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ENERGY COST AND FOOD SECURITY IN WEST AFRICA

(西アフリカにおけるエネルギー費用と食料安全保障)

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EXECUTIVE SUMMARY

Food security is the capacity of people to access enough quality food, irrespective of their background. It is triggered by a wide range of factors, such as security, peace, geographical location, growth, income, financial management capacity, infrastructure, environment, food storage capacity, among others. These factors are parts of the four pillars of food security, which are food availability, access, utilization, and stability. Each of the four pillars is essential to achieve adequate food security. However, food access has been seen as a critical determinant of food security. It is also the most spread in regions like Africa. Food access has a physical and financial aspect. While physical access is more prominent in rural areas and includes all factors that facilitate the procurement of food at a given location and given time, financial access refers to the capacity to afford good quality food. It is more spread in urban areas.

West African economies have been facing many challenges to reach a sustainable food security level. To date, all countries have a self-sufficiency ratio lower than 100%, which raises two concerns. First, the capacity of supply to meet the level of demand. Second, the ability of people to access the currently available foods. Most efforts are being made to address the first concern. Initiatives such as Scaling Up Nutrition (SUN), Global Strategic Framework for Food Security and Nutrition (GSF), the Sustainable Development Goals (SDGs), Rome Principles for Sustainable Global Food Security, among others, put much emphasis on physical access to food, with high priorities placed on remote areas. However, several shreds of evidence have pointed out, on the one hand, income as a key determinant of food security, and, on the other hand, food prices as potential indications of food security. Yet, less work has been done to investigate this fina
ncial side of food security.

This research addresses the issue of food security in West Africa from the financial perspective and explores a relevant factor that can harm government budget, as well as households' financial leeway, namely fuel prices. In fact, a large number of West African countries are oil net-importers and highly rely on the conditions of international crude oil market. The small power of these economies increases their vulnerability in the sense that their domestic policies do not significantly impact international commodity prices. In addition, the depreciation of exchange rate increases their import costs and can considerably deteriorate government budget.

The study focuses on Burkina Faso, Ghana, Cote d'Ivoire, Niger, and Nigeria. It proposes to explore the following central question: to what extent fuel costs contribute to food insecurity in West Africa? To address this question, the research adopts several steps. The analysis gives a global picture of the impact of crude oil prices uncertainty on domestic prices of goods and services in general, using a Generalized Autoregressive Conditional Heteroskedasticity with effects in Mean, referred to as GARCH-M. It also investigates the transmission channel of international crude oil prices to domestic fuel prices, and the transmission channel of domestic fuel prices to domestic food prices. The estimation technique used for this purpose is a combination of a Vector Autoregressive Model, a Vector Error Correction Model, and a pass-through elasticity. The analysis is disaggregated at domestic local markets and focuses on 3 countries sharing a common border, namely Burkina Faso, Ghana, and Cote d'Ivoire. Finally, a more in-depth investigation of the nexus between food security and fuel cost is explored at the microeconomic level, through a survey targeted towards more than 400 households. The selected country for the survey is Burkina Faso, where households are highly exposed to food insecurity and the vast majority of the urban population uses motorbike, and therefore, highly relies on fuel. The sampling approach is a combination of a stratified and geographical method. The main objective is to understand how fuel consumption impacts households' food consumption and what is the implication for food security. The methodology in this part is a combination of qualitative and quantitative analyses. The qualitative section is explorative and uses graphs and contingency tables. The quantitative segment uses ordered probit and logit models, a robust OLS, as well as a quantile regression.

Results confirm that, first, crude oil price uncertainty has some inflation triggering behavior and can justify government interventions in the fuel market. Second, domestic fuel prices transmit at a higher rate to food prices, as opposed to international crude oil prices transmission to domestic fuel prices. The capacity of domestic fuel prices to absorb international crude oil price shocks depends on government choice of domestic fuel prices adjustment mechanism to international crude oil prices. High absorption capacity essentially deteriorates government budgets and can jeopardize other social expenditures. Besides, factors such as world food prices and exchange rate have additional and significant influences in this pass-through. Third, many households are highly exposed to food insecurity and poor dietary diversity, whether moderate or severe. About 8% are severely food insecure. The more food-insecure households are, the more they tend to put high responsibility on fuel prices.

Thus, fuel prices play important roles in driving food insecurity, especially in cities where people highly rely on fuel purchases, such as Bamako in Mali, or Ouagadougou in Burkina Faso. The evidence of the high contribution of fuel prices to food insecurity is confirmed by the analysis of households' responses to different scenarios of fuel price changes. During shrink in fuel prices, many households, especially the least wealthy, choose to improve their food consumption. When fuel prices increase smoothly, many reduce their food consumption.

The overall analyses shows that food insecurity is partially triggered and strengthened by two joint factors: the high pass-through of domestic fuel prices to food prices that increases poor consumers' vulnerability to fuel price shocks and food insecurity; and the high dependency on fuel purchase and motorcycle as primary locomotion that jeopardizes food budgets as well as food security.

These findings suggest that the current regulation of fuel prices should use less budget, without necessarily and totally suppressing fuel subsidies. Lowering food prices that are highly consumed by the poor is necessary for a direct impact on the poor. Strengthening safety at borders and improving cooperation between countries is essential to lessen the negative impacts of smuggling and arbitrages at borders that can undermine food and fuel policies. Developing public transport services and incentivizing motorbike owners can help to reduce their reliance on fuel purchases and vulnerability to fuel price shocks.

Besides, the survey reveals that studies aiming at linking dietary diversity to food security and livelihood should be undertaken with caution and consider each tribe's habits. An inadequate dietary can stem from habits and cultures and not necessarily from poverty. In this regard, the research suggests further investigations in areas of sociology and anthropology.

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Abbreviations

ADF	:	Augmented Dickey–Fuller
AfDB	:	African Development Bank
ARCH-M	:	Autoregressive Conditional Heteroskedasticity with Effect in Mean
CFA	:	Communauté Financière Africaine (African Financial Community, local currency)
CPI	:	Consumer Price Index
DF-GLS	:	Dickey–Fuller Generalized Least Squares
EBFSS	:	Experience-based Food Security Scales
ECOWAS	:	Economic Community of West African States
EIA	:	Energy Information Administration
FANTA	:	Food and Nutrition Technical Assistance
FAO	:	Food and Agricultural Organization
FDI	:	Foreign Direct Investment
GARCH	:	Generalized Autoregressive Conditional Heteroskedasticity
GDP	:	Gross Domestic Product
GHS	:	Ghanaian Cedi (Local Currency)
GSF	:	Global Strategic Framework for Food Security and Nutrition
HDDS	:	Households Dietary Diversity Score
HFSSM	:	Household Food Security Survey Module
IMF	:	International Monetary Fund
INSD	:	Institut National de la Statistique et de la Démographie (National Statistical and Demographical Institute, Burkina Faso)
LM	:	Lagrange multiplier
MGARCH	:	Multivariate Generalized Autoregressive Conditional Heteroskedasticity
NPA	:	National Petroleum Authority (Ghana)
OPEC	:	Organization of the Petroleum Exporting Countries
PNDES	:	Plan National de Développement Économique et Social (National Economic and Social Development Plan, Burkina Faso)
PNSA	:	Programme National de Securité Alimentaire (National Policy on Food Security, Burkina Faso)
PP	:	Phillips–Perron
SAP	:	Système d'Alerte Précoce (Early Warning System)
SC	:	Schwarz (Information) Criterion
SEECCM	:	Single Equation Error Correction Model
SDGs	:	Sustainable Development Goals
SIR	:	Société Ivoirienne de Rafinerie (Ivoirian Oil Refinery Company)
SONABHY	:	Société Nationale Burkinabé des Hydrocarbures (Burkina Faso National Oils Company)
SUN	:	Scaling Up Nutrition

UNDESA	:	United Nations Department of Economic and Social Affairs
UPPF	:	Unified Petroleum Price Fund (Ghana)
VAMU	:	Vulnérablité Alimentaire en Milieux Urbains (Food Vulnerability in Urban Settings, Burkina Faso)
VAR	:	Vector Autoregressive
VAT	:	Value-added Tax
WAEMU	:	West African Economic and Monetary Union

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CHAPTER 1: Introduction

According to the FAO (1996), food security exists when all people, at all-time possess the physical and economic capacity to access sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Food insecurity is a state of "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways" (Bickel et al., 2000). Barriers such as poor road conditions, low harvests, lack of appropriate means of transportation to access markets, inadequate storage capacities determine the physical incapacity to access safe food. As for economic access to safe food, it is mainly triggered by low income. Other factors that can instigate food insecurity through direct or indirect impacts on physical or economic access to safe food include slow growth (Timmer, 2005), inequality (Sen, 1981), peace (Breisinger et al., 2011, Boeing, 2016), geographical disadvantage (Gleeson and Carmichael, 2001), environment (McMichael, 2011; Gouel, 2013; Nelson, 2014), financial management capacity (Gulliford et al., 2005; Nolan et al., 2006), among others. The U.S Department of Agriculture highlights four dimensions that need to be accomplished and maintained simultaneously to achieve food security. These dimensions are availability (of food), access (to food), utilization (capacity to use and obtain nourishments from food) and stability (of the first three dimensions) (Brown et al., 2015).

Three factors determine food availability in West Africa: production, import, and aid. Food production consists of cereals (such as maize, rice, millet sorghum), and cash crops (cotton, nuts, sesame, soya, etc.). Other crops include cowpeas, yam, potatoes, fruits, vegetables, animal, and forest products. A portion of food is imported, essential to remedy the self-insufficiency of countries. Rice comes on the top of imported foods, followed by wheat and cereals. Milk and animal products are also parts of imports, although their share in total import is relatively low. Governments are actively supporting domestic production of staple foods (especially rice) to leverage farmers' income, boost domestic demand and circumvent financial outflows. Along with domestic production and import, countries such as Burkina Faso, Mali and Niger often receive food aid from various development partners. This assistance is relatively low in quantity as opposed to domestic production. Import is generally targeted towards specific areas (remote and rural areas) and in specific periods (generally when food stock runs out before a new harvest).

Food access represents an essential component of the analysis of food security in the region. It has physical and financial components. In most countries, physical access is prominent in remote and rural areas. Many production areas are challenging to reach due to poor road conditions and lousy transport infrastructures. Some food-deficit areas, such as Northern regions in Burkina Faso, Mali, and Niger, are far-to-reach and highly unsafe due to the presence of terrorist groups. In urban cities, infrastructure is well present, and food markets well supplied. However, financial access to food is a predominant challenge. Urban households entirely depend on market supply for their subsistence, which implies a minimum income. The high number of poor constructions and slums in these urban areas is an indication of the possible existence of food-insecure households. Even in well-built accommodations, limited income or high expenditure can trigger a sort of hidden food insecurity, where individuals/households are not aware, and policymakers barely capture.

Food stability, both in quantity and price, is another dimension of food security. The 2018-2021 Burkina Faso National Policy on Food Security (PNSA, 2017) identifies four factors affecting food stability: i) loss in production, due to poor stocking and conservation methods, and underdeveloped infrastructures; ii) the incapacity of production from rainy seasons to compensate that of dry seasons. This results in high imbalances between regions and markets; iii) high fluctuations in food supply due to reduced availability of food in hunger seasons. Weak stocking and conservation methods primarily cause this poor availability; iv) insufficient institutional food stocks. Other random factors affecting food stability include droughts, lack of rain, and the invasion of insects.

Food utilization is determined by the capacity to benefit from food nutrients effectively. Reduced food utilization can lead to food insecurity even if availability and access to food are at their optimal level. Inadequate stocking capacity of food considerably deteriorates the quality of food and can sometimes lead to poisoning. Another important factor affecting food utilization is the spread of taboos in some tribes and communities. Prohibition of some types of foods on certain genders, age groups, and in specific periods of the month/year can threaten quality nourishments and slower mental as well as physical developments. A similar effect can be instigated when some compelling cultural practices push people to drink unclean water for the sake of the “spirits.” In some communities, eggs are prohibited to children and women.

Several initiatives have been implemented at international, regional, and national levels to curb food insecurity and more generally fight poverty. These international initiatives include the Sustainable Development Goals (SDGs), Scaling Up Nutrition (SUN), Global Strategic Framework for Food Security and Nutrition (GSF), Rome Principles for Sustainable Global Food Security, as well as the numerous West African and African food security and agriculture initiatives. These initiatives prove that food insecurity remains an issue and curbing it is an essential priority for the region. Through improving agricultural productivity, with the support of international development partners, the region's goal is to ensure that all people, irrespective of their location and livelihood do not experience food distress.

Of the four dimensions of food security, food access is the most recurrent and most prominent in the region. Extensive works have so far been done on physical access to safe food, and the current initiatives mostly address this matter. Yet, food could often be available, but financially inaccessible, the more so as a large number of West African households live below the poverty line (World Bank, 2018). In this regard, several studies have pointed out income as an important determinant of food insecurity and hunger (Rose 1999; Gicheva et al., 2010; Tuttle et al., 2017). This means, for instance, that high domestic prices can undermine food security. In fact, in early 2008, the surge in domestic prices of goods and services (and in food prices in particular) in Burkina Faso drove the country into a series of demonstrations and protests, pushing the government to suspend consumption tax for a few months. Although, there were numerous contributory factors to these increases, the fundamental reason was found to be the sudden rise in international crude oil prices, which had been steadily rising over the past several years (Archives Nationales, 2008). From $27.65 in June 2003, the price of the barrel exceeded $122.80 in May 2008, which represented an almost 77.5% increase (EIA, 2017). Burkina Faso is an example of all West African economies frequently facing the spillovers of crude oil prices and highly exposed to food insecurity. In countries with low living standards, prices of goods and services play some crucial roles in the dynamics of these economies.

To reduce the burden of high food prices to the poor, low input cost policy has widely been applied. Since fuel is one of the key determinants of transports costs (Dillon and Barrett., 2016), the control of domestic fuel prices can be motivated by the objective of protecting fuel buyers and reducing the uncertainty about crude oil prices volatility. By maintaining domestic fuel prices at an affordable level,

governments aim at keeping changes in transport costs sluggish and thereby food prices (and domestic prices in general) at a sustainable level. This idea is documented in Baumeister and Kilian (2014), who also claim that the impact of high domestic fuel prices on food prices is more prominent in developing countries than in developed or emerging economies. Developing countries have a high consumption of crop foods, directly linked to fuel prices and transport costs.

On the contrary, developed and emerging economies have a high consumption of processed foods. Bacon and Kojima (2008) also posited that monitoring price of petroleum products has the objectives of retrenching the volatility of domestic retail prices and mitigating the impact of higher prices on the poor. Yet, inefficient monitoring of fuel prices can lead to non-desired distortions. First, the administration of fuel prices can undermine the positive effects of market forces such as competitivity, lower prices, and equilibrium. Second, if governments' actions on prices win over market forces, there is a possibility that the difference in real fuel prices across countries lead to smuggling or arbitrages to exploit the prices difference (fuel smuggling exists in some porous borders of Africa. See Hayduk, 2012). This situation can alter fuel prices pass-through to food prices and wane down the expected results of low fuel prices. In a region with a high dependency on fuels, fuel prices can play essential roles in food insecurity.

Hence, this research proposes to investigate the following central question: to what extent does fuel cost contribute to food insecurity in West Africa? From this central question, three sub-questions that underline the objectives of the research and guide the flow of the study are derived. First, at the macroeconomic level, how does international crude oil prices volatility (or uncertainty) impact prices of goods and services in general? The intuition or hypothesis behind this question is that higher uncertainty on crude oil prices can trigger inflation and can be a justification for the government to regulate fuel prices. Second, at the disaggregated level, what does the transmission channel of international crude oil prices and food prices to domestic food prices imply in terms of food security? The underlining hypothesis is that market location, and government pricing mechanism (among others) can determine financial access to food. Finally, at the microeconomic level, how does fuel prices impact households' food security? This question is motivated by the intuition that in a region with high reliance on fuels, it is likely that households contract their food consumption to adjust rises in fuel prices.

The study starts with a background of West African economies and provides an overview of the drivers of growth, some key macroeconomic indicators, and development issues in the region. Chapter 2 investigates the first research question on the impact of crude oil price uncertainty on domestic prices of goods and services in general. Chapter 3 addresses the second research question, which is the analysis of the pass-through of crude oil prices to some staple food prices in three West African countries sharing a common border (Ghana, Burkina Faso, and Cote d'Ivoire). Chapter 4 (third research question), analyzes at the microeconomic level the impact of fuel prices on households' consumption. Finally, chapter 5 draws the conclusion and policy implications.

1.1. Background

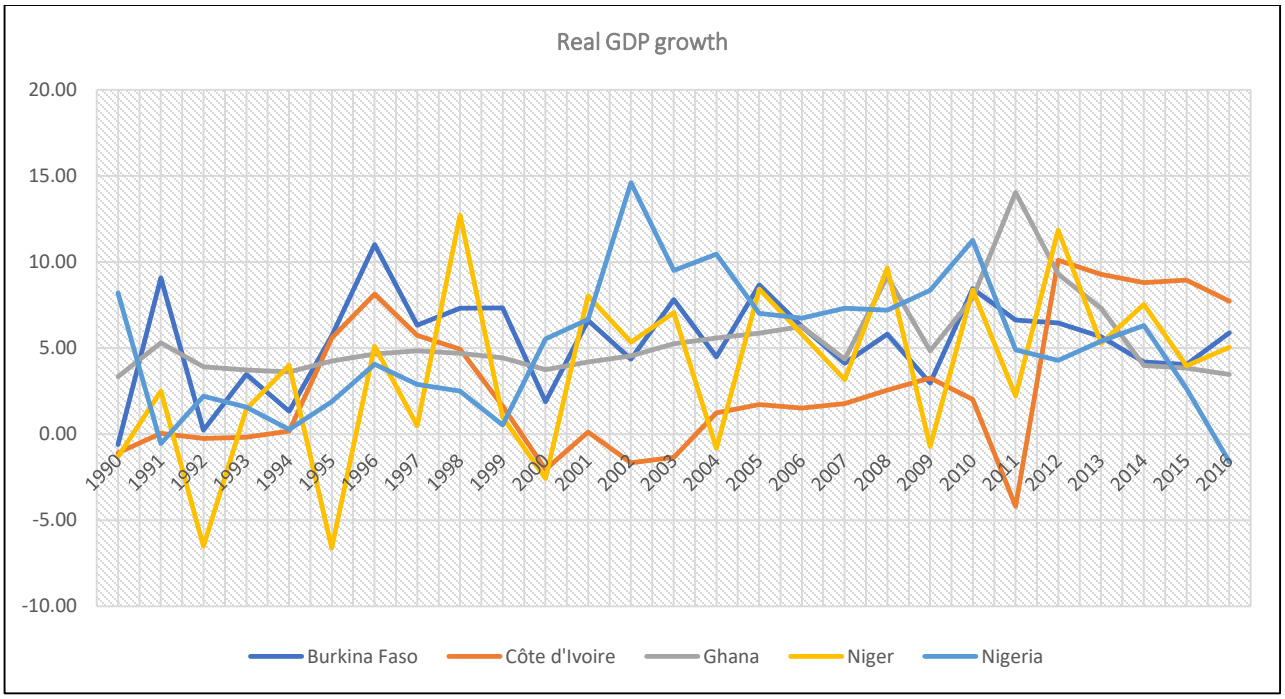
West Africa is a mix of landlocked, coastal, dry, improved economic indicators, and heavily indebted countries. The region covers 5,112,903 km^2 with a total population of about 362,201,579 in 2016 (World Population Prospects, 2017). The region is composed of big economic contributors such as Nigeria with its large oil reserves, Ghana and Cote d'Ivoire with their Coffee and Cocoa. Recently, rise in terrorism in the northern part of the region (Algeria, North of Nigeria, Mali, North of Burkina Faso, Niger) has contributed to strengthening the collaboration and information sharing system between countries, which can open future stronger cooperation in areas other than security. ECOWAS or Economic Community of West African States is the largest regional organization, headquartered in Abuja (Nigeria) and composed of 15 countries. Among these countries, WAEMU or West African Economic and Monetary Union is the most integrated organization in terms of cooperation. It is composed of 8 countries with a similar history, same currency (pegged to Euro), free trade, and common macroeconomic policy directives. The headquarters is in Ouagadougou, Burkina Faso.

