigerian government to increase local production and ensure food security. Rice is also one of the most imported grains in Nigeria with average import of 2.081mt per year (United State Department of Agriculture (USDA) 2014). In this regard, the Nigerian government wants the rice imports ban to be more effective in order to encourage local production. The output expected in the chain consists of two products: the paddy rice which is supplied at production level and also serves as input for processing, whilst, milled rice is the final consumable product that comes from processing.

2. Research objective

The overall objective of this study is to assess the disruption risk management at different points (production, processing and storage) along the grain production to consumption chain.

The specific research questions are:

i. What is the average rice volume supplied by different points of the chain and what is the volatility of rice volume at different points in the chain?

ii. What are the critical rice sufficiency thresholds at different points of the chain?

iii. What is the cost-effectiveness of different risk management strategies?

3. Conceptual framework

The conceptual framework was structured to capture and explain the model for the study. The output and input parameters are explained and the data necessary for the analysis are stated. The threshold for each stage is also stated. The risk indications are explained to illustrate strategies for output management. The impact of the occurrence of disruption is also provided. Figure 1 describes the design for the model built in Microsoft Excel for the analysis of specific objective three. It captures the disruption impact at the different points of the chain. The model explained as thus, if the volume supply from the stages is below threshold level due to disruption impact, then risk management strategies will be applied to dissipate the shortages. This brings the volume back to threshold level and the expected output supplied at different points. Also the cost implication for each strategy is evaluated to identify the most cost effective strategies. It is assumed in this model that the output of one stage is an input of next stage. However, it's important to mention that storage stage would not be investigated in the model due to short supplied of milled rice at the processing. Therefore, storage stage is not part of the model. This is included in the conceptual framework because it could be used for other grains that have excess supply at processing.