This study focuses on five West African economies, namely Burkina Faso, Cote d'Ivoire, Ghana, Niger, and Nigeria. The selection of these countries is motivated by the objective to have a closer and more in-depth analysis, as a large number of countries would give a general picture. Also, countries are selected for heterogeneity purpose, as they are composed of economies with the following features: landlocked, coastal, least developed, emerging, fixed exchange regime, flexible exchange regime, member of WAEMU, non-member of WAEMU. The last reason is data availability. Countries were selected to have the longest possible data span at both national and regional levels. The term West Africa in this research refers to these five countries.

A large portion of land in West African countries is dedicated to agriculture, although this sector tends to decline in terms of employment, due to growing manufacturing and service sectors, especially in countries like Cote d'Ivoire, Ghana, and Nigeria. The region has maintained a dynamic economic growth over decades (figure 1.3) supported by strong economies like Nigeria, which contributes to about 70% of West African economic growth, followed by Cote d'Ivoire and Ghana. However, development that follows economic growth has not been satisfactory, and inequality is still persistent. In terms of development process, traditional theories identify three stages. A country starts its development process from the agricultural sector where labor demand is in increase and the society at a traditional level. Boost in agricultural sector generates pressures on industrial and manufactural sectors for transforming agricultural products in order to meet local demand. This pressure on the industrial and manufacturing sectors also affects labor demand, which starts outflowing the agricultural sector. The final next stage is the expansion of the service sector to facilitate people's transactions, interconnection, and access to their needs. This configuration of development stages, as detailed by Rostow (1960) has been experienced by most developed and emerging economies.

In the case of West Africa, however, the service sector tends to grow earlier and faster than the manufacturing or industrial sectors. The difference is explained by the fact that the manufacturing and industrial sectors receive relatively low investments and are generally limited to food industries and the processing of primary products. On the other hands, with the spread of globalization, the development of information and telecommunication technologies, the service sector tends to spread at a fast pace, with the support of international development partners. However, in some countries, the manufacturing and industrial sectors are receiving great attentions and are scheduled to be future priorities. It is the case of Plan National de Développement Économique et Social (PNDES) 2016–20 (or National Economic and Social Development Plan) of Burkina Faso, which emphasizes on industry and manufactory as future growth engines.

Figure 1.1. Real GDP growth



Data source: World Bank Database.

1.2. Components and drivers of growth

In terms of contribution of each sector to economic growth, over decades, agriculture has been playing a significant role in food security and the dynamics of West African economies. Agriculture products are centered on international commodities and domestic consumption. Nigeria, one of the largest agrarian economies in the region, produces, transforms, and commercializes a wide range of products at different scales. The most predominant crops include yam, sorghum, palm oil, millet, plantain, cassava, maize, rice, cocoa beans, sesame, beans, cashew nuts, and rubber. Although the agricultural sector makes a significant contribution to total export in Nigeria, the sector still lacks sufficient labor force (like the majority of Sub-Saharan African countries). In 2010, the sector employed around 30% of the labor force (Nigerian Bureau of Statistics, 2010). This rate remains low, given the size of agricultural lands in the country. The low employment rate in the agricultural sector in Nigeria can be explained by the spreading industrial sector, particularly the oil sector, which has a high contribution to the economy of Nigeria. Ghana and Cote d'Ivoire have many similarities. The similar weather conditions, and major industrial sectors (lead by gold and oil) and agricultural products (including cocoa, coffee, cassava, plantain, and yam) are some reasons explaining their similar economic trends over time. From 1960 to 2014, the two countries had an average economic growth of 3.9 % and 3.6%,

respectively (African Development Indicator database, 2015). In Cote d'Ivoire, Ghana, and Nigeria, cocoa is one of the leading international commodities. The three countries are the first, second, and fourth-largest cocoa producers in the world, respectively (International Cocoa Organization, 2016).

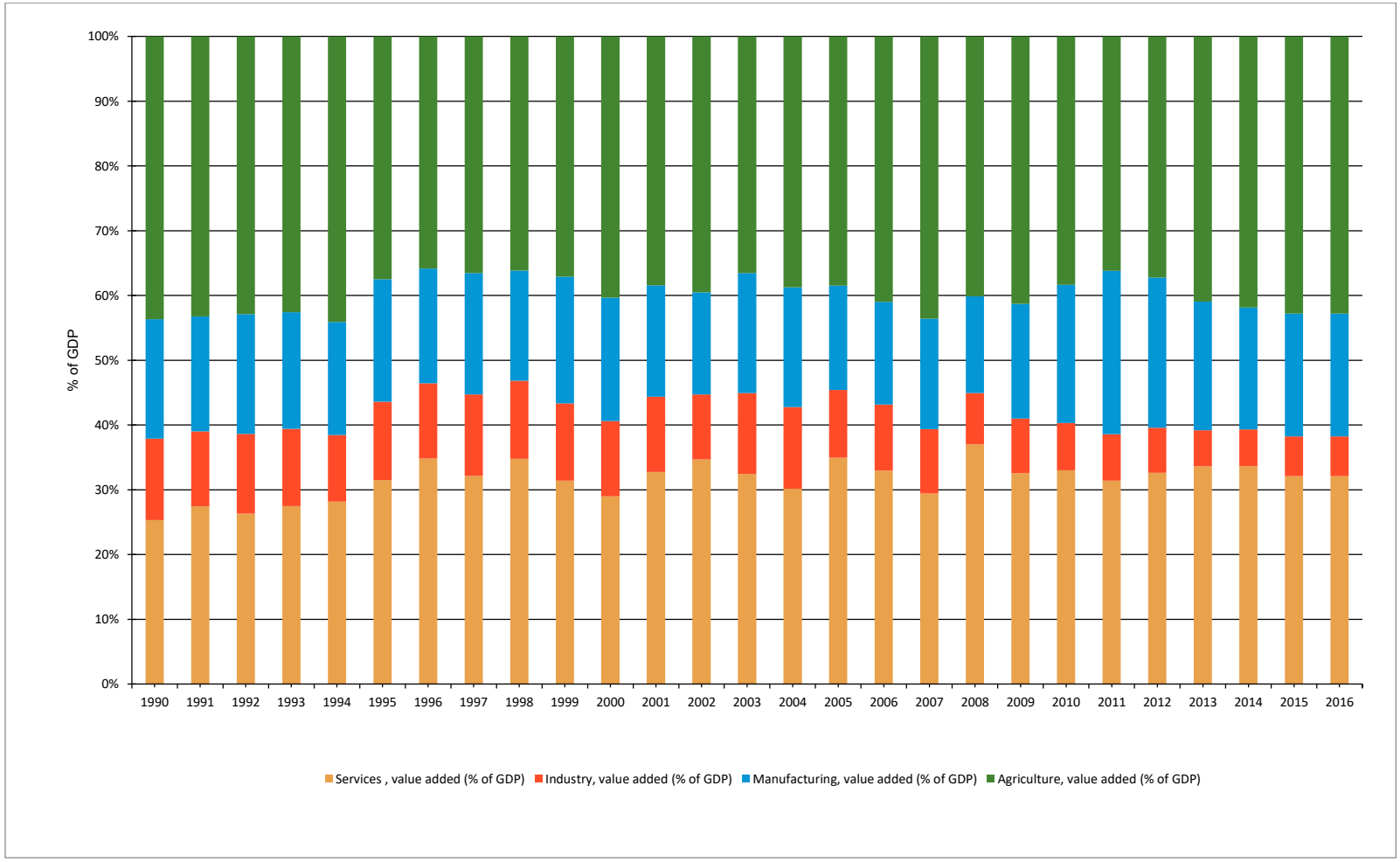
Burkina Faso and Niger have less than 45% of their land used for agriculture. In these countries, in addition to agriculture, livestock is another important sector that uses a portion of land. The two countries remain significant suppliers of livestock in the region. The primary domestic production includes nut, maize, corn, sorghum, millet, beans, and more generally, products that do not use excessive water, as the two economies are dry and landlocked. Cotton is the leading internationally traded commodity in Burkina Faso. The country is the world's 10th largest cotton producer (United States Department of Agriculture, 2015). Niger has the lowest production of cotton and is ranked 60th in the world. Despite this low production compared with Burkina Faso, the cotton sector in Niger uses an integral part of the labor force and contributes to the country's development. In addition, Niger has set numerous initiatives and programs (such as Géocoton, a program that aims to triple the production of cotton in Niger) to vitalize the cotton sector, in accordance with the country strategy « Les Nigériens nourrissent les Nigériens » (Nigeriens feed Nigeriens), which is included in the National Plan for Food Security and Sustainable Agricultural Development vision 2035 (initiated in 2012).

Manufacturing and industrial sectors in West Africa are in a growing phase. Their contribution to GDP is low as opposed to the agricultural sector. The weakness of the two sectors represents a significant loss for the region. In fact, the region is composed of countries that have an essential contribution to international trade due to their high production and abundant resources. The lack of transformation capacities places these countries in the situation of high suppliers of raw products to the world (usually at non-satisfactory prices) and high importers of final products (at higher costs). The commonly cited example is cocoa. The region exports around 65% of cocoa beans internationally, but imports nearly 95% of its chocolate, due to the lack of chocolate manufacturing industries. The same example applies to cotton and garment. Manufacturing and industrial sectors are dominated by Nigeria, Ghana, and Cote d'Ivoire, due to their extractive industries. With the "High Five" priorities set by the African Development Bank, industrialization is set to receive growing attention. In Nigeria, efforts are being made by the government to reduce its reliance on the oil sector and to wane down the impact of decreasing international crude oil prices. Cote d'Ivoire is developing chocolate industries to increase

its gains from cocoa. In Burkina Faso, The National Economic and Social Development Plan 2016-2020 aims at doubling the contribution of the manufacturing sector to economic growth by 2020, with an emphasis on agro-industries, services, and solar energy industries.

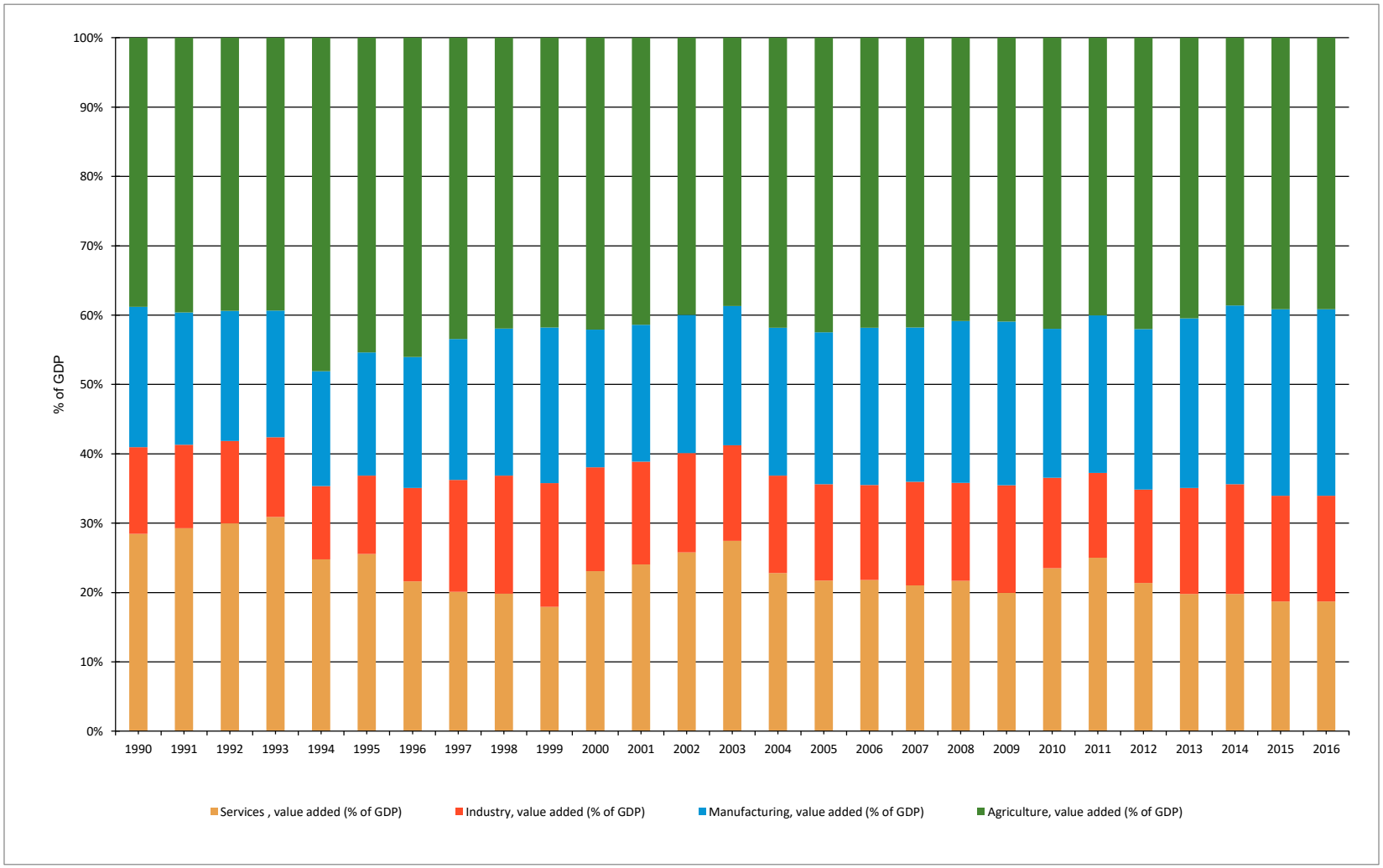
The service sector also has a significant contribution to growth in West Africa. It is dominated by transportation, telecommunication, trade, and financial services. In 10 years, the contribution of the service sector to GDP has nearly doubled, rising from 29.3% to 51.6% (between 2005 and 2015, AfDB, 2016). Financial services are in constant expansion. These services are now accessible due to the development of the internet and cellphones. Financial transactions such as credits purchases, sending and receiving money, phone, electricity, and water bills payments via cellphones are currently widely spread. This expansion is expected to contribute to curbing financial exclusion; the more so as poor and rural households can access them at low costs. Trade in the region is highly concentrated in the informal sector. Most streets in urban areas are occupied by small sellers and resellers who regularly compete to win the demand, at the benefice of buyers. Traded goods are usually foods, drinks, and clothing. In some countries like Burkina Faso or Mali, gasoline is often sold by small sellers. These types of gasoline are usually deficient in quality, low in price, and unsafe for the environment. The transport sector is dominated by small private firms, who work on enabling access to all parts of the country and the cities. The advantage of these services is that they can access difficult-to-reach areas (such as poor road conditions or very narrow paths) as their services are not limited to four wheels vehicles, but also includes tricycles and motorbikes. With the recent opening of the first metro in Nigeria, as well as Cote d'Ivoire's plan to create its metro, the contribution of the service sector in West Africa's economic growth is set to spike.

Figure 1.2a. Contribution to growth: Burkina Faso



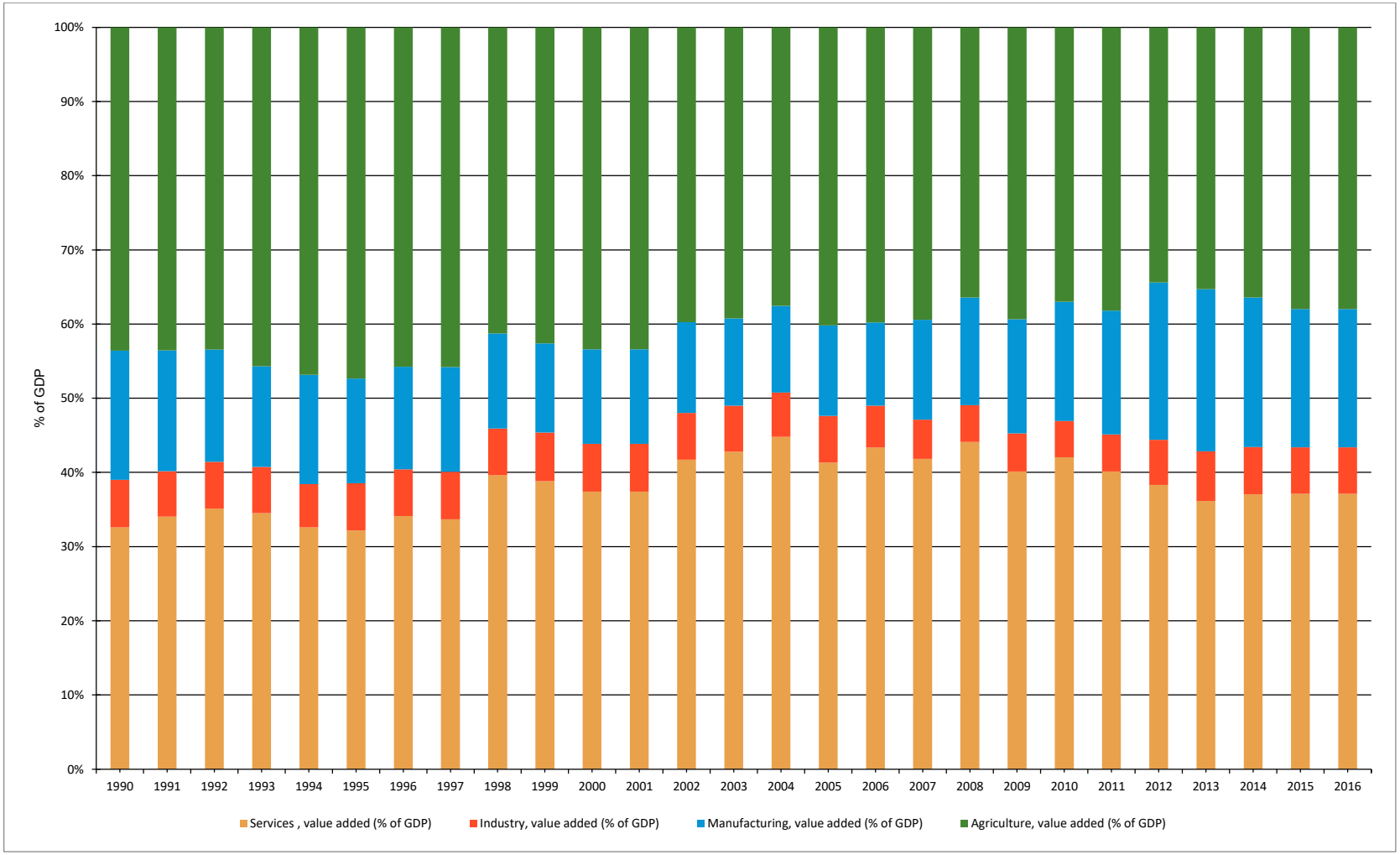
Data source: African Development Bank Database.

Figure 1.2b. Contribution to growth: Cote d'Ivoire



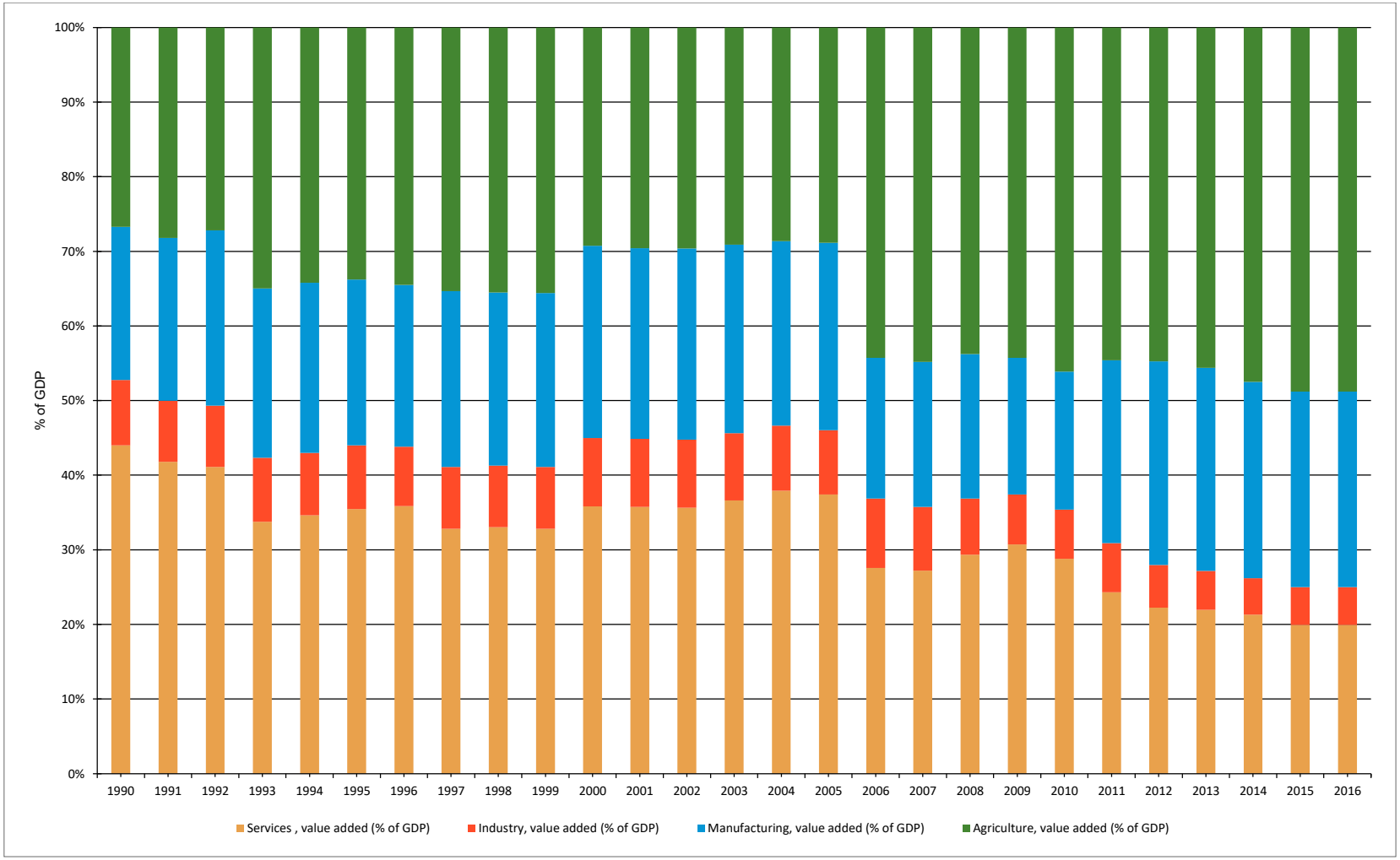
Data source: African Development Bank Database.

Figure 1.2c. Contribution to growth: Niger



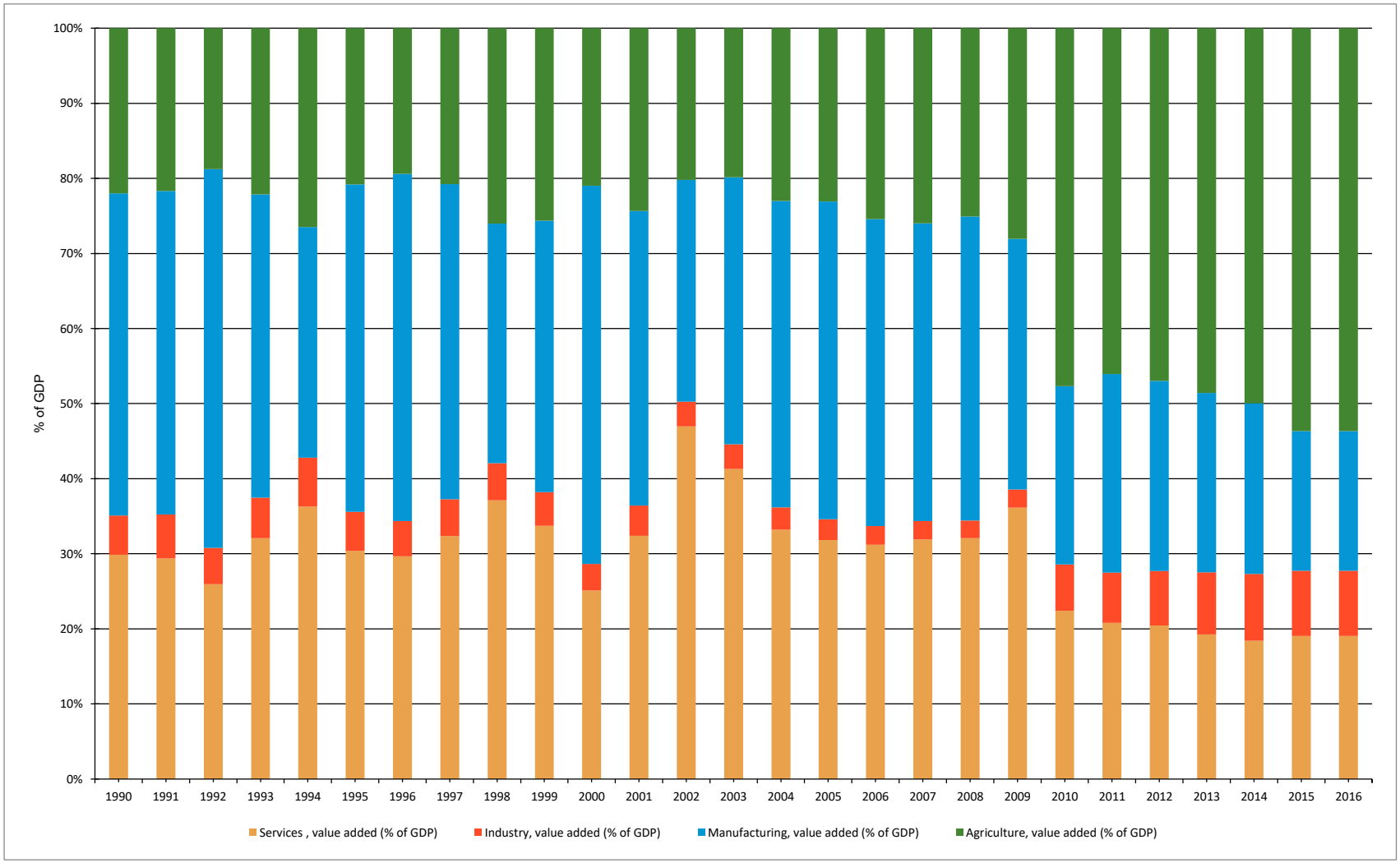
Data source: African Development Bank Database.

Figure 1.2d. Contribution to growth: Ghana



Data source: African Development Bank Database.

Figure 1.2e. Contribution to growth: Nigeria



Data source: African Development Bank Database.

1.3. Key macroeconomic indicators

Nigeria and Ghana have maintained a good economic record, thanks to political stability that has strengthened business confidence and encouraged investments. The average per capita GDP growth in the two countries is close to 3%, higher than that of Cote d'Ivoire, Burkina Faso and Niger (in Niger the average growth is negative, tables 1.1a to 1.1e). However, growth in Nigeria is highly dependent on oil rent. Crude oil price plummets often severely hit the Nigerian economy. The recent case was the 2011 crude oil prices shock that harshly shrunk country's growth. To wane down these spillovers, Nigeria is diversifying its economy. Cote d'Ivoire has vast growth potentials, but political instability represents a significant threat. As can be seen in figure 1.1**,** the 1998 coup, the 2002 and 2011 series of political turmoil have either slowed or pulled down the country's economic growth. Nigeria and Ghana have been in a proper stance, but their choice of exchange rate regime is not accompanied by more robust macroprudential polices. As a result, domestic prices of goods and services are less stable. Unlike Burkina Faso, Cote d'Ivoire, and Niger who use a pegged exchange regime (pegged to Euro), Nigeria and Ghana adopt a flexible exchange regime. As presented tables below, the average inflation in Nigeria and Ghana over the past decade is around 20% while this average is below 4% in Burkina Faso, Cote d'Ivoire, and Niger. This evidence reinforces the idea that fixed and pegged exchange regimes have the advantages of reducing future prices uncertainty and inflation. High inflation is detrimental for external trade and harms competitivity vis-à-vis the rest of the world.

There are lots of disparities and few similitudes between countries in terms of total debt and the external sector. Cote d'Ivoire has the highest level of debt (113.40% of GDP). This high rate is explained by the recent tremendous recovery and transformation process the country has been engaged in, in the wake of 15 years of political instability. Foreign direct investment has remained low (12. 82%), like in most West African countries. Only Ghana presents a relative better outlook with a ratio of 17% of GDP. The trade balance is deficient in most countries due to high imports and low exports. Thanks to their primary commodity that are highly traded internationally (cocoa and crude oil), the average trade balance in Cote d'Ivoire and Nigeria has been in surplus. This trade surplus explains the high amount of international reserves the two countries accumulate from exports. However, high reliance on the exports of few commodities can create severe shocks on the trade balance, due to increasing global commodities shocks.

Table 1.1a. Economic stance: Burkina Faso (2017)

COUNTRY	INDICATOR	AVERAGE
BURKINA FASO	Inflation, consumer prices (annual %)	3.04
	Total debt (As % of GDP)	35.41
	Current account balance (As % of GDP)	-7.65
	Trade balance (As % of GDP)	-7.67
	Real per Capita GDP Growth Rate (annual %)	2.49
	FDI Inflows (In % of Gross Fixed Capital Formation)	6.40
	Gross international reserves (millions of US$)	511.21
	Central government, total revenue and grants (% of GDP)	18.94

Data source: African Development Bank Database.

Table 1.1b. Economic stance: Cote d'Ivoire (2017)

COUNTRY	INDICATOR	AVERAGE
COTE D'IVOIRE	Inflation, consumer prices (annual %)	3.93
	Total debt (As % of GDP)	113.40
	Current account balance (As % of GDP)	-0.94
	Trade balance (As % of GDP)	13.27
	Real per Capita GDP Growth Rate (annual %)	0.54
	FDI Inflows (In % of Gross Fixed Capital Formation)	12.82
	Gross international reserves (millions of US$)	3039.75
	Central government, total revenue and grants (% of GDP)	18.81

Data source: African Development Bank Database.

Table 1.1c. Economic stance: Ghana (2017)

COUNTRY	INDICATOR	AVERAGE
GHANA	Inflation, consumer prices (annual %)	20.43
	Total debt (As % of GDP)	38.71
	Current account balance (As % of GDP)	-6.51
	Trade balance (As % of GDP)	-8.22
	Real per Capita GDP Growth Rate (annual %)	2.73
	FDI Inflows (In % of Gross Fixed Capital Formation)	17.00
	Gross international reserves (millions of US$)	1835.90
	Central government, total revenue and grants (% of GDP)	18.09

Data source: African Development Bank Database.

Table 1.1d. Economic stance: Niger (2017)

COUNTRY	INDICATOR	AVERAGE
NIGER	Inflation, consumer prices (annual %)	3.18
	Total debt (As % of GDP)	61.20
	Current account balance (As % of GDP)	-10.09
	Trade balance (As % of GDP)	-5.52
	Real per Capita GDP Growth Rate (annual %)	-0.08
	FDI Inflows (In % of Gross Fixed Capital Formation)	12.35
	Gross international reserves (millions of US$)	360.58
	Central government, total revenue and grants (% of GDP)	16.88

Data source: African Development Bank Database.

Table 1.1e. Economic stance: Nigeria (2017)

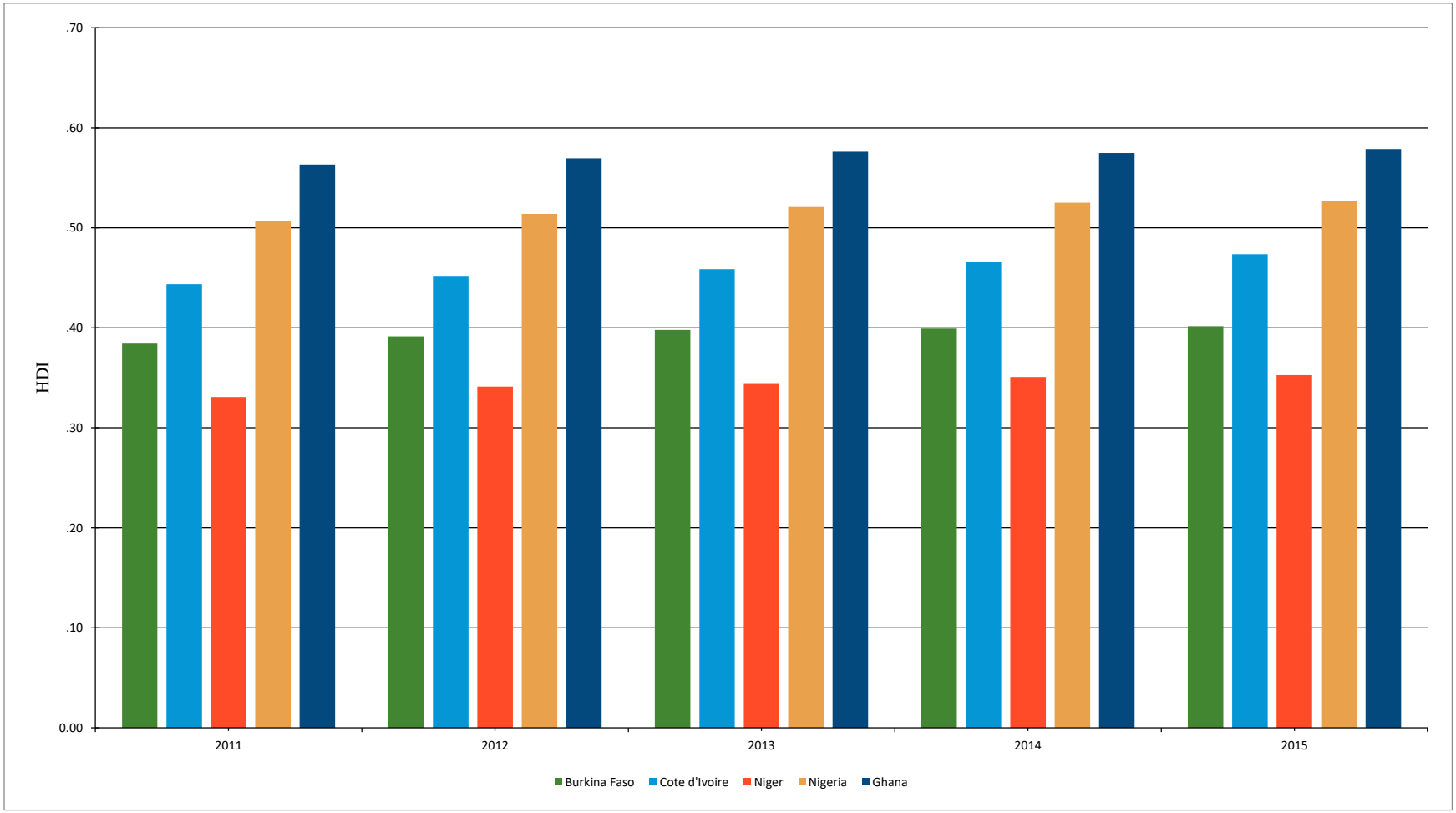
COUNTRY	INDICATOR	AVERAGE
NIGERIA	Inflation, consumer prices (annual %)	19.22
	Total debt (As % of GDP)	23.64
	Current account balance (As % of GDP)	2.20
	Trade balance (As % of GDP)	7.61
	Real per Capita GDP Growth Rate (annual %)	2.74
	FDI Inflows (In % of Gross Fixed Capital Formation)	12.31
	Gross international reserves (millions of US$)	20672.96
	Central government, total revenue and grants (% of GDP)	18.86

Data source: African Development Bank Database.

1.4. Development issues

Around the year 1960, Ghana and South Korea had a similar per capita growth. Within three decades, South Korea's per capita GDP was ten times that of Ghana. This example of Ghana and Korea depicts the slow development pace of West African countries, despite good economic growth, and a large amount of natural and mineral resources. While most emerging economies are moving from the state of aid-recipient countries to aid-donors, West African countries, and African countries, in general, are still lagging. Governance, corruption, security, foreign aid mismanagement, brain drain, to mention just a few, are some factors that contribute to undermining the region' development. Most countries in the region rank at the bottom of the human development index and the improvement of the index remains sluggish, as can be seen in figure 1.3.

Figure 1.3. Human Development Index

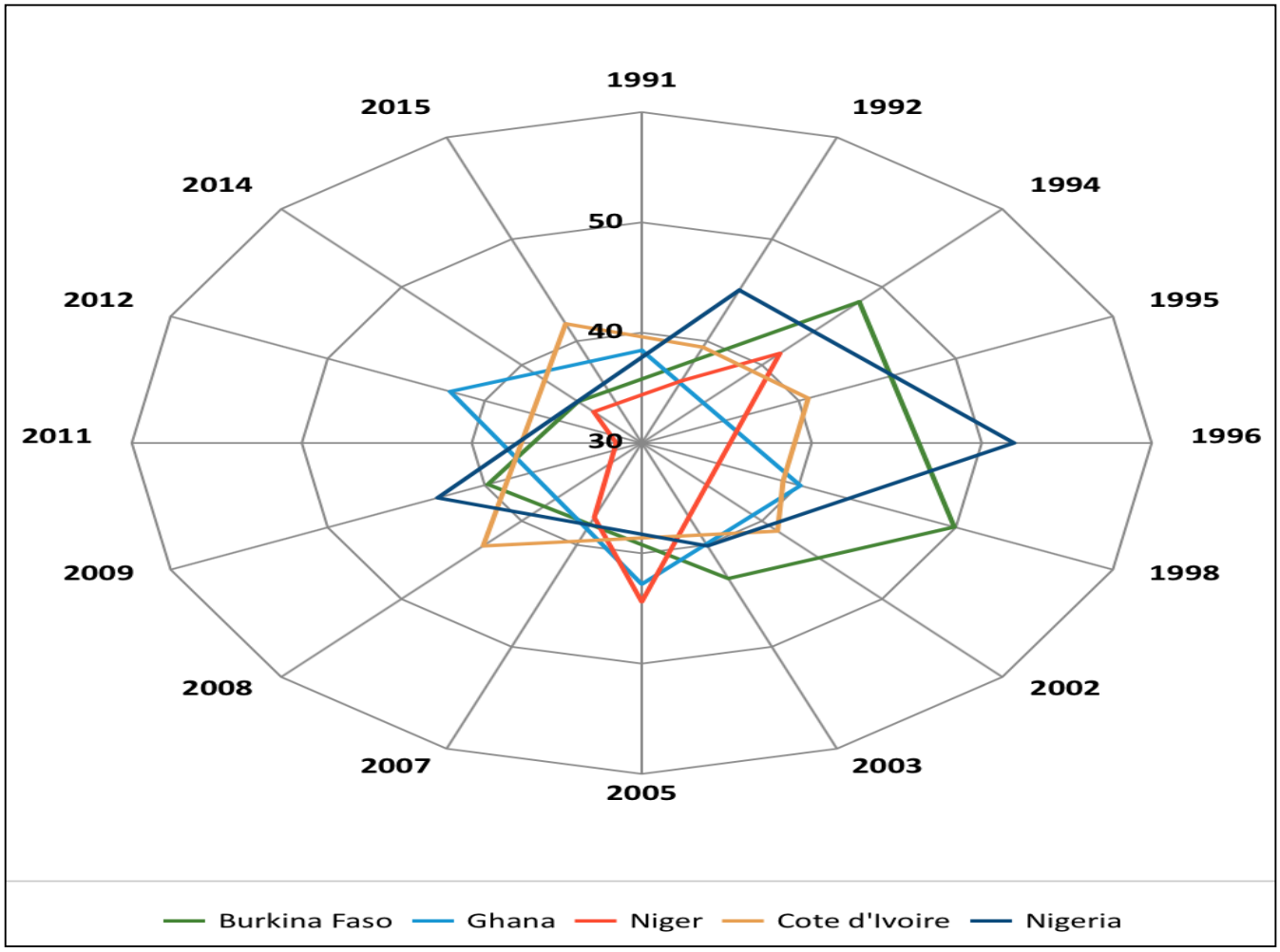


Data source: African Development Bank Database.