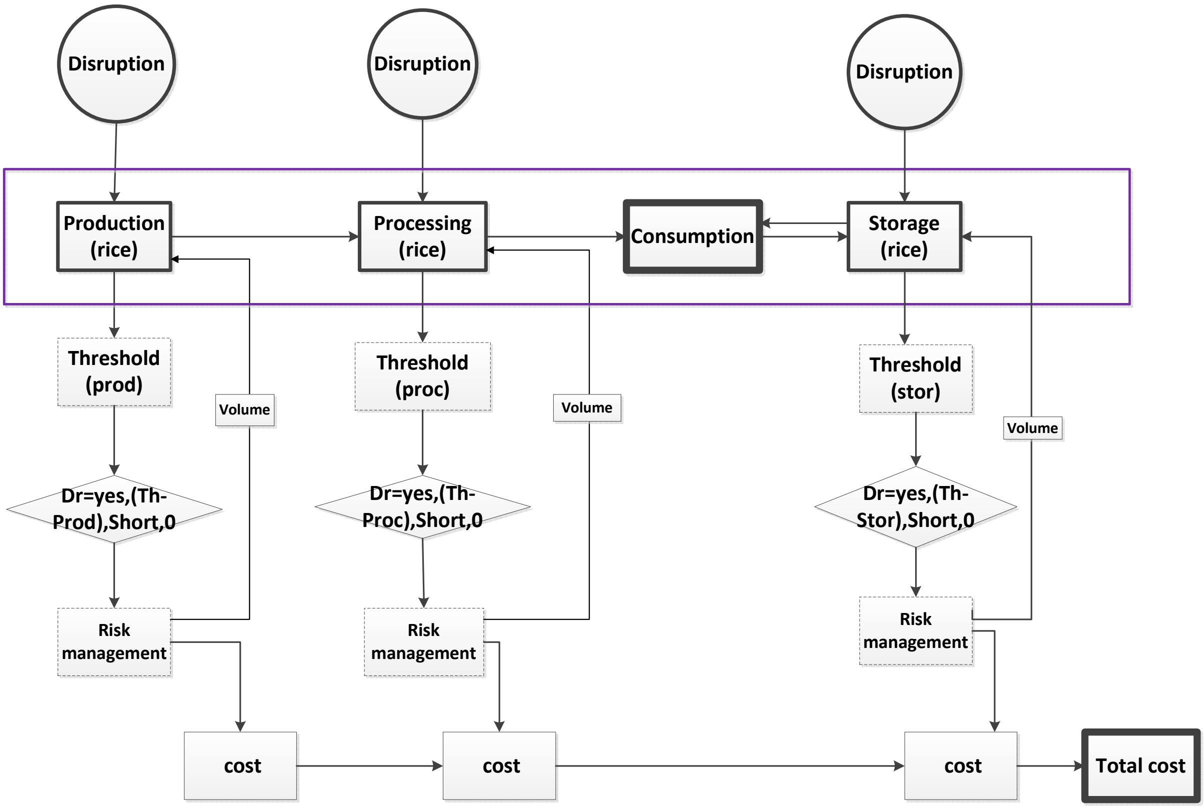

Figure 1: Schematic simulation model structure

Bold boxes: These indicate that both disruption and chain stages are stochastic.

Dash boxes: These indicate both threshold level and risk management strategies are deterministic.

Double bold boxes: These indicate the output (the actual quantity available for consumption) and total cost of risk management strategies.

Purple bold box: It indicates that all the stages are on the same chain.

The model is built in Microsoft Excel and IF function is used to determine the uncertainties as follows:, if disruption occurs, output supplied is reduced, when the output corrected for impact is deducted from thresholds, it gives the amount of shortage caused by impact of disruption, then risk management strategies are applied. This will be added back to the initial quantity at the stage. In a case where the quantity is equal or greater than thresholds, then no need of risk management strategy.

In figure 1, only disruption risks occurring in the stages are investigated. Therefore, we assumed there is no disruption risk between the stages. Note: these model shows what happens if there is disruption occurrence, if the commodity falls below the critical threshold as a result of disruption impact, the risk management strategies are applied. This will be added back to the commodity available to meet with the set threshold level. Also the cost for quantity applied is being evaluated.

The above model shows the commodity flow and the effect of disruption factors on the quantity that comes out from each stage of the chain. The quantity supplied from production to processing, where the paddy is being removed, then ready for consumption. As shown in figure 1, we store the excess quantity that may remain after consumption. This is part of stock available for next year consumption. The effect of disruption results in quantity uncertainty which makes quantity less than critical threshold level. This has a number of implications on each actor in the chain. These implications may be shortage of grain to processed, stored, low income and consumption. In other to meet the threshold level, actors or the government have to drive some strategic measures such as import, stock reserve or increase grain production to upgrade the quantity to threshold level.

The above framework shows the quantity of grain supplied from production, processing and storage e

4. Methodology

The inputs for the model were gathered through a literature review (Daramola 2005) and personal communication with experts. Also data on rice volume from the United State Department of Agriculture were employed in the simulation (United State Department of Agriculture (USDA) 2014). This consists of different parameters fitting in the model. These parameters include the following; average flow, disruption factors, impact, threshold level, risk management and cost. In some cases, assumptions are made where the specific data could not found.

Normal commodity flows at different points over a period of 15 years (2000-2014) were determined to find the average quantity flow and the fluctuation over the years. Table 1 shows average volume supplied from production and processing, and what consists storage after consumption. The reason for these 15 year data is to give the average volume on which subsequent analysis is built on.

Table 1. Production, storage and processing of rice (2000-2014) in Nigeria

Year	**Production** (paddy rice)	**Processing** (milled rice)
2000	3.29*	1.97*
2001	2.75	1.65
2002	2.92	1.75
2003	3.11*	1.87*
2004	3.33*	2.00*
2005	3.56*	2.14*
2006	4.04*	2.54*
2007	3.18	2.01
2008	4.17*	2.63*
2009	3.54	2.23
2010	4.47*	2.82*
2011	3.56	2.87*
2012	3.76*	2.37
2013	4.40*	2.77*
2014	4.04*	2.55
Mean	3.61	2.28
SD	0.52	0.40
Min	2.75	1.65
Max	4.47	2.87
Normal mean*	3.82	2.40
SD*	0.47	0.40

(United State Department of Agriculture (USDA) 2014), unit: million tonnes
*Normal mean: This is the average of volume assumed not to be affected by disruption over the period. This means the average volume supplied under normal circumstances. The normal mean will be used as the basis for normal flow in the model.