In all three dimensions of the Human Development Index (life expectancy at birth, education, and GDP per capita), the region performs weakly. The low life expectancy is attributed to political instability, insecurity, and weak health system. Education remains a challenge as most people are rural, and a lot of cultural/tribal values are still skeptical about the importance of education and literacy. Per capita GDP is relatively low, due to high population dynamics (that growth cannot contain in terms of employment), inequality, poor income distribution, to mention just a few. As presented in figure 1.4, the GINI indexes (a measurement of income inequality) for Ghana, Burkina Faso, Cote d'Ivoire, Niger, and Nigeria show that inequality remains a critical challenge in each of the five countries. Nigeria, the most significant contributor to the region's growth, has one of the highest GINI indexes, implying that the country is of the most unequal in terms of redistribution of wealth to the poor.

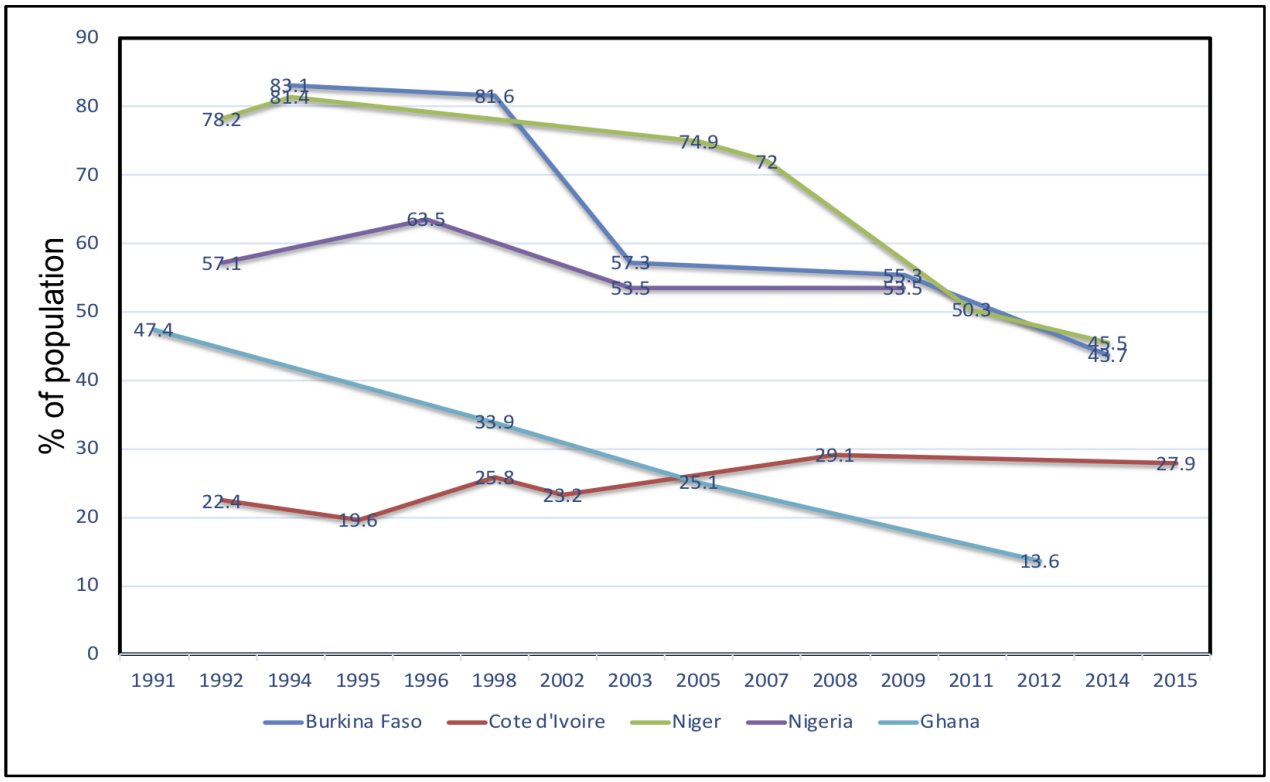
Poverty headcount ratio that measures the percentage of people living below a threshold (in this study, 1.9$ a day) has remained alarming for most countries, despite some improvement. Figure 1.5 shows that over the past decade, the percentage of people living below 1.9$ a day has been declining, but has remained high, as the target is 0%. Ghana has experienced a sharp improvement, moving from 47.4% in 1991 to 13.6 % in 2012. Cote d'Ivoire has faced counter-improvements, perhaps due to 10 years of political instability. From 22.4% in 1992, the ratio increased to nearly 28% in 2015. Niger and Burkina Faso, the two most impoverished and landlocked among the five countries, have the highest ratio. About 50% of people in the two countries live below 1.9$ a day.

Figure 1.4. Inequality: GNI index



Data source: African Development Bank Database. Note: the larger the web, the more unequal the country

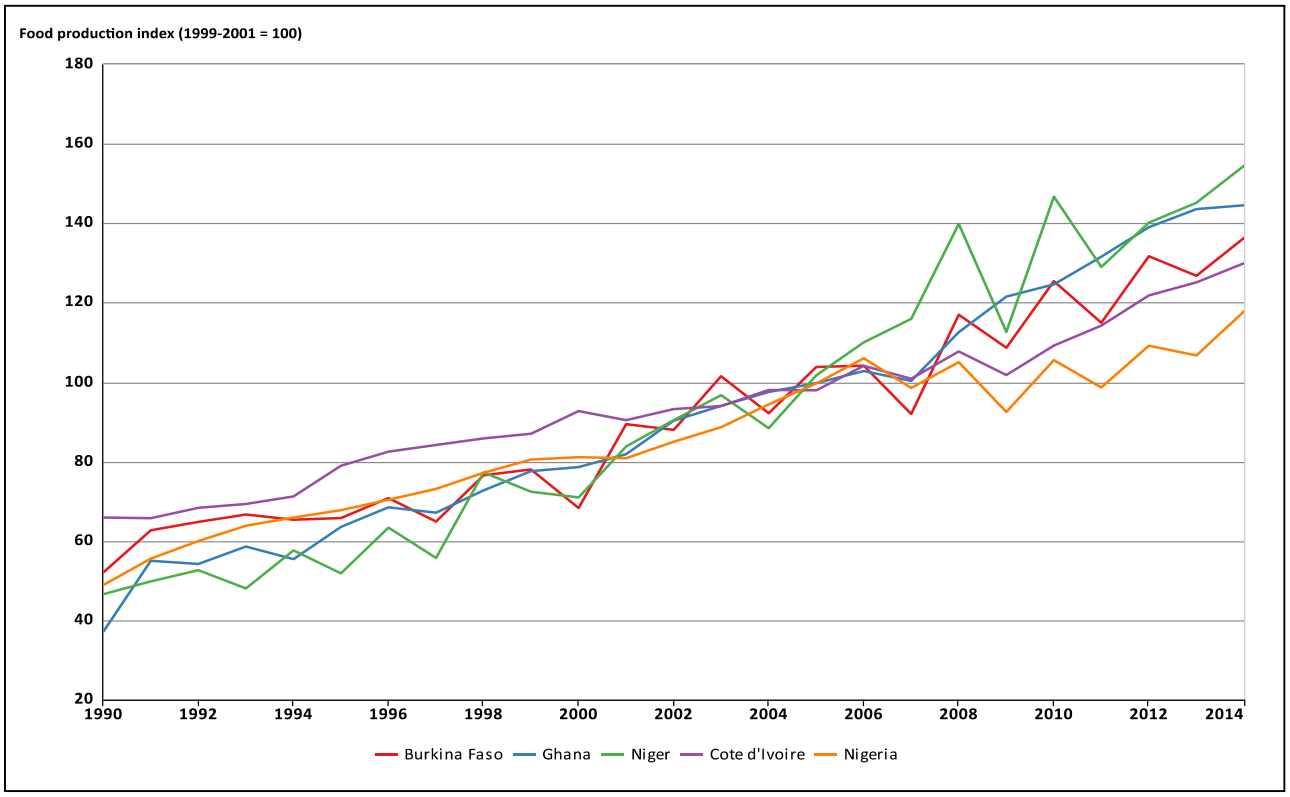
Figure 1.5. Poverty headcount ratio (1.9 $ a day)



Data source: African Development Bank Database.

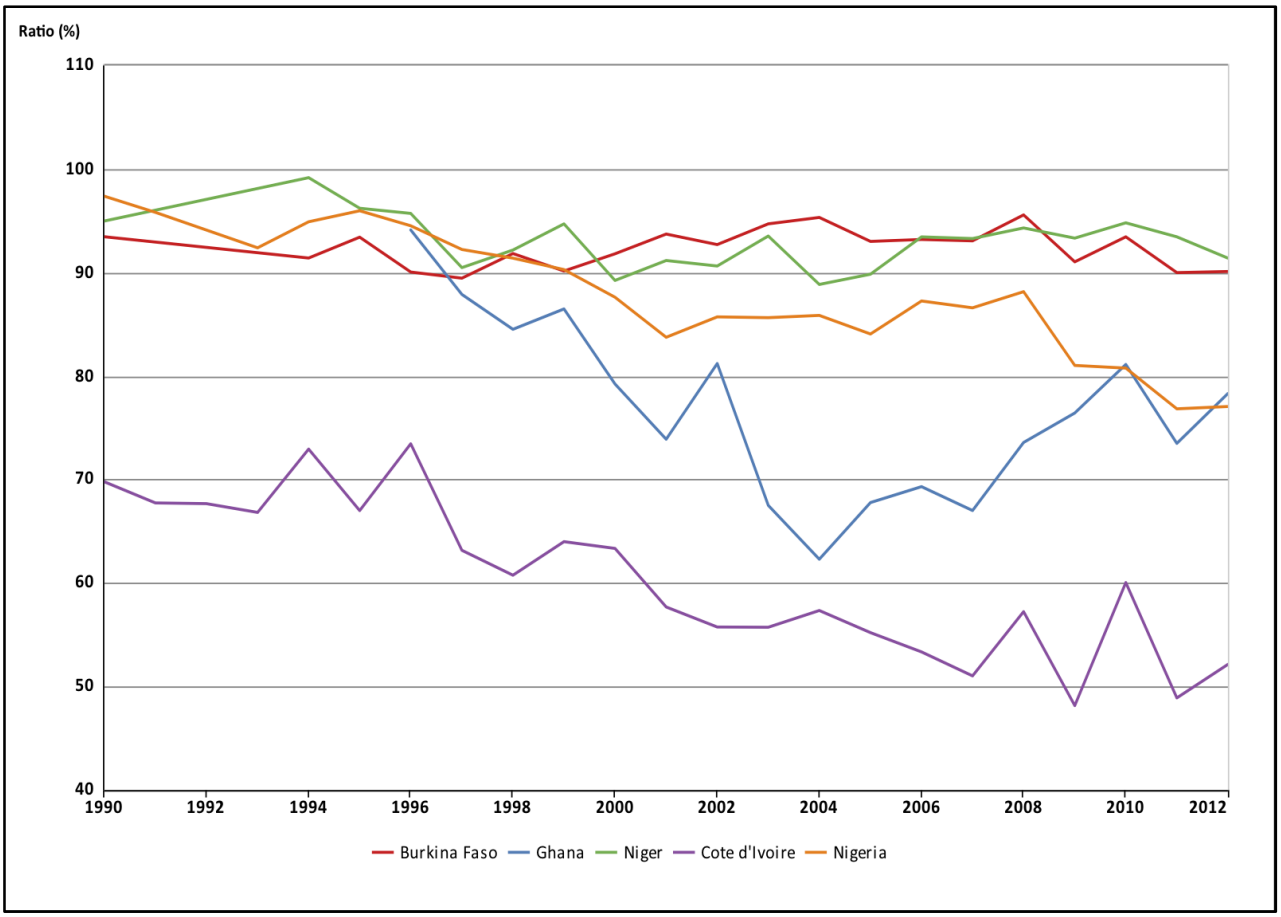
Despite the increasing food production over years (figure I.6), all five countries have not been food-sufficient yet. Figure I.7. shows that none of the countries have reached a 100% self-sufficient (self-sufficiency ratio measures the extent to which a country can adequately respond to its needs. The higher the ratio, the higher the self-sufficiency). Given the downward trend of the ratio over time, there is a concern that the actual agricultural production might not suffice to respond to people's needs. This alarming evidence comes from the fact that in rural areas, food security is more explained by physical access than other factors. Poor roads, lack of appropriate means of transportation to access markets, inadequate storage capacities (that reduce the quality and the longevity of agricultural products) are some factors affecting physical access to food. In urban areas, financial access instigates food insecurity and self-sufficiency. Although food can be supplied to urban areas, low income can limit people's access to food.

Figure 1.6. Food production index



Data source: African Development Bank Database.

Figure 1.7. Food self-sufficiency ratio (SSR, %)



Data source: African Development Bank Database.

SSR = production x 100/(production +imports –exports)

CHAPTER 2: Crude oil prices uncertainty and domestic prices of goods and services

This chapter addresses the first empirical question: at the macroeconomic level, how does international crude oil prices volatility (or uncertainty) impact domestic prices of goods and services in general?

The section provides a broad picture of the impact of crude oil prices on domestic prices of goods and services, by looking at a different aspect, namely, uncertainty or risk. It is clear that crude oil prices affect domestic prices, but whether or not uncertainty or risk about crude oil prices also affects domestic prices is the focus of this study. Also, uncertainty or risk can perhaps motivate prices regulation. The concept of uncertainty is mostly applied in areas such as investment, risk, stock, and markets; and serves as a central point for individuals' decisions. Central Banks' actions on the interest rate, money supply, and demand are also partially determined by the degree of uncertainty about future macro-financial indicators. In fuel markets, as prices are generally set and regulated by the government, direct actions on market prices depend on government policy choices. Thus, it is possible that higher risk or uncertainty on future prices of crude oil, irrespective of the country's oil endowment drive government's decision to regulate the market, for the sake of consumers' welfare.

2.1. Review of the literature

The high volatility of crude oil prices and the various effects that crude oil price shocks have on global economic activities since the great recession of the 1970s is perhaps the reasons of the increasing number of researches that has been conducted to uncover these spillover channels. According to the literature, crude oil prices transmit to the economy through several mechanisms. For the supply-side argument (Keane and Mignon, 2008), oil constitutes a vital input for industries. Increased oil prices mean a rise in operating costs for organizations, and consequently a decrease in production output. This reduction leads to a shrink in growth, which can be followed by a recession, and a decline in real wage and employment (Brown and Yücel, 1999, 2002). The demand side argument incorporates the discretionary income effect (Kilian, 2008) and explains recessions (following an oil price surge) by the contraction in domestic demand, as consumers have limited resources left after paying their energy bills. The contraction of domestic demand depends upon the energy share in total consumption, and there is a correlation between the rate this occurs and the level of inelastic energy consumption

(the more, the faster). Fluctuations in crude oil prices can lead to uncertainty about future prices of goods and services, thus pushing consumers to postpone their consumption of durables (Pindyck, 1991). The pass-through between crude oil prices and inflation can be direct or indirect. In the first configuration, a change in crude oil prices is reflected in either input cost variations that directly impacts the level of domestic prices (see supply sides effects, Lardic and Mignon, 2008), or in the cost of energy that causes households to change their consumption bundles (Lee et al., 1995). The indirect effect can stem from the central bank's policy. The policy chosen by the central bank is driven by the degree of anticipation of shocks, as well as the national or regional policy directives. The central bank can decide to raise interest rates in anticipation of inflation pressures resulting from crude oil price hikes (Bernanke, Gertler, and Watson, 1997). Although this intervention can be efficient in stabilizing GDP, the impact on domestic prices can be detrimental to the economy and can jeopardize future growth (Barsky and Kilian, 2002).

The incorporation of asymmetries and uncertainty in the response of macroeconomic aggregates to oil price volatility contributed to the rekindling of the debate on crude oil price spillovers. The first theoretical frameworks integrating the concepts of uncertainty and asymmetries emerged in the 1980s (without any empirical evidence) when the major recession followed the 1979 oil price hike while the strident plunge of oil prices in 1986 did not cause any expansion in the global economic activity. This shocking observation prompted researchers to revisit crude oil prices pass-through to the economy (Hamilton, 1988; Pindyck, 1991; Hooker, 1996a, 1996b, 2002). Many of the studies attempted to establish a correlation between asymmetry and uncertainty. For Bernanke (1983) and Pindyck (1991), changes in energy prices create uncertainty about future energy costs. This uncertainty leads to postponing irreversible investment decisions and jeopardizing future growth. Also, the behaviors of firms differ, whether it is an increase or a decrease in energy prices, due to the uncertainty effect. For example, when the energy price increases, uncertainty impels the firm to reduce its investments due to the rise in energy cost and the contraction of domestic demand. However, when energy prices decrease, costs reduce and demand upturns. Nevertheless, investment does not increase, as the firm delays its reactions due to the offset effect that uncertainty has on investment under this price fall.

Note that most of these analyses are purely theoretical. The most formal empirical analysis was conducted by Edelstein and Kilian (2007a, 2007b), where they tested the symmetrical/asymmetrical

response of a non-residential fixed investment to positive and negative energy price shocks. They failed to reject the null hypothesis of symmetry in the response of a non-residential fixed investment to energy price shocks. However, Killian (2008) opposes this finding by arguing that the high p-value of the statistical tests is due to sampling issues of the energy consumption data and weak statistical power. Other economists such as Elder and Serletis (2010) tested the effects of oil price uncertainty on GDP, durables consumption, and several measures of investment using a VAR GARCH with effect in mean. They found that accounting for uncertainty contributes to a deteriorating negative dynamic response of economic activity to a negative oil price shock while weakening the response to a positive oil price shock.

Most of the existing research on oil prices uncertainty focus on developed economies, especially the United States. This interest is justifiable as the United States is a good representation of economic dynamism and shocks in the U.S. economy has significant knock-on effects on global activity. However, the results and interpretations ascertained from developed countries cannot be broadly applied to developing economies, as they differ significantly, particularly in terms of uncertainty. Also, the literature lacks comparative studies between countries as well as the incorporation of uncertainty and asymmetry in the crude oil price-domestic prices relationship. The introduction of asymmetrical issues (at post-estimation) as well as cointegration test prior to the analysis are two important features of the study from the academic standpoint, as most studies either directly estimate the model or go for stationary test only. Furthermore, alternative specifications that account for different proxies of crude oil prices and break in the series (such as the 2008 crude oil price shock) are additional features of this research.

2.2. Data

Monthly data on consumer price index (CPI, constant December 2010) and Brent oil (the most used benchmark in West Africa) are collected from the IMF International Financial Statistics and the Energy Information Administration (EIA), respectively. The price of oil is converted in real terms by deflating by the U.S. consumer price index (collected from EIA). Five west African countries have been selected for the analysis, namely Burkina Faso, Cote d'Ivoire, Ghana, Niger, and Nigeria. Mali has not been including due to a large number of missing values in its price series. The selection was based on the countries' differences in terms of oil endowment and the absence of missing value in

the data, as the favored model in the analysis requires continuous observations. The period of study covers January 1990 through December 2013 for a total of 288 observations.

From the data, it is observed that in most countries, the consumer price index is above 50. The highest deviation around the mean is in Nigeria and Ghana. The standard deviation of CPI of the two countries is approximately 40, which represents double that of the three other countries. In other words, domestic prices have the highest fluctuations in Ghana and Nigeria. All CPI distributions are platykurtic (less fat tail) as they present negative excess kurtosis. Also, the non-zero skewness of CPI indicates that the distribution of the variable is asymmetric for all countries. These two characteristics of the data series show that the series are not normally distributed and justify the rejection of the Jarque Bera normality hypothesis for all countries.

Table 2.1. Summary statistics crude oil prices

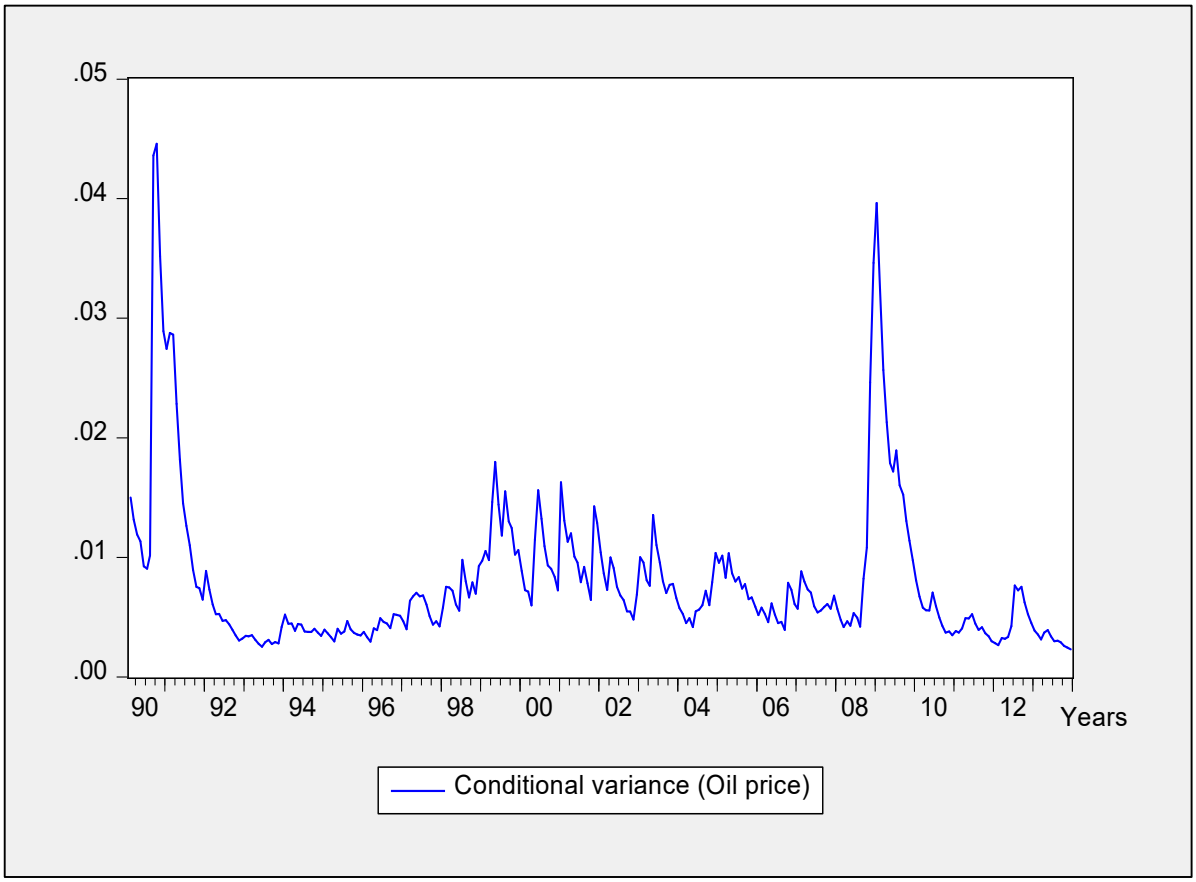
Variables	Mean	Median	Max	Min	Std. Dev.	Obs.
Crude oil price	50.3	34.48	131.86	13.07	30.39	288

Table 2.2. Summary statistics CPI

Country	Variables	Mean	Median	Max	Min	Std. Dev.	Obs.
Burkina Faso	CPI	79.11	79.59	109.33	48.12	18.1	288
Cote d'Ivoire	CPI	77.91	79.86	109.46	41.64	20.41	288
Ghana	CPI	43.68	29.85	138.39	1.83	40.42	288
Niger	CPI	79.35	81.25	109.02	43.79	18.17	288
Nigeria	CPI	49.27	37.92	139.82	2.35	39.16	288

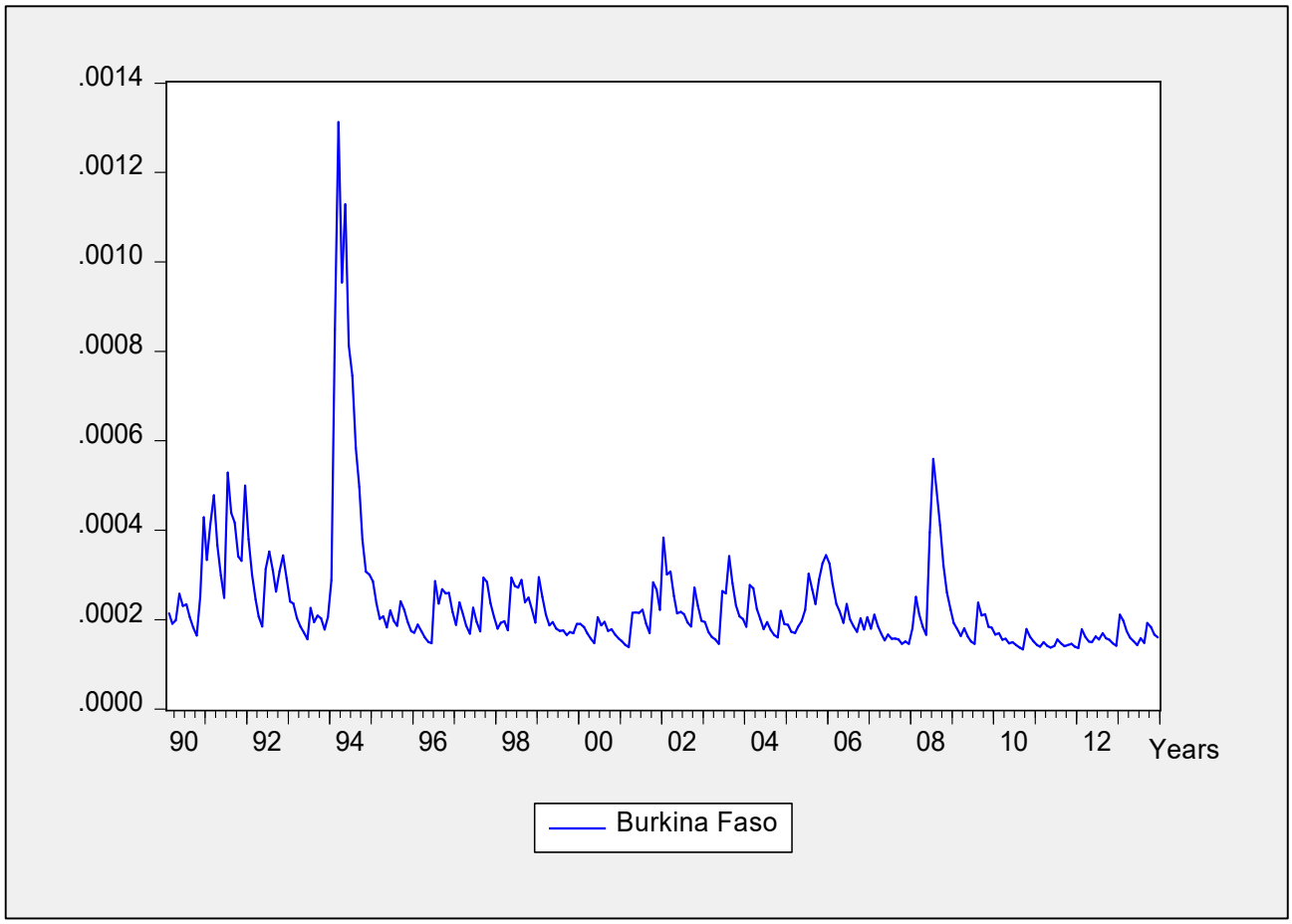
The implementation of GARCH-type models requires the presence of non-constant variance and volatility clustering in the data generating process. These effects can be evaluated through the conditional variance of each series. Figures 2.1 and 2.2 (panels a to e) depict the conditional variance of oil price and CPI obtained from the ARCH estimation. In the absence of ARCH effect, the conditional variance is represented as a line, implying a zero variance (homoscedasticity). In figures 2.1 and 2.2 (panels a to e), the volatility clustering is apparent, and each series presents an ARCH effect. The most unstable conditional variance is in Nigeria.

Figure 2.1. Oil price volatility (conditional variance)



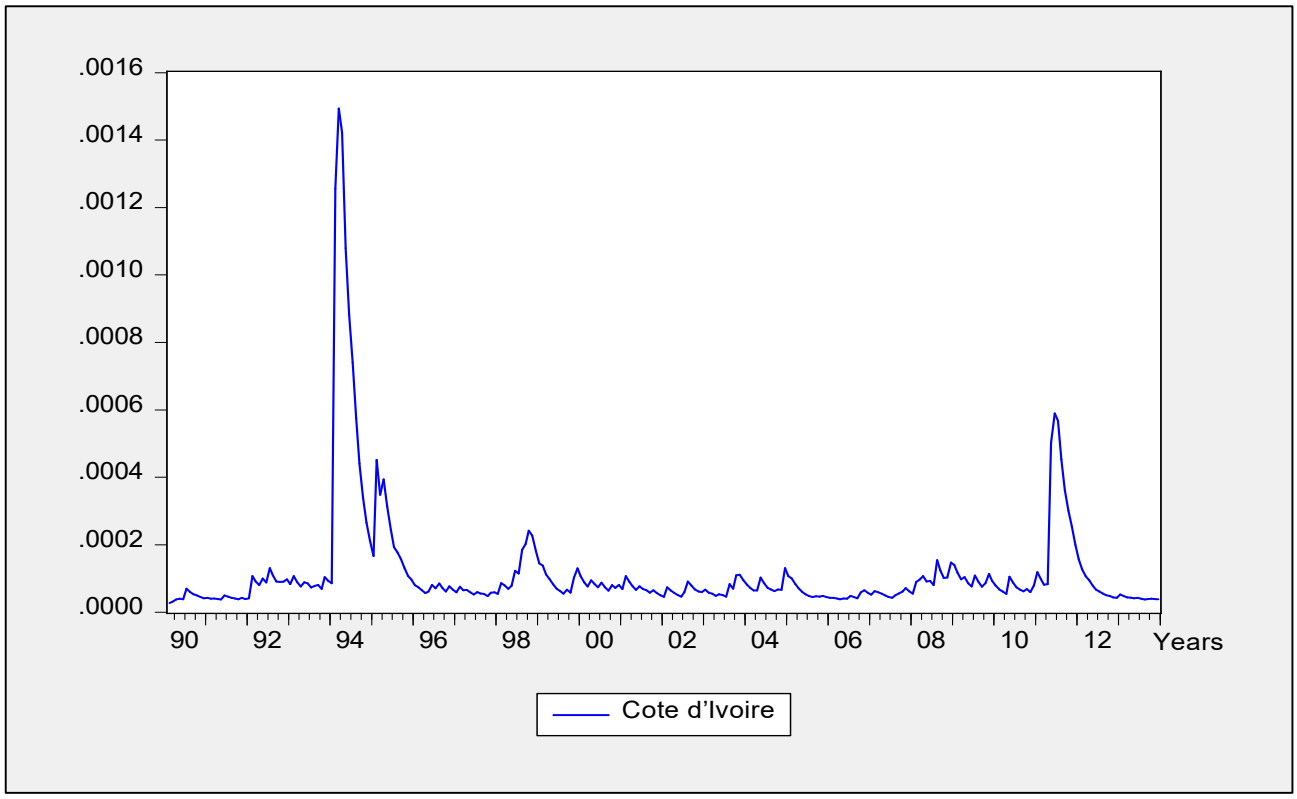
Data source: IMF International Financial Statistics.

Figure 2.2a. CPI volatility (conditional variance) by country



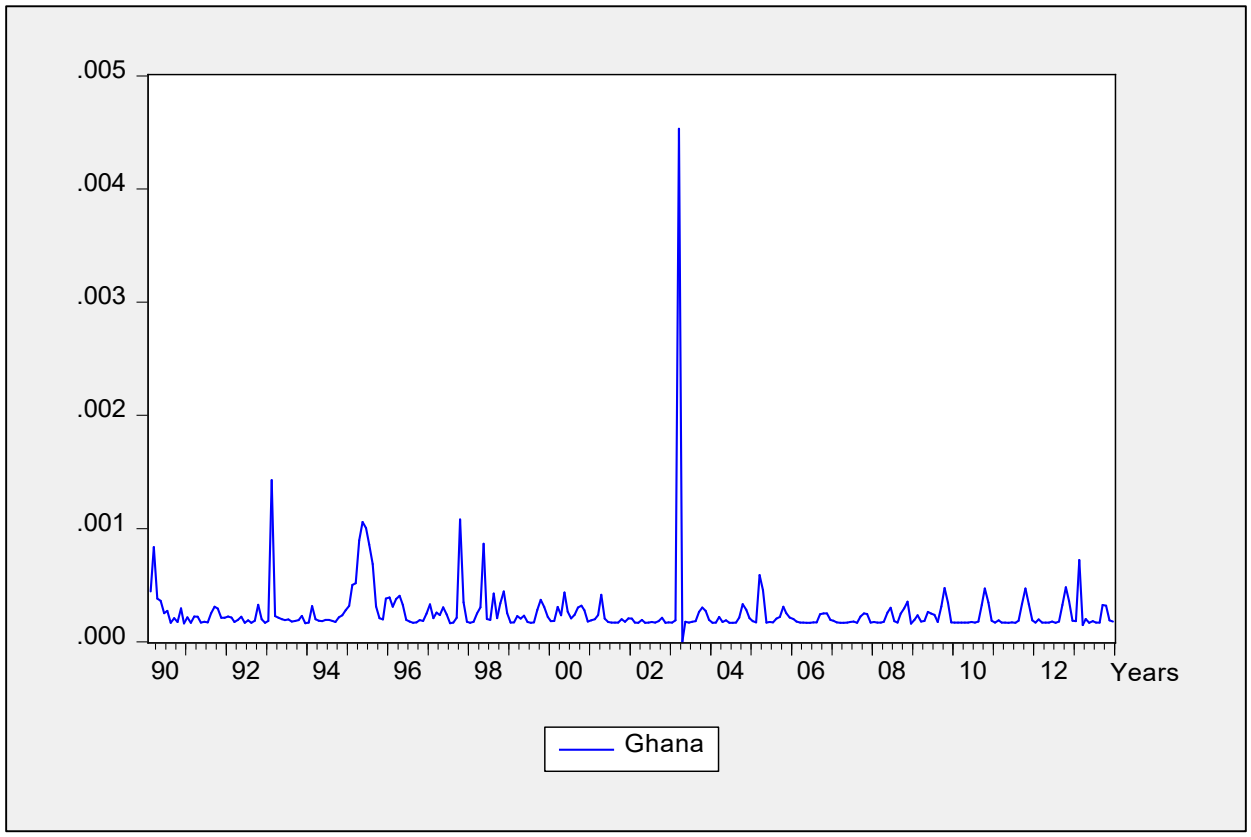
Data source: IMF International Financial Statistics.

Figure 2.2b. CPI volatility (conditional variance) by country



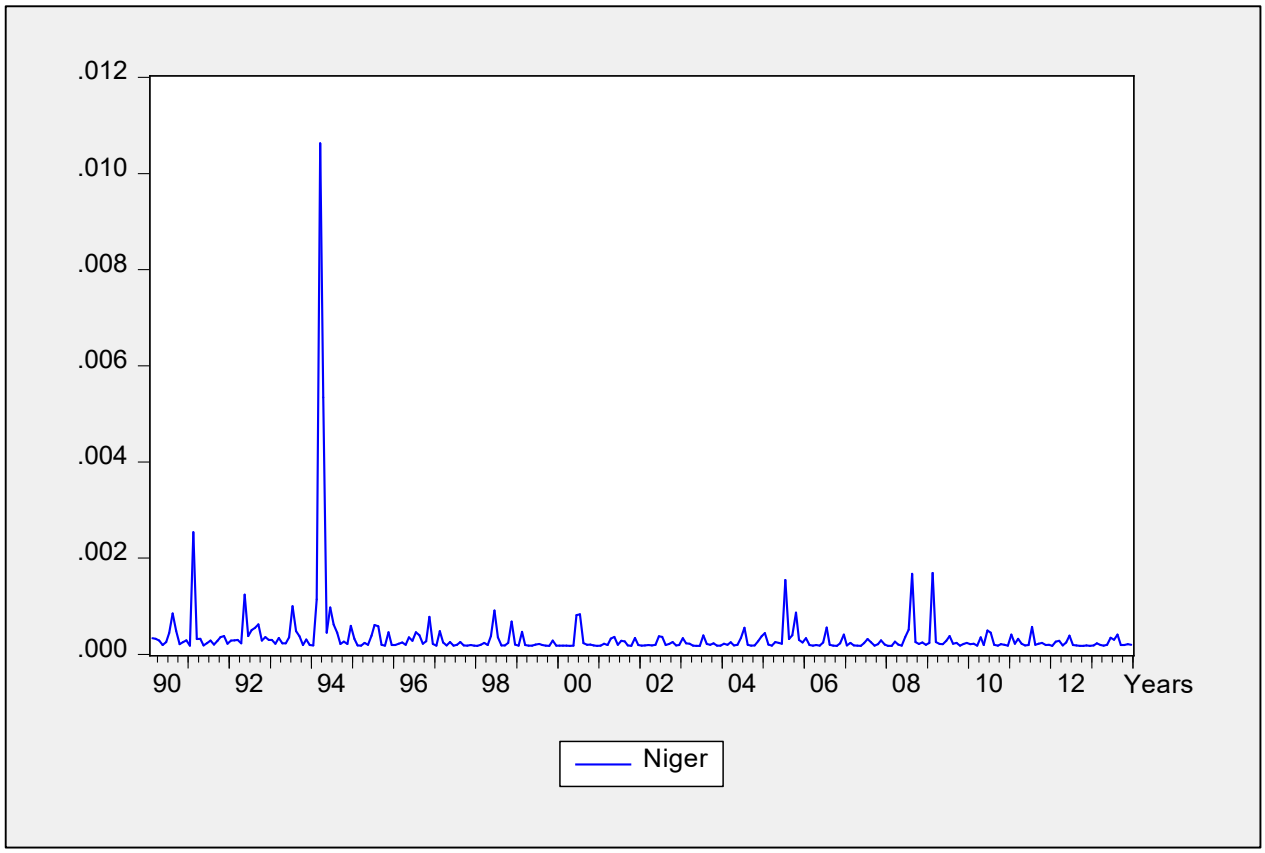
Data source: IMF International Financial Statistics.