5. Simulation model

Simulation analysis is used to model disruption factors. These are based on the probability distribution of the occurrence over a period of years. This will help to simulate the effect of input on the output. The Nigeria grain chain is used to investigate the effect of disruption events on volume uncertainty at different points of the chain, such as production, processing and storage. The effects of this uncertainty are examined using simulation model. This stochastic model is specially built in Microsoft Excel for this study and @risk is added to simulate the data. The visual representation of the model can be seen in figure 1. Below in table 10, the parameters for the analysis are stated. Poisson distribution is used for disruption factor because is a discrete distribution and depict the occurrences of an event over time. Whilst Normal distribution is used for average volume supplied because is a continuous distribution and subject the uncertain volume supplied to many different sources of uncertainty or error.

Table 2. Parameter values in the default situation

Parameters	Distribution type	Description	Parameterization	Unit
Volume of production	Normal	Mean SD	3.82 0.47	Mt/year
Volume of processing	Normal	Mean SD	2.40 0.40	Mt/year
Disruption				
Weather/natural disasters	Poisson	Lambda	0.50	Frequency /year
Political instability	Poisson	Lambda	0.43	Frequency /year
Biological risk	Poisson	Lambda	0.57	Frequency /year
Infrastructure risk	Poisson	Lambda	0.66	Frequency /year
Impact				
Percentage impact on volume supplied[a] (Production and processing)		Volume supplied Correct for disruption impact	({1, 2, 3, 4} {10%, 20%, 30%, 40%})	Mt/year
Threshold level				
Production stage	Deterministic		10.3	Mt/year
Processing stage	Deterministic		6.0	Mt/year
Cost of risk management strategies				
Increase in production	Deterministic	Cost/unit	€482	Per tonne
Import of milled rice	Deterministic	Cost/unit	€520	Per tonne

Table 2 shows the stochastic distribution used for the simulation. This enabled us to fit the parameters into the model and see how they affect the output default. The results are discussed using mean, range, 5% percentile and 95% percentile. The 5% percentile means there is a 5% chance that output value is below 5% percentile value while 95% percentile indicates there is a 95% chance that output value is above 95% percentile value. The descriptive statistics provide mean, minimum, maximum and the range of values of 5000 iterations. [a]Percentage impact on volume supplied: This is the percentage of impact based on the number of occurrences of disruption on the normal volume to give the volume supplied corrected for disruption. It can be interpreted as follows: if disruption event happened once within a year, it will has 10% reduction in average volume supplied, if the disruption event happens twice within a year, it will has 20% reduction in average flow, if the disruption event happens three times within a year it will has 30% reduction in average volume supplied, whilst if it happens four times within a year it will has 40% reduction in average volume flow.

6. Sensitivity analysis

Sensitivity analysis shows variations in the output value of a model that can be assigned to different sources of changes in the model inputs (Saltelli et al. 2008). The model varies the inputs value to get the effect on the output. In this model there are five input parameters; volume of production; volume of processing; and, disruption factors, the threshold level, disruption impact and cost of risk management strategies. To investigate what the effect of one input uncertainty has on the output, one input parameter will be changed at a time, whilst the other four parameters stay constant. Sensitivity analysis was conducted on, disruption impact, disruption probability and threshold level to see what happened to the output default value. In this situation when one input varies the others remain constant.

Table 3. Parameter values for sensitivity analysis

Category	Default value	Sensitivity value
Disruption	0.57/year	0.85/year
Biological risk (production)	0.66/year	0.80/year
Infra-structure risk (processing)		
Threshold level	10.3 mt	11.8 mt
Production	6.0 mt	7.5 mt
Processing		
Impact	({1, 2, 3, 4} {10%, 20%, 30%, 40%})	({1, 2, 3, 4} {20%, 30%, 40%, 50%})
Percentage impact on volume supplied[a] (Production and processing)	0.57/year	0.85/year

7. Results

In this section, the results of the simulation in the default situation are given. The results below, shown in Table 4, show uncertainties of output shortage and cost.