Figure 2.2c. CPI volatility (conditional variance) by country



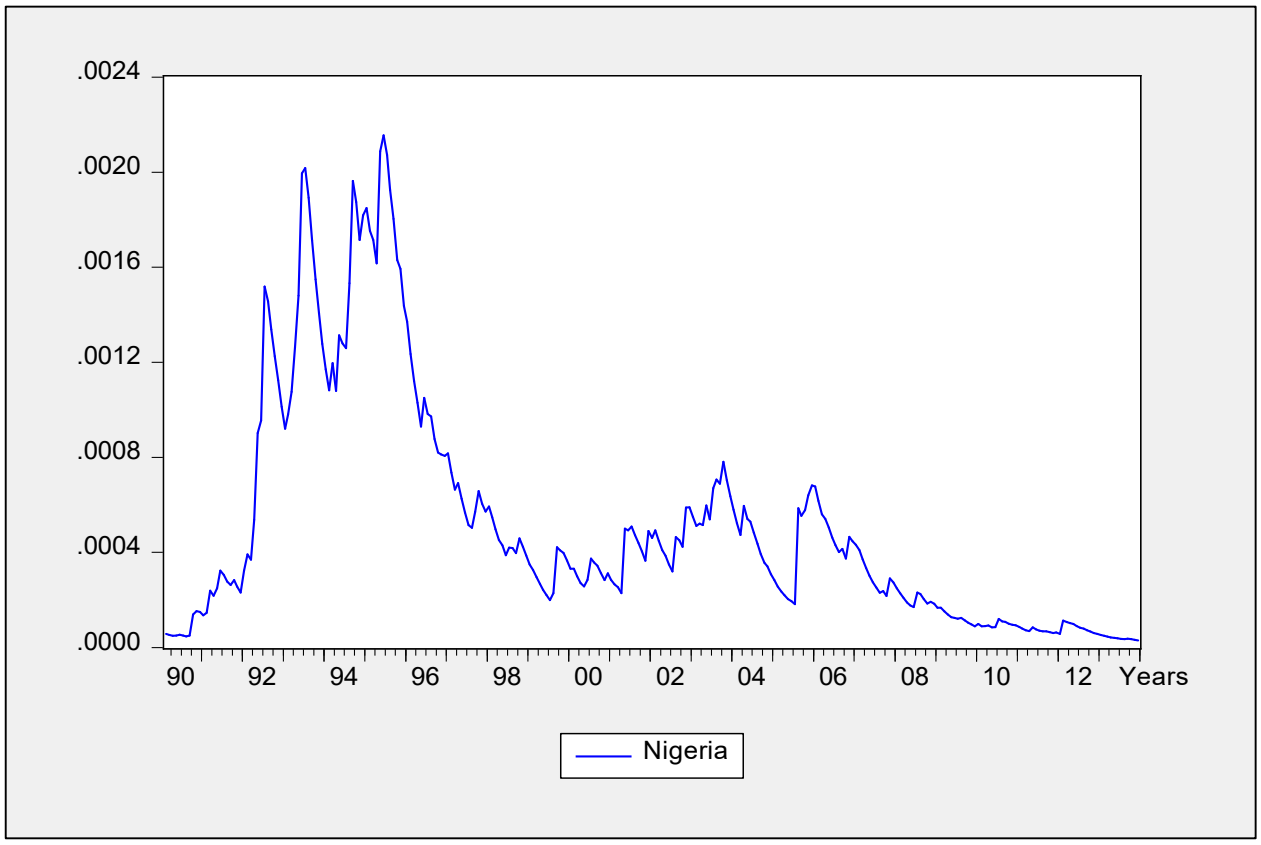
Data source: IMF International Financial Statistics.

Figure 2.2d. CPI volatility (conditional variance) by country



Data source: IMF International Financial Statistics.

Figure 2.2e. CPI volatility (conditional variance) by country



Data source: IMF International Financial Statistics.

A set of unit root tests is conducted on the logarithm first difference of each variable to evaluate their order of integration and determine the appropriate model specification. The unit root tests are reported in table A2.2 (appendix). As benchmarks, the following tests are selected: Augmented Dickey-Fuller (ADF, Dickey and Fuller,1981), Phillips Perron (PP, Phillips, and Perron, 1988), Dickey-Fuller GLS detrended (DF–GLS, Elliott et al., 1996) and KPSS (Kwiatkowski et al., 1992). While the ADF, PP and DF-GLS tests are based on the null hypothesis of no unit root in the data series, the KPSS test

has an opposite null hypothesis (the series is stationary). For each test, the Bartlett (1963) kernel is employed as the spectral estimation method, and the bandwidth is selected using the Newey-West automatic lag selection (Newey and West, 1987, 1994). The ADF and PP results indicate that the first difference of all series is stationary. Except for Ghana, where the null hypothesis of no unit root in the logarithm first difference of CPI is not rejected, the results are similar for the DF-GLS test. However, this result is contrasted by the KPSS test. The non-rejection of the KPSS null hypothesis implies that the series is stationary. Similarly, for Nigeria, the KPSS test rejects the null hypothesis of stationarity at a 10% level. As the ADF, PP and DF-GLS tests show stationarity, it can be concluded that the logarithm first difference of both CPI and oil price series are I (0).

Additionally, to investigate the possible existence of a long-term relationship between CPI and oil prices, the Johansen cointegration test (Johansen 1988, 1991) is conducted on the log-level of the variables for each country (table A2.2). Both the maximum Eigen statistic and the trace statistic are lower than their 1% and 5% critical values, implying that series are not cointegrated. As no cointegration is found between CPI and oil price series, the error correction term is therefore excluded from the model specification.

2.3. Methodology

The study analyses the effect of oil price uncertainty on domestic price, the analysis employs the bivariate VAR Generalized Autoregressive Conditional Heteroskedasticity with effects in mean, referred to as GARCH-M as in Elder (2004) and Elder and Serletis (2009, 2010). The estimation procedure is consistent with the efficiency of GARCH (1,1) found in various empirical research and widely applied in studies (such as Hansen and Lunde, 2005; Sadorsky, 1999). The model is an extended version of the ARCH-M model introduced by Engel et al., (1987) to capture the risk associated with the return of three measures of debt instruments (six-month treasury bills, two-months treasury bills, and AAA corporate bonds), where the risk is due to unexpected yield fluctuations. The GARCH model, which was developed by Bollerslev (1986), is more efficient in dealing with heteroskedasticity as the conditional variance equation includes both ARCH and GARCH terms. In other words, the predicted deviation of a variable around the mean in the next period is a weighted average of the long-term average deviation, the current variance and a new set of information (the recent squared residual). In addition to modeling heteroskedasticity and volatility clustering, GARCH allows tracking the persistence of volatility. In the GARCH model, with effects in mean, the

heteroskedasticity term is assumed to affect the mean equation. This effect has often been used as a proxy for uncertainty (Engle, 1982; Engel et al., 1987; Bollerslev, 1986; Elder, 2004; Elder and Serletis, 2009, 2010).

In the specification of the data generating process underlining the structural system, consider y a vector composed of domestic prices (cpi) and crude oil prices (oil). Two equations need to be specified: a mean equation and a variance equation. The two equations are specified as follows:

Mean equation: $y_t = \Phi + \Gamma y_{t-1} + \Psi\sqrt{h_t} + \varepsilon_t$ (1)

Variance equation: $h_t = \omega + \varepsilon^2{}_{t-1} + h_{t-1}$ (2)

where

$\varepsilon_t|\Omega_{t-1} \sim iid\ N(0, H_t)$; h is a matrix of variance of Cpi and crude oil prices. Precisely:

$h_t = \begin{bmatrix} h_{\Delta ln\ cpi \Delta ln\ cpi,t} \\ h_{\Delta ln\ oil \Delta ln\ oil,t} \end{bmatrix}$; $H_t = \begin{bmatrix} h_{\Delta ln\ cpi \Delta ln\ cpi,t} & h_{\Delta ln\ cpi \Delta ln\ oil,t} \\ h_{\Delta ln\ oil \Delta ln\ cpi,t} & h_{\Delta ln\ oil \Delta ln\ oil,t} \end{bmatrix}$; $y_t = \begin{bmatrix} \Delta ln\ cpi \\ \Delta ln\ oil \end{bmatrix}$;

$\varepsilon_t = \begin{bmatrix} \epsilon_{\Delta ln\ cpi} \\ \epsilon_{\Delta ln\ oil} \end{bmatrix}$; $corr\ (\epsilon_{\Delta ln\ cpi}, \epsilon_{\Delta ln\ oil}) = 0$ (errors are assumed not correlated); Φ and ω are vectors of constants; Ω_{t-1} is the information set in period $t-1$; H_t is a matrix of conditional variance-covariance; Γ a matrix of coefficients on the lagged variables y_{t-1} and Ψ a matrix of coefficient parameters on $\sqrt{h_t}$.

To capture the impact of crude oil volatility on domestic prices Ψ coefficient of equation (1) is set to Ψ_1.This correspond to $H_{2,2}$ in the specification of matrix H.

A detailed explanation of the model can be found in Elder (2004) and Elder and Serletis (2009, 2010). Appendix A.2.1 also provides some general explanations regarding the model and some of the parametrizations.

The hypothesis tested is whether an increasing uncertainty of oil prices impacts domestic prices. A positive and significant coefficient on $\sqrt{h_t}$ implies that higher uncertainty of oil prices has a heightening effect on domestic prices. In other words, uncertainty regarding oil prices can cause domestic prices to rise. As no cointegration was found between oil price and CPI, taken at level (appendix A2.3), the structural specification does not contain any error correction term. Due to their

minimal power in the international market, any volatility in the domestic prices of the selected countries is considered insignificant in terms of impacting the global oil market. As such, shock on oil is assumed to affect domestic prices, with no feedback from domestic prices to oil prices. The purpose of this exclusion restriction is to reduce the number of parameters and thereby simplify the system in terms of estimation. The overall estimation uses number of lags determined by the Schwarz Information Criterion, with a maximum number set to 12.

Furthermore, to evaluate the impact of oil price uncertainty on domestic prices, the analysis applies a set of asymmetry tests to capture the volatility response to news of both domestic prices and oil prices, although the latter is not too mandatory, given the focus of this study. The tests follow the Engle and Ng (1993) tests for *sign-bias*, *negative size-bias*, and *positive size bias* in the variance, and is based on the following steps:

1. Estimate the symmetric GARCH (1,1)
2. Generate the residual denoted $\widehat{\varepsilon_t}$and the squared value $\hat{\varepsilon}_t^{\,2}$
3. Generate a dummy variable S_{t-1}^{-} that takes the value 1 if $\hat{\varepsilon}_{t-1}$is strictly negative and 0 otherwise.

The sign-bias, negative size-bias, and positive size-bias are tested using the following equation:

$$\hat{\varepsilon}_t^{\,2} = \alpha_0 + \alpha_1 S_{t-1}^{-} + \alpha_2 S_{t-1}^{-}\hat{\varepsilon}_{t-1} + \alpha_3 S_{t-1}^{+}\hat{\varepsilon}_{t-1} + \lambda_t \qquad (3)$$

$$S_{t-1}^{+} = 1 - S_{t-1}^{-}$$

$$S_{t-1}^{-} = \begin{cases} 1, & \hat{\varepsilon}_{t-1} < 0 \\ 0, & \hat{\varepsilon}_{t-1} \geq 0 \end{cases}$$

Where α_0 is a constant, $\alpha_i (i = \overline{1,3})$ are the parameters used for testing the presence of biases, and λ_t is the error term. The sign bias test assesses the effect of both positive and negative shocks on domestic price volatility (not captured by the model). The sign-bias test is a test of exclusion restriction on α_1 ($H_0: \alpha_1 = 0$). Thus, a significant α_1 implies that positive and negative news have different implications for domestic price volatility, irrespective of the size of the shocks. The size-bias is captured by α_2 and α_3. While α_2 tests for a presence of negative size bias in the response of domestic price to news (α_2 tests the null hypothesis that large and small negative shocks have similar

effects on domestic price volatility), α_3 focuses on the hull hypothesis that large and small positive have the same implication for domestic price volatility (positive bias). Further to the sign-bias, negative size-bias, and positive size-bias tests, a joint test is conducted to assess the null hypothesis of no sign-bias and size-bias in the volatility response of domestic price ($H_0: \alpha_1 = \alpha_2 = \alpha_3 = 0$). The test is carried out through the application of the Lagrange Multiplier (LM) test and the condition $TR^2 \sim \chi^2(3)$ where T is the number of observations and R^2 the squared multiple correlations (Engle and Ng, 1993).

2.4. Results and interpretations

The impact of oil price uncertainty on domestic prices is captured by the coefficient on the standard deviation in the CPI equation. The coefficient is estimated for each country selected and is reported in table 2.3. The measurement of uncertainty is a test of exclusion restriction on Ψ in equation (1). The null hypothesis is that uncertainty about oil price does not affect domestic, irrespective of the country's oil resources. The result indicates positive significance point estimates of the coefficient in almost all countries. This denotes that a consequence of oil price uncertainty in all but one of the countries is inflation. The exception is Niger, where the coefficient is insignificant. Furthermore, the impact of oil price uncertainty on domestic price is higher in resource-abundant countries. As can be seen from the table, in Nigeria and Ghana, the impact is 0.67% and 0.80%, respectively. Although Cote d'Ivoire is an oil producer, the impact of oil price uncertainty on the country's domestic prices is relatively lower than in Ghana, which could potentially be explained by their different oil rent levels. For example, oil rent in Cote d'Ivoire was estimated to be 4% of GDP in 2015, whereas, in Ghana, this figure was approximatively 1.7% of GDP (World Bank, 2015). In fact, at fixed prices, higher oil rent is an indicator of dynamism in the country's oil sector. The dynamism of the oil sector has a knock-on effect on the economic activity, and higher risk or uncertainty on oil price can have a harmful effect. Although Nigeria is a big oil producer in Africa, the impact of oil price uncertainty on domestic prices is lower than in Ghana. Reasons for this difference can be found in the structure of the two economies. Ghana is known to have a high inflation rate, as the depreciation of Cedi upturned the import cost of goods. Also, the government of Ghana has maintained an expansionary policy over time, creating more pressure on domestic prices. The combination of these effects negatively impacts producers supply price and consequently, households' purchases decisions. Therefore, uncertainty on the condition of the international market (including the oil market) can lead to higher pressure on domestic prices.

As posited by Christiano and Fitzgerald (2003) usually, households and businesses do not take inflation into account in their decision making when the inflation rate is relatively low. From this perspective, it can be postulated that increasing inflation leads to more uncertainty in households and businesses' decisions. An essential aspect of the differences between Nigeria and Ghana is their choice of oil price benchmark. Nigeria is a member of OPEC and uses the OPEC basket reference as a benchmark, along with Brent price. In appendix A2.4, Brent oil price is replaced by OPEC reference basket price to evaluate the possible stability of the points estimates. The increasing uncertainty pushes producers to increase prices and can prompt households to rush purchases of non-durables as future prices can inflate. Subsequently, due to these actions, domestic prices also increase. The noteworthy point is that, despite its non-inclusion in the analysis, exchange regime can partially explain the results. As a fixed exchange regime has the advantage of providing better precision in terms of forecast of macroeconomic variables, partly due to the exclusion of the central bank's intervention compared with the flexible exchange regime, it can be predicted that the effect of oil price uncertainty on domestic prices is higher in counties adopting a flexible regime (such as Ghana and Nigeria) than countries using a fixed exchange rate (Burkina Faso, Cote D'Ivoire and Niger). The reason for that is that economic agents in countries with flexible exchange regimes incorporate the risk due to currency parity into their decision-making process (Kenen, 2000).

Appendix A2.4 is related to alternative estimations. The major financial crisis that has led to a plunge in oil price is excluded from the analysis. The model is estimated until June 2008, which marked the beginning of the oil crisis. The coefficients of the point estimates for every country do not significantly deviate from the main result (A2.4b). Also, the nominal price rather than the real price of oil is employed to assess Hamilton's (2008) argument regarding using nominal or real oil price. Hamilton (2008) asserts that it does not make much difference in summarizing the size of any given shock whether using the nominal price or the real price of oil, as in most of these shocks, the change in nominal prices is an order of magnitude larger than the change in overall prices. The result remains robust and concurs with Hamilton (2008). Finally, the OPEC reference basket (a weighted average of petroleum blends prices produced by OPEC members, including Bonny Light of Nigeria) is used as an alternative benchmark. The coefficient in Niger becomes positive and significant, whereas that of Burkina Faso, although positive, becomes insignificant. For Cote d'Ivoire and Ghana, the coefficient does not substantially deviate, and the significance level remains unchanged. However, the estimate

for Nigeria increases significantly and outpaces that of Ghana. The coefficient moves from 0.67% to 0.83%.

From the alternative estimations, it can be argued that the impact of oil price uncertainty on domestic prices is robust to the period of analysis and the type of price used, and partially depends on the oil benchmark used, whether Brent or OPEC basket.

Table 2.3. Results

Variables	Burkina Faso	Cote d'Ivoire	Ghana	Niger	Nigeria
	Cpi	Cpi	Cpi	Cpi	Cpi
Coef. on $h(t)^{1/2}$: impact of oil price uncertainty on Cpi (Ψ_1 in Mean Equation or $H_{2,2}$)	0.155***	0.292***	0.802**	-0.023	0.671***
	(0.060)	(0.062)	(0.064)	(0.055)	(0.065)
Cpi (-1)	0.51***	0.423**	0.33***	0.71*	0.45**
	(0.063)	(0.001)	(0.021)	(0.012)	(0.34)
Constant	0.035*	0.045**	0.114	0.022	0.006***
	(0.017)	(0.0231)	(0.023)	(0.035)	(0.034)
R-squared	0.234	0.456	0.56	0.77	0.17
Log likelihood	304.132	488.44	345.233	673.445	564.234
SIC	-3.345	-4.34	-3.56	-5.19	-6.56

* significance at 10% ** significance at 5% ***significance at 1%. Sample size for OPEC reference basket: 2003m01-2013m12. A post-2008 crisis could not be estimated as the sample period was short.

The next table reports the parameters of the free elements in the variance equation specified in the VAR GARCH-M model. The estimation of the parameters in the variance equation helps to identify the presence of ARCH and GARCH effects in the data generating process, although the graphs of the conditional variance provide an overview of the volatility. The ARCH effect is given by the coefficient on $\varepsilon_i(t-1)^2$ and the GARCH effect by the coefficient on $H_{i,i}(t-1)$. As depicted in the table, all five of the selected developing countries display ARCH effect in both oil prices and CPI. This implies that news about domestic prices volatility (respectively oil price volatility) from previous periods have a significant role in explaining the current volatility of domestic prices (respectively oil prices). In addition, the coefficient on $H_{i,i}(t-1)$ indicates a presence of GARCH effect in oil prices and CPI series. There are only two exceptions in these results, which are related to the CPI equations

of Ghana and Niger. Firstly, in Ghana, because of the non-negativity restriction, the co-efficient is null, and secondly, in Niger, the co-efficient is insignificant. The significance of the GARCH term in the majority of the countries infers that the previous periods' forecast variance of oil prices and CPI explain the current volatility of the two variables. The last column of the table represents the persistence of volatility of both oil prices and CPI. The persistency of volatility, given by the sum of the parameters on the ARCH and GARCH terms, measures the rate at which volatility dies out over time (Campbell et al., 1996; Chan, 2010). A number equal to or greater than 1 indicates persistent volatility (volatility does not die out) and a non-stationary process. The GARCH specification should, therefore, be transformed into an integrated one (Integrated GARCH or IGARCH). From the table, it appears that oil and CPI volatility are not persistent and reduce over time. In general, domestic price volatility stabilizes faster than oil prices, perhaps due to the relatively lesser number of factors interacting with domestic prices than with oil price.

Table 2.4. VAR-GARCH-M model: Estimation of the parameters in the variance equation

Country	Equation	Conditional Variance	Constant	$\varepsilon_i(t-1)^2$	$H_{i,i}(t-1)$	Persistency of volatility
Burkina Faso	$\Delta ln\ oil$	$H_{1,1}(t)$	0.034	0.177***	0.782***	0.959
			(0.026)	(0.056)	(0.056)	
	$\Delta ln\ cpi$	$H_{2,2}(t)$	0.038**	0.140***	0.696***	0.836
			(0.002)	(0.037)	(0.095)	
Cote D'Ivoire	$\Delta ln\ oil$	$H_{1,1}(t)$	0.033	0.186***	0.777***	0.963
			(0.003)	(0.059)	(0.056)	
	$\Delta ln\ cpi$	$H_{2,2}(t)$	0.007***	0.216***	0.754***	0.97
			(0.002)	(0.049)	(0.030)	
Ghana	$\Delta ln\ oil$	$H_{1,1}(t)$	0.035	0.180***	0.778***	0.958
			(0.026)	(0.058)	(0.057)	
	$\Delta ln\ cpi$	$H_{2,2}(t)$	0.019***	0.349***	0.000	0.344
			(0.002)	(0.095)		
Niger	$\Delta ln\ oil$	$H_{1,1}(t)$	0.034	0.180***	0.779***	0.959
			(0.026)	(0.057)	(0.057)	

	$\Delta ln\ cpi$	$H_{2,2}(t)$	0.015***	0.595***	0.043	0.638
			(0.002)	(0.076)	(0.051)	
Nigeria	$\Delta ln\ oil$	$H_{1,1}(t)$	0.036	0.180***	0.778***	0.958
			(0.027)	(0.057)	(0.057)	
	$\Delta ln\ cpi$	$H_{2,2}(t)$	0.003*	0.088***	0.906***	0.994
			(0.002)	(0.016)	(0.012)	

The persistency of volatility is given by the sum of the parameters on $\varepsilon_i(t-1)^2$ and $H_{i,i}(t-1)$. The 0.000 in the table refers to the non-negativity constraint imposed in the parameterization. * significance at 10% ** significance at 5% ***significance at 1%

Table 2.5. Residual diagnostic from the VAR-GARCH-M model

Country	LM test of ARCH effect in the residual		Autocorrelation (Ljung-Box Q-stat)			
	F-statistic	Prob.	Q-Stat	Prob.	Q^2-Stat	Prob.
Burkina Faso	0.714	0.398	2.955	0.565	1.533	0.821
Cote d'Ivoire	0.041	0.838	6.232	0.182	0.321	0.988
Ghana	0.655	0.418	1.460	0.834	1.016	0.907
Niger	0.0125	0.910	2.987	0.560	1.096	0.895
Nigeria	0.344	0.557	24.13	0.000	0.984	0.912

Controlling for growth, money supply, and exchange rate gives a similar result: in general, there is a positive impact of crude oil price uncertainty on domestic prices of goods and services. The interpretation has to be carried out with caution. The reason is that CPI and crude oil prices have volatility patterns as they fluctuate on a daily, weekly, or monthly basis, while control variables such as GDP or money supply are not volatile. Given the fact that the table is constructed from annual data (monthly or quarterly GDP data do not exist) and with a model suitable for volatile indicators, only the key insight from the table can be drawn.

Table 2.6. VAR-GARCH-M estimation. Controlling for growth, money supply and exchange rate

	Variables	Burkina Faso	Cote d'Ivoire	Niger	Ghana	Nigeria
		Cpi	Cpi	Cpi	Cpi	Cpi
Mean Equation	$h(t)^{1/2}$	1.275***	1.884**	1.041	1.984***	0.193
		(0.709)	(0.001)	(1.435)	(0.109)	(3.784)
	Δln(Crude oil)	0.159**	0.003	0.164**	0.16***	0.069*
		(0.061)	(0.024)	(0.032)	(-0.043)	(0.039)
	Δln(real GDP)	1.775***	-0.198	0.996***	0.016***	0.094
		(0.503)	(-0.189)	(0.045)	(0.006)	(0.515)
	Δln(Money supply M2)	0.006	0.042	-0.246***	0.272***	-0.085
		(0.164)	(0.03)	(0.018)	(0.005)	(0.038)
	Δln(Exchange rate)	0.274***	0.277***	0.269**	0.774***	0.089
		(0.064)	(0.051)	(0.113)	(0.003)	(0.164)
	Constant	5.04***	-0.025***	-12.991***	-0.984***	0.106
		(0.011)	(0.006)	(1.192)	(0.022)	(0.098)
	R-squared	0.456	0.65	0.423	0.566	0.75
	Log likelihood	435.544	645.323	657.433	455.53	734.301
	SIC	-6.46	-7.01	-7.764	-6.655	-7.453
Variance Equation	$\varepsilon_i(t-1)^2$	0.401	0.547**	0.126	0.922***	0.126***
		(0.426)	(0.005)	(0.141)	(0.321)	(0.032)
	$H_{i,i}(t-1)$	0.683***	0.156*	0.678	0.097	0.579**
		(0.189)	(0.078)	(0.699)	(0.39)	(0.247)
	Constant	-0.001	0.003**	0.002	0.002*	0.002
		(0.003)	(0.001)	(0.003)	(0.001)	(0.002)
	Persistence of volatility	1.084	0.703	0.804	1.019	0.705

Note: annual data * significance at 10% ** significance at 5% ***significance at 1%. Note on exchange regime: Burkina Faso, Cote d'Ivoire and Niger use a common fixed exchange regime with Euro. The variable exchange rate is included in the regression for each of the three countries for two reasons. First crude oil price is in USD. Second there is a floating regime between Euro and USD. Thus, the three countries' exchange regime is indirectly floating with respect to USD. As the three countries adopt the same currency, the coefficient on Δln(Exchange rate) does not differ much from one country to another.

The tests of asymmetry (table 2.7) investigate the hypothesis of asymmetries in the volatility response of domestic prices to news, as described in the previous section. It appears from the table that the bias in the volatility response is driven by the positive size of the shocks rather than the negative size or the sign of the shocks. In each of the countries, the null hypothesis of no positive size-bias is strongly rejected at all percentage levels. This suggests that large and small positive shocks have different implications for domestic price volatility. In fact, in most developing countries such as sub-Saharan Africa, inflation tends to rise when the price of oil products (such as gasoline) increases due to the opportunity for profit maximization for the sellers.

Conversely, due to government interventions in the form of subsidies, tax exemptions and price regulations which protect both consumers and producers, it is not preordained that an unexpected and substantial oil price hike will result in a similar rise to the domestic price rate. The negative size-bias test shows that only Ghana and Nigeria display a minimally significant result (10%). Overall, the LM joint test shows strong evidence of asymmetry in the response of domestic prices to news. This finding, combined with the sign-bias test produces an interesting insight into the interpretation as it shows that asymmetry in domestic price volatility responses to news does not solely depend on the sign of the shocks, but is a combination of both the sign and size of the shock. The result from the oil price equation is added to capture the response of oil price to news. The test shows similar results to the CPI equation, with the exception that both negative size-bias and positive size-bias present comparable magnitude and significance levels. The LM joint test shows that the asymmetrical response of oil price volatility to news is a combination of sign-bias and size-bias.

Table 2.7. Tests of asymmetry of the volatility response to news

	Variables	Sign-bias	Size-bias (Negative)	Size-bias (Positive)	LM joint test (Sign-and-size-bias)
Country	$\Delta ln\ oil$	0.0004 (0.0028)	-0.0990*** (0.0029)	0.0813*** (0.0245)	29.8744***
Burkina Faso	$\Delta ln\ cpi$	0.0001 (0.0008)	-0.0027 (0.0045)	0.0156*** (0.0034)	20.1016***
Cote d'Ivoire	$\Delta ln\ cpi$	0.0002 (0.0006)	-0.0039 (0.0067)	0.0220*** (0.0033)	45.6737***
Ghana	$\Delta ln\ cpi$	-0.0007 (0.0001)	-0.0129* (0.0070)	0.0112** (0.0047)	9.5399**
Niger	$\Delta ln\ cpi$	0.0004* (0.0002)	0.0040 (0.0109)	0.0457*** (0.0054)	47.1631***
Nigeria	$\Delta ln\ cpi$	0.0001 (0.0001)	-0.0090* (0.0052)	0.0215*** (0.0038)	33.4942***

* significance at 10% ** significance at 5% ***significance at 1%

In summary, a broad literature on oil price volatility attempts to capture the macroeconomic spillover effects of oil price movements using different approaches. Only a few studies have highlighted the role of uncertainty in oil price movements in developing countries. This study contributes to filling the gap by focusing on domestic prices in five developing African economies. The approach follows Engle and Ng's asymmetry tests (1993), and the Elder (2004), Elder and Serletis (2009, 2010)'s bivariate VAR GARCH-M model used to analyze oil price uncertainty, where uncertainty is measured by the conditional standard deviation of the one-period-ahead forecast error of the change in the price of oil. The investigation of the effect of oil price uncertainty on domestic price shows a positive, substantial, and significant coefficient. There is a strong correlation between uncertainty of oil price and increasing domestic prices. The point estimates seem to be highly associated with the country's oil endowment. Thus, not only crude oil prices impact domestic prices of goods and services, but also uncertainty has some effects. Oil-producing developing countries are more sensitive to oil price uncertainty than non-oil producing developing economies. Besides, responses of domestic prices to shocks are proven to be asymmetric. The bias in the volatility response of domestic price is driven by the positive size of the shocks rather than the negative size or the sign of the shocks. Combining the findings from the impacts of oil price uncertainty with the tests of asymmetry, it is apparent that economic agents are oil risk-averse. Uncertainty about oil price creates biases in both producers and consumers' behaviors, leading to more asymmetries in the response of domestic prices.

Uncertainty about prices of crude oil can be a strong motivation behind the government's regulation of domestic fuel prices. The control of domestic fuel prices aims at waning down the severe impacts of crude oil price hikes. The next chapter analyzes the transmission of crude oil prices to domestic prices, by focusing on some specific staple foods, vital for the attainment of food security in the region.

CHAPTER 3: International crude oil pass-through to domestic food prices, the implications for food security

This chapter investigates the following second research question: at the disaggregated level, what does the transmission channel of international crude oil prices to domestic food prices imply in terms of food security?

According to the World Bank (2011), an increasing number of poor people are suffering, and more people could become poorer due to high and volatile food prices. Food prices have commonly been used as strong indicators in food security analyses in most developing countries (see for example Timmer, 2000; Bekkers et al., 2017; Swinnen and Squicciarini, 2012; Kalkuhl et al., 2013; Ceballos et al., 2017) for primarily two reasons. First, the number of developing countries have data quality issues that do not allow a comprehensive analysis of food security issues in all its dimensions. Second, food price levels and stability are indicators of market conditions that can reflect changes in some or all dimensions of food security as they incorporate factors such as traders' expectations, food access, availability, and shocks (Brown, 2014). As mentioned in the previous chapter, crude oil prices uncertainty impacts domestic price level. In the fuel sector, governments have actively been engaged in pricing regulation to accommodate uncertainty about future prices of crude oil, crude oil price shocks, as well as to wane down their spillover effects.

Governments, in general, apply different mechanisms of pricing. The most common are: (i) liberalization where market forces determine fuel prices; (ii) automatic adjustment or a regular and systematic correction of fuel prices on a basis of a formula; (iii) ad hoc adjustment where prices are set irregularly and often frozen; and (iv) automatic fuel pricing combined with price smoothing. The first three are the most adopted mechanisms in developing countries (Coady et al.,2010). Either choice of mechanism impacts domestic fuel prices and can sometimes severely affect budgets. The next chapter presents an overview of fuel pricing in the three countries of interest, namely Burkina Faso, Cote d'Ivoire, and Ghana.

3.1. Fuel pricing in Burkina, Cote d'Ivoire, and Ghana

In Burkina Faso**, f**uel prices are set by an interdepartmental committee which includes the national oil company SONABHY (Société Nationale Burkinabé des Hydrocarbures), Ministry of Commerce, and Ministry of Finance. Prices are set monthly based on the first 25 days of the previous month of crude oil prices in the international market. Prices across the country, although slightly different, are highly aligned to those in the capital city Ouagadougou. Subsidies are theoretically avoided. Besides, the country applies the WAEMU (West African Economic and Monetary Union) taxes, customs duties and taxes, VAT etc. No flexibility is given to operators in the oil market to set their own prices. Pricing in Burkina Faso is close to an automatic adjustment.

In Cote d'Ivoire fuel prices are set following a ministerial decree from the government (involving the Ministry of Commerce). There are two major players in the industrial and retail sectors: the oil refinery company (SIR) and the state-owned oil company (Petroci). An automatic adjustment is applied when international crude oil prices exceed specified thresholds. Government still has some discretion in deciding the full pass-through of international crude oil prices and often freeze prices. Fuel prices are uniform across the country for gasoline, diesel, and kerosene. The government applies WAEMU taxes, customs duties, and taxes, VAT etc. The general configuration of fuel pricing in Cote d'Ivoire is close to an ad hoc adjustment.

In Ghana, prices are set by a policy committee where the main actor is the National Petroleum Authority (NPA). The NPA is in charge of regulating the petroleum downstream industry. The pricing mechanism often varies due to the variation in taxes, levies, margins, crude oil price volatility, and exchange rate. Ghana brought several changes in its fuel pricing environment. In 2005 there was a liberalization of fuel prices and a setting of fuel price ceilings in line with world prices. In the same year, there was an establishment of the Unified Petroleum Price Fund (UPPF) to ensure an equal price of petroleum products across the country. In 2006, a fuel price stabilization fund was set. In 2007 there was a change in the frequency of fuel prices review from once to twice a month. In early 2009 there was a reduction of the frequency of fuel price adjustments. In Mar 2010, the Commodity Price Risk Management Policy was implemented to hedge petroleum products. The overall environment of fuel pricing in Ghana is similar to an automatic adjustment.

3.2. Review of the literature

Timmer (2017) posits that food prices are indicatives of food security from two perspectives, which are prices level and stability. High prices deplete households' purchasing capacity and can justify higher consumption of low-quality foods. Likewise, highly volatile food prices increase uncertainty about future prices and can push households to spend a large share of their income for current consumption (hence, crowd out their future purchasing power). A frequently cited case is the food crisis that hit Zimbabwe before the year 2010, partially due to the hyperinflation faced by the country over the years (Chinaka and Banya, 2007; Bloomberg, 2017; Lynch, 2008). The various factors that diffuse food prices are some reasons that make the analysis of food security complex. As economies become more integrated, weather more severe, security more problematic, an accurate assessment of countries' achievements in terms of food security will involve a spate of indicators. Analyses prove to be challenging in poor regions since information remains flawed, transportation system weak and infrastructure sprouting. In some regions, government efforts can be hindered by porous borders exploited by arbitrageurs whenever there is a comparative advantage between regions in terms of price and transport cost.

Food price instability or disruptions in food stocks due to weather shocks can increase domestic food prices and expose poor people to food insecurity (Gouel, 2013; Nelson, 2014). This situation can justify the implementation of food supply polices (example of Burkina Faso, see Arze et al., 2011). For Per and Caicedo (1978), low-income consumers tend to spend a large proportion of their income on food. Thus, food security policies aiming at increasing food supply have little effects in curbing malnutrition due to the incapacity of poor people to increase their consumption. The issue of food insecurity should be followed by policies that boost real income of consumers.

Some studies have underscored transport and input costs as factors that can harm welfare and reduce households' consumption capacities. Baig et al. (2007) argue that high domestic fuel prices can hinder consumers' choices and real expenditures through directs and indirect channels. The direct channel refers to purchases of petroleum products (gasoline for private transport and kerosene for lightening). The indirect channel comprises of food prices, transportation, and electricity costs that impede consumers' consumption during an increase in domestic fuel prices as producers pass inputs costs to output prices. This indirect channel is emphasized by Dillon and Barrett (2016) who apply an error correction model on international and domestic prices of maize and oil for the three African countries.

Their finding suggests that transport costs are the main drivers of commodity price shocks on local food prices compared to maize prices themselves. In this line of research, authors such as Baffes and Dennis (2013), Wright (2014), Headey and Fan (2008), and Rosegrant et al. (2008) focus on crude oil as a driver of food crises. It is worth mentioning that as maize is used for both consumption and biofuel, crude oil prices can transmit to global maize prices (Mallory et al., 2012), although the transmission does not always appear strong (Zhang et al., 2007; Zilberman et al., 2013; Enders and Holt 2012; Serra et al., 2011).

In terms of analytical approach, most studies have been focusing on cointegration, error corrections, and GARCH-type models. Conforti (2004) combines error correction models, Granger causality tests, and asymmetric transmissions on several agricultural markets in Asia, Latin America, and Africa. His finding suggests that price transmissions between markets are less complete in Africa than they are in Asia and Latin America. Mundlak and Larson (1992) use a cointegration analysis and show that in less than 40% of the countries analyzed there is no cointegration between domestic and international prices. These findings seem to depend on the type of models partially. For example, Baquedano and Liefert (2014) use a single equation error correction model (SEECCM) and find that in more than 80% of cases, local prices and international prices are cointegrated. Authors like Deb et al. (1996) and Ai et al. (2006) raise the issues of misspecifications in cointegration analysis that can lead to misleading results and interpretations. Ceballos et al. (2017) model the dynamics of monthly price return volatility in international and domestic markets using a MGARCH approach. They find little evidence of volatility transmission from international to domestic markets for maize and a fair transmission for rice.