Table 4 Expected grain shortages and risk management cost

Category	Average	5% percentile	95% percentile
Production (Paddy rice)	6.94 mt	5.98 mt	7.82 mt
(Processing) Milled rice	3.75 mt	3.04 mt	4.45 mt
Cost of paddy rice (Cost of risk management)	€3.34 billion	€2.89 billion	€3.77 billion
Cost of milled rice (Cost of risk management)	€1.95 billion	€1.59 billion	€2.31 billion

The results show the default distribution of different disruption factors. There are shortages, on average, of output of paddy rice of 6.94 mt/year. This will cost €3.34 billion on average to dissipate the total shortages. The results above show that there is a 90% probability that shortage volume of paddy rice will be greater than 5.98 mt but less than 7.82 mt with accompanying cost that ranges between €2.89 billion and €3.77 billion in a given year. For milled rice, there is a 90% probability that the consumption shortage will be greater than 3.04 mt but less than 4.45 mt with an average consumption shortage of 3.75 mt in a year. The corresponding cost uncertainties for the volume ranges from €1.59 billion of 5% percentile to €2.31 billion of 95% percentile with average cost of €1.95 billion. Table 3 shows the existing gap between volume supplied and threshold level, the shortages caused by disruption impact, risk management strategy and the cost.

7.1 Output shortages on thresholds

There is a big gap between rice sufficiency and the current rice volume supply in Nigeria. The simulation analysis conducted at different stages in the rice chain shows the uncertainties of the rice shortfalls in Nigeria. With respect to rice sufficiency, there is a deficit of 6.94 mt of paddy rice and 3.34 mt of milled rice on average per year. These shortfalls can range between a 5.09 mt minimum and 8.91 mt maximum of paddy rice; for milled rice this ranges between a 2.18 mt minimum and 5.17 mt maximum in a year. In a year, there can be a 5% probability that the shortfalls will rise above 7.82 mt of paddy rice and 4.45 mt of milled rice. With this result, there is a 90% probability that Nigeria will face shortfalls between 5.98 mt to 7.82 mt of paddy rice, and 3.04 mt to 4.45 mt of milled rice, every year. The level of shortage will depend on the percentage of impact and frequency of disruption factors. Table 3 show that Nigeria is under-supplied by 6.48 mt of paddy rice, and 3.60 mt of milled rice. Whilst disruption impact caused a shortage on average 0.46 mt of paddy rice, and 0.15 mt of milled rice.

7.2 Cost implication of output shortages

In order to be able to dissipate the shortage, the cost to finance it is simulated. These costs were based on different strategies used at different points of the chain. The results show that Nigeria will spend on average €3.34 billion to increase paddy rice production, while spending €1.95 billion to import rice in a year. The uncertainties in the cost range from €2.38 billion minimum for paddy rice and €1.18 billion minimum for milled rice, to a spend maximum of €4.19 billion for paddy rice and €2.75 billion for milled rice in a given year. In addition, there is a 90% probability that Nigeria will not spend anything less than €2.89 billion, but less than or equal to €3.77 billion in a year to increase paddy rice production. There is also a 90% probability that Nigeria will spend nothing less than €1.59 billion, but less than or equal to €2.31 billion, to import rice in a year. This is supported by a recent publication on daily newspaper that Nigeria spends 1 billion naira (€4.54 million) on daily basis for the importation of milled rice (Njeze 2015). The risk management applied to dissipate the shortage will cost on average €3.12 billion for shortage due to under-supplied of paddy rice, and 1.87 billion for shortage due under-supplied of milled rice in a year. Whilst €0.22 billion will dissipate shortage of paddy rice due to disruption event in a year, and on average €0.08 billion will be used to import of milled rice in a year.

7.3 Sensitivity analysis results

During the sensitivity analysis all variables are kept constant while one variable varies between different amounts. The input parameters were presented in Table 3.

Table 5. Sensitivity analysis results

	Default		Sensitivity	
Parameter	**Expected output shortage value**	**Expected cost of risk strategy (paddy and milled)**	**Sensitivity results Value (average)**	**Expected cost of risk strategy (paddy and milled)**
Increased biological risk (Paddy rice)	6.94 mt/year	€3.34 billion	6.99 mt/year	€3.37 billion
Increased infra-structure risk (Milled rice)	3.75 mt/year	€1.95 billion	3.79 mt/year	€1.97 billion
Higher threshold level at production (Paddy rice)	6.94 mt/year	€3.34 billion	7.95 mt/year	€3.83 billion
Higher threshold level at processing (Milled rice)	3.75 mt/year	€1.95 billion	5.26 mt/year	€2.73 billion
Increased impact at production (Paddy rice)	6.94 mt/year	€3.34 billion	7.21 mt/year	€3.48 billion
Increased impact at processing (Milled rice)	3.75 mt/year	€1.95 billion	3.87 mt/year	€2.01 billion

The variables that are varied are the volume supplied correct for disruption, disruption factors (biological risk and infra-structure risk), and threshold level to see the effect on the expected output default. The results show that when the probability of occurrence of biological risk increased from 0.57 to 0.85, the average output default increased from 6.94 mt to 6.99 mt of paddy rice, whilst the corresponding cost increased from €3.34 billion to €3.37 billion. More so, the probability of occurrence of infra-structure risk increased from 0.66 to 0.80, the average output default increased from 3.75 mt to 3.79 mt of milled rice and the corresponding cost increased from €1.95 billion to €1.97 billion. Also, when the threshold level at production increased from 10.3 mt to 11.8mt, the average output default increased from 6.94 mt to 7.95 mt of paddy rice and corresponding cost increased from €3.34 billion to €3.83 billion. Whilst, the threshold level at processing increased from 6.0 mt to 7.5 mt, the average output default increased from 3.75 mt to 5.26 mt of milled rice and corresponding cost increased from €1.95 billion to €2.73 billion. More so, when the summed impact of disruption increased by 10%, the average output default increased from 6.94 mt to 7.21 mt at production and 3.75 mt to 3.87 mt at processing.

8. Discussion, conclusions

In this section, model is discussed. It will be followed by conclusions and recommendations for further research.

8.1 Discussion

A specific model is designed for the study to investigate disruption risk management in grain chain in Nigeria. The model used normative approach and personal assumptions due to limited data available to investigate grain chain. The following variables were capture in the model: disruption factors, average flow, threshold level, risk management strategies, and the cost for risk management strategies. The model variables were parameterised using discrete and normal distribution. The probability of occurrence of disruption factors were summed together in the analysis and one discrete distribution was assumed.

In addition, storage stage though included in the conceptual framework but was not investigated due to limited data. However, this model can be used to examine other types of grains by re-structuring the model to fit in alternatives the country settings. In order for the model to be applicable, it should be adjusted to the specific situation in the studied country to show the direction of the flow. Nonetheless, the model can be used as an example or guideline for other type of grains. Also, the model structure can be use to evaluate sufficiency level of two different types of grain in a particular country.

Also, no disruptions such as transportation were assumed within the stage, therefore only disruptions at the stage level were assumed in the model. More so, example of grain (rice) investigated here is under-supplied in Nigeria, that means, there is existing shortages not accounted for by disruption. Therefore with impact disruption event, it further increases the total shortages to be dissipated. However, the model may give output shortage due to disruption impact alone if there is no existing shortage. Also, the shortage amount may be increased if disruption factors within the stages are included in the model.

Furthermore, the model gives different forms of output in different stages, for instance, paddy rice is supplied from production. This is not in a consumable form while it moves to processing where the chaff is removing to give milled rice that is ready for consumption.

The sensitivity results give slight increase amount different from the default value when the model input increases. This may be due to the fact that the increases in inputs may not equally proportional to the increase in output.

Finally, for further research a study can be done to examine the joint effects of disruption risk in-between the chain stages and the impact on the quantities that move to the next stage. This may help to examine the influence it has on threshold level.

8.2 Conclusions

The first objective of this study is to determine the average volume and volatility of rice supplied at different points of the rice grain chain. The average volume of rice supplied from production, processing and storage were determined to be 3.61 mt, 2.28 mt and 0.68 mt per year respectively. These range from minimum to maximum and expected standard critical thresholds of 6 mt of milled rice and 10.3 mt of paddy rice.

The second objective of the study is to determine critical rice grain sufficiency thresholds at different points of the chain. The critical level that Nigerian hold as standard from production is 10.3 mt per year of paddy rice and 6 mt per year of milled rice. Two strategies were included in the analysis to dissipate shortages; these were an import of milled rice and an increase in rice production. The range of shortages were determined to be 5.09 mt per year of paddy rice and 2.18 mt per year of milled rice at as a minimum, with 8.91 mt per year of paddy rice and 5.17 mt per year of milled rice at its maximum. These quantities show the ranges of additional needed volume to be supplied in order for Nigeria to reach its threshold level. Hence, the risk management was applied to bring it back to the threshold level.

The third objective is to determine the most cost effective strategies used to dissipate shortages. It was determined based on the volume of shortages and quantities needed to dissipate it. The results show that the consumption default fluctuates with 6.94 mt on average, with standard a deviation of 0.56 observed from paddy rice output; milled rice fluctuates with 3.75 mt on average, with a standard deviation of 0.42. It is observed that there is a 90% probability that the output default will be between 5.98 mt of paddy rice, 3.04 mt of milled rice and 7.82 mt of paddy rice per year, 4.45 mt of milled rice. Nigeria will record a shortfall of 6.94 mt of paddy rice on average every year and 3.75 mt of milled rice on average every year. There are two strategies adopted to address the shortfall in the study. First, if Nigeria wants to use an increase in rice production to address the paddy rice shortage, it will cost a total sum of €3.34 billion on average. On the other hand, using an import approach for rice milled to address the shortfall will cost a sum of €1.95 billion on average.

9. References

Agwu, N.M., I.N., N. & C.I., A., 2012. Climate Variability: Relative Effect on Nigeria's Cassava Productive Capacity. *Report and Opinion*, 15(12), pp.11–14.

Akande, T.(2003). An Overview of the Nigerian Rice Economy. Unpublished Paper: The Nigerian Institute of Social and Economic Research (NISER), Nigeria.

Aker, J.C., 2010. *Rainfall Shocks, Markets and Food Crises: The Effect of Drought on Grain Markets in Niger.* University and Centre for Global Development, Washington.

Babalola, O.Y., 2003. *Economics of commercial storage of grains: A case study of selected markets in Ogun state.* University of Agriculture, Abeokuta.

Baltenweck, I. & Stall, S., 2007. Beyond one size-fits-All. Measures for commodity system in Kenyan Highlands. *Journal of Agricultural Economics*, Vol 58 pp(3), pp.536 – 548.

Barret, C., 2008. Smallholder market participation: concept and evidence from Eastern and Southern Africa. *food policy*, vol 33, pp.pp. 299–317.

Daramola, B., 2005. Government policies and competitiveness of Nigerian rice economy. In *Rice policy and food security in Sub-Saharan Africa*. Cotonou, Republic of Benin: WARDA.

Deffenbaugh, N.S. et al., 2008. Global warming presents new challenges for maize pest management. *Journal of Environmental Research Letters*, 3, p.9.

Dévelopment, R., 2010. *A Look at the Agricultural Giant of West Africa: Special Issue: Nigeria Grain De Sel.*,

Dorward, A., Kydd, J. & C., P., 2008. *Traditional domestic markets and marketing systems for agricultural products*,

Famine Early Warning Systems Network (FEWSNET), 2008. Nigeria Food Security Outlook. , p.8.

Federal Ministry of Agriculture and Rural Development (FMARD), 2006. *Progress in implementation of Presidential Initiative on Rice, Cassava and Vegetable Oil Development Programme.*,

Gabre-Madhin, E.Z., 2006. *Building institutions for markets – the challenge in the age of globalization*, Addis Ababa, Ethiopia.: Ethiopia strategy support program, International food policy research institute.

Greig, L., 2009. An analysis of the key factors influencing farmer's choice of crop, Kibamba ward, Tanzania. *Journal of Agricultural Economics*, 60(3), pp.699 – 715.

IITA (International Institutes of Tropical Agriculture), 2007. *Doubling maize production in Nigeria in two years: Project description.*, Ibadan, Nigeria.

International Food Policy Research Institute (IFPRI), 2009. *Constraints to increasing Agricultural productivity in Nigeria*,

Kostov, P. & Davidova, S., 2013. A quantile regression analysis of the effect of farmers' attitude and perceptions on market participation. *Journal of Agricultural Economics*, 64(1), pp.112–132.

Lire, E., Jeffery, A. & Harrold, A., 2000. Changing in Consumption and Saving behaviour before and after Economic Shocks: Evidence from Zimbabwe. In *International Food and Agribusiness Management Association*. Chicago, pp. 1–39.

Njeze, F.A.V.N. newspaper., 2015. Nigeria losses 1 billion naira daily on rice importation. *Vanguard newspaper*.

Odozi, J.C., 2014. Rice-Self Sufficiency and Farm households: the Role of Climate Change and Technology Response in Nigeria. *Journal of Poverty, Investment and Development - An Open Access International*, 3.

Ogunbiyi, M.O., 2011. Assessment of Postharvest Handling and Quality Control Practices of Rice in North Central Nigeria: A Case Study of Lafia, Nasarawa State. *Journal of Developments in Sustainable Agriculture*, 6(2), pp.143 –163.

Oguoma, O.., Nkwocha, V.. & Ibeawuchi, I.I., 2010. Implications of middlemen in the supply chain of agricultural products. *Journal of Agriculture and Social Research (JASR)*, 10(2).

Organization for Economic Cooperation and Development (OECD), 2000. *Stabilisation Policies in Developing Countries after the 2007-08 Food Crisis* In Jonatha. A. P. for P. Reduction, ed., Paris.

Paterson, R.R.M. & Lima, N., 2010. How will climate change affect mycotoxins in food? *Journal of Food Research International Institute for Biotechnology and Bioengineering, Centre of Biological Engineering, Universidade do Minho, Braga, Portugal.*, 43(1), pp.1902–1914.

Peel, M.C., Finlayson, B.L. & McMahon, 2007. Updated world map of the Köppen-Geiger climate classification. *Hydrology and Earth Systems Science*, 4(1), pp.439–473.

Saltelli, A. et al., 2008. *Global Sensitivity Analysis,* The Primer, Chichester: John Wiley & Sons, Ltd.

Thongrattana, P.T., 2012. *Analysis of the uncertainty factors affecting the sustainable supply of rice production in Thailand.* University of Wollongong.

Ukeje, E., 2006. Modernizing Small Holder Agriculture to Ensure Food Security and Gender Empowerment: Issues and Policy.

United State Department of Agriculture (USDA), 2014. Assessments of commodity and trade issues. *Grain and Feed Annual, Nigeria.*

Yeboah, N.. et al., 2014. Agricultural Supply Chain Risk Identification- A Case Finding from Ghana. *Journal of Management and Strategy.*, 5(2), pp.31–48.

Zanello, G., 2012. Mobile phone and radios: effects on transactions osts and market participation for households in Northern Ghana. *Journal of Agricultural Economics*, 63(3), pp.694–714.

First Author: Mr Kehinde Paul Adeosun Email address: paul.adeosun@unn.edu.ng Institution: Department of Agricultural Economics, University of Nigeria, Nsukka Degree earned:M.Sc - Management Economics and Consumer Studies, Wageningen Unversity, Netherlands B.Agric - Agricultural Economics, Department of Agricultural Economics, University of Nigeria, Nsukka, Nigeria. Research Interests- Farm management, risk management in Agriculture, Agribusiness and production economics

Second Author: Dr. Mrs Patience Ifeyinwa Opata Email address: Patience.opata@unn.edu.ng Institution: Department of Agricultural Economics, University of Nigeria, Nsukka Degree earned: PhD in Agribusiness and marketing, M.Sc- Agricultural Finance and Project Analysis , B.Sc - Agricultural Economics, Department of Agricultural Economics, University of Nigeria, Nsukka, Nigeria, All the degrees from University of Nigeria, Nsukka, Research Interests: Agribusiness and marketing in developing countries, agricultural finance, gender studies, food security of poor households.