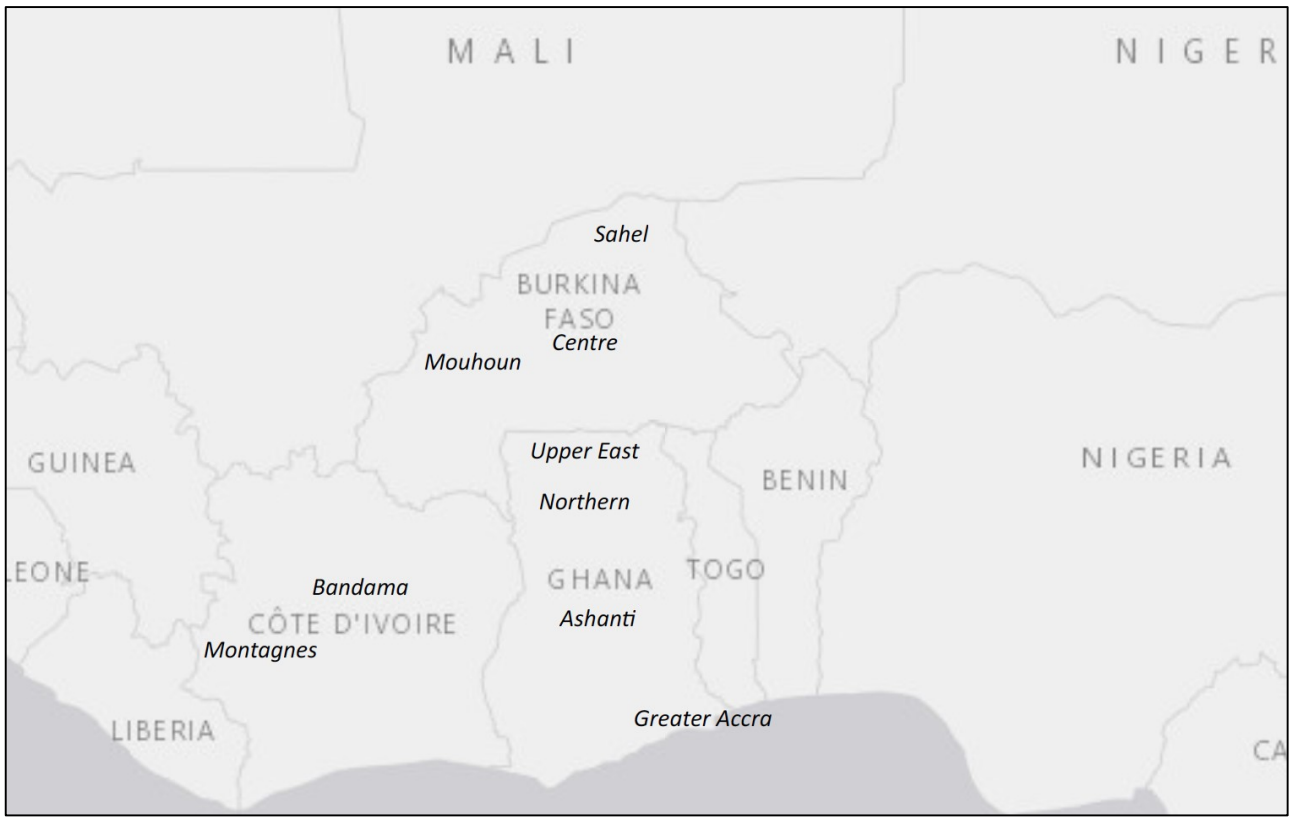
Similarly, Gardebroek et al. (2016) could not uncover the evidence of interdependence between markets from their MGARCH approach. Some studies have introduced models that allow more flexibility in the parameters. It is the case for Zhao and Goodwin (2011) who use a BEKK model to confirm the hypothesis of transmission between corn and soybean prices in the U.S. Their result is confirmed by Hernandez et al. (2014) who adds wheat prices, and two more regions (Asia and Europe) to the analysis. Valera and Lee (2016) compare Markov Switching unit root tests and Augmented Dickey-Fuller tests and evidence mixed results in the analysis of random walks in rice prices.

The literature on food prices fluctuations and food security lacks enough investigations at the disaggregated level and is mostly focused on aggregated data. Given the weakness of infrastructures such as transport and telecommunication, the imperfect information and the possible arbitrage in border regions, there is a possible existence of significant price disparities between regions within a single country. Analyses and interpretations can, therefore, suffer weaknesses. This study contributes to the literature by analyzing the pass-through of international crude oil prices to food prices in three west African countries sharing a common border and derives the implications for food security in the region. In fact, domestic fuel pricing does not solely aim at retail price stabilization, but also, at reducing the impact of crude oil shocks on domestic markets (Mitchell 2008; Tyner, 2010) especially in net oil-importing countries. Besides, analyzing countries sharing a common border can help hypothesizing on possible arbitrage or smuggling, which has some implications on fuel and food policies. Furthermore, from the academic viewpoint, in addition to the disaggregated level approach, no study has attempted to link the analysis of crude oil price spillovers to countries' domestic fuel pricing mechanisms. Such contribution to the analysis of crude oil price transmissions channel can significantly impact the interpretation of parameters (as will be discussed later in the chapter) and policy related measures, irrespective of the country analyzed.

3.3. Data

The study covers Cote d'Ivoire, Burkina Faso, and Ghana, three West African countries sharing a common border. The three countries are highly dependent on agriculture as their primary source of growth and grains as main staple foods. The analysis focuses on foods such as maize, sorghum, and rice at the national level and in different subnational markets (figure 3.1). Maize, sorghum, and rice are produced and highly consumed domestically. There is a negligible import from other countries, except for rice. Nevertheless, international food prices volatility has negligible effects on West African economies (Minot, 2014). Note that following several series of researches including in Ceballos et at., (2017), Minot (2014), Dillon and Barrett (2016*)* and Bekkers et al.,(2017) domestic production (proxied by GDP) is not included in the analysis. The reason is that this variable is available on a yearly basis while crude oil prices, exchange rate, maize prices, rice prices, sorghum prices, and domestic fuel prices fluctuate on a monthly basis. Considering domestic production would imply converting the series of prices into yearly, which will result in high loss of information and inaccurate estimations.

Figure 3.1. Regions and markets of study



Source: author, from Mapchart

The weak impact of international rice prices on imported food prices in West Africa can be explained by the diversity of West African trade partners and the growing domestic production policies. Sorghum is directly consumed or transformed for breweries; its price can be affected by the conditions in the brewery sector. Maize is used for both consumption and biofuel production and can therefore compete with crude oil. However, there is a negligible import of maize, and a trivial scale and embryonic biofuel policy in Cote d'Ivoire, Burkina Faso, and Ghana. Due to its location (Sahel) and the frequency of poor harvest, food prices in Burkina Faso frequently surge and plummet (figure 3.2b). Compared with Ghana and Cote d'Ivoire, crops yield improvements in Burkina Faso highly rely on technical and financial development partners.

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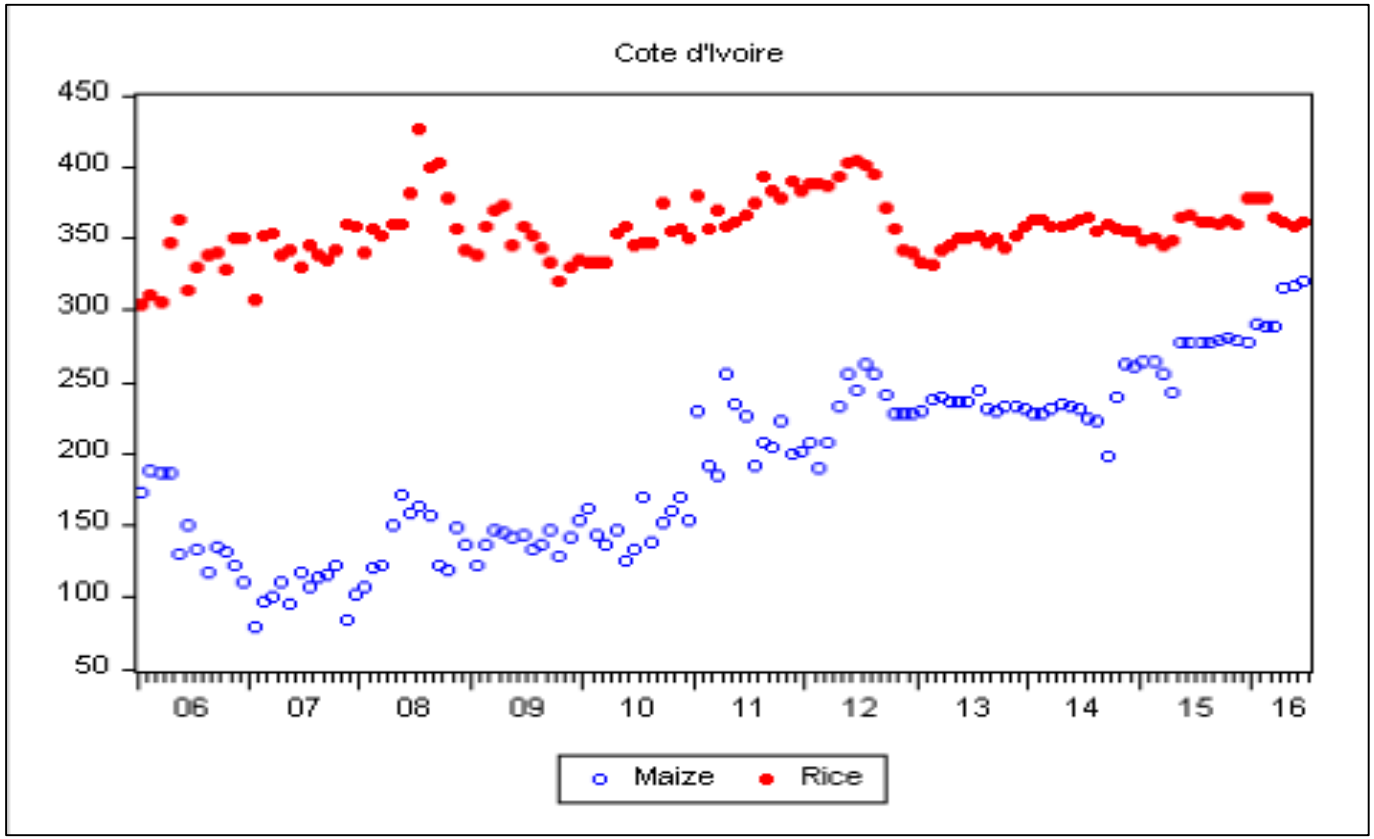
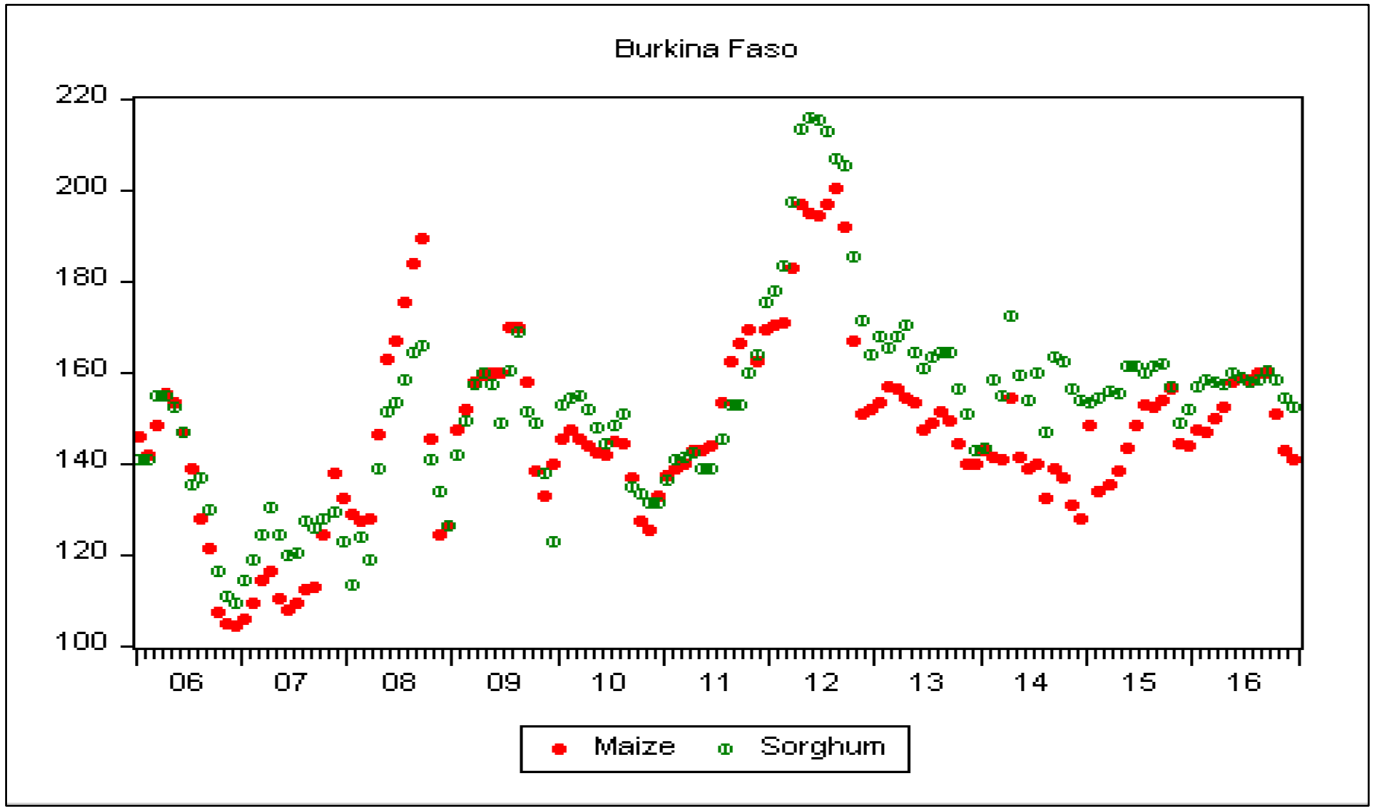
Figure 3.2a. Trends of the selected staple food



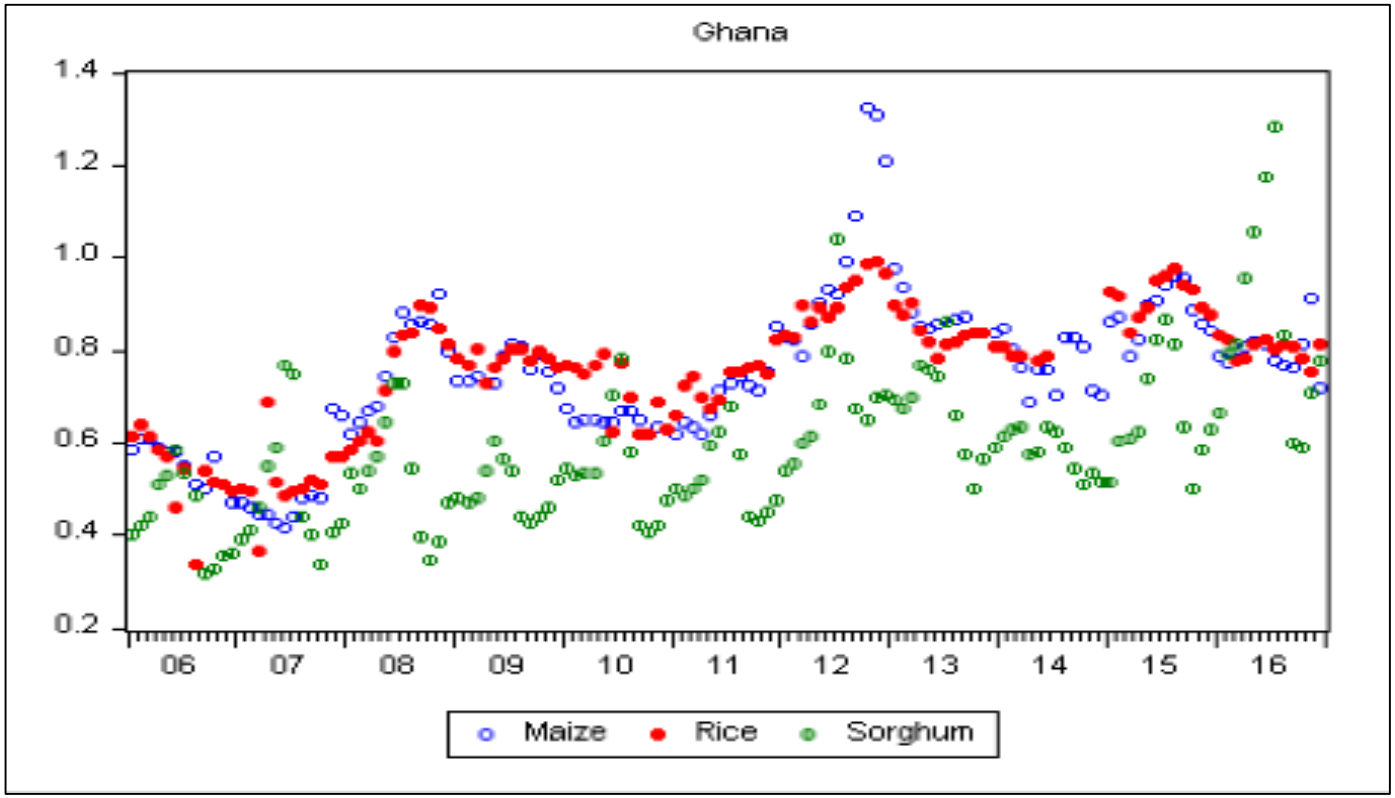
Data source: World Food Program. Prices are in local currency. Cote d'Ivoire: CFA, Burkina Faso: CFA, Ghana: GHS

Figure 3.2b. Trends of the selected staple food



Data source: World Food Program. Prices are in local currency. Cote d'Ivoire: CFA, Burkina Faso: CFA, Ghana: GHS

Figure 3.2c. Trends of the selected staple food



Data source: World Food Program. Prices are in local currency. Cote d'Ivoire: CFA, Burkina Faso: CFA, Ghana: GHS

For each country, 2 or 3 staple food prices are selected among maize, sorghum, and rice. The selection is based on the importance of the food in daily consumption, the existence of large regional markets and a long span of data. These prices data are collected from the World Food Program Vulnerability Analysis and Mapping, as well as Faostat databases. For Cote d'Ivoire, maize and rice prices are gathered. For Burkina Faso, prices of maize and sorghum; and for Ghana, prices of maize, sorghum, and rice.

Additionally, data on food price index, exchange rate, crude oil prices, and domestic fuel prices are included in the analysis. Food price indexes (national and international) are compiled from Faostat databases and national statistical institutes of each country. Exchange rate data is collected from IMF International Financial Statistics and crude oil prices data from the U.S Energy Information Administration. For domestic fuel prices series (pump prices), lots of efforts have been made to compile data from varies statistical services in each country (Burkina: National Statistical and Demographic Institute; Ghana: Statistical Services and National Petroleum Authority; Cote d'Ivoire: National Statistical Institute and National Refinery Company). All data are expressed in real terms and deflated using the consumer price index. Prices are expressed in local currencies (Cote d'Ivoire and Burkina Faso, CFA; Ghana, GHS). The sample period covers 2006 to 2016, with slight variations to accommodate data limitations. In all countries, both national and regional data summary of food prices (table 3.1, panels a,b,c) show high deviations, with about 100% gap between minimum and maximum prices over the sample period. Also, there is a significant disparity between regions and countries.

Table 3.1a. Food prices summary: Cote d'Ivoire

	Maize			**Rice**		
	Cote d'Ivoire	Bandama	Montagnes	Cote d'Ivoire	Bandama	Montagnes
Mean	191.731	132.931	195.256	356.486	341.886	355.968
Median	191.632	130.590	198.955	356.195	343.176	350.599
Max	319.588	231.060	321.774	426.396	410.110	478.734
Min	79.057	61.050	88.908	303.971	294.943	282.710
Std. Dev	60.386	30.522	53.492	21.228	26.211	33.268

Skew, skewness; std. dev, standard deviation

Table 3.1b. Food prices summary: Burkina Faso

	Maize				Sorghum			
	Burkina	Mouhoun	Sahel	Centre	Burkina	Mouhoun	Sahel	Centre
Mean	146.513	153.625	175.911	152.041	152.024	126.989	162.914	169.547
Median	145.225	147.753	178.894	150.052	153.772	125.372	159.900	161.491
Max	200.229	276.466	276.646	276.723	215.598	238.551	276.132	280.807
Min	104.202	100.588	126.579	105.685	109.168	71.011	115.466	124.844
Std. Dev	19.832	36.396	28.302	35.566	20.707	34.635	34.438	36.630

Skew, skewness; std. dev, standard deviation

Table 3.1.c Food prices summary: Ghana

	Maize					Sorghum					Rice			
	Ghana	Greater Accra	Upper East	Northern	Ashanti	Ghana	Greater Accra	Upper East	Northern	Ashanti	Ghana	Greater Accra	Upper East	Northern
Mean	0.749	0.66	0.711	0.774	0.849	0.592	0.698	0.639	0.467	0.571	0.751	0.828	0.49	0.469
Median	0.76	0.645	0.706	0.748	0.829	0.592	0.698	0.639	0.467	0.571	0.784	0.803	0.507	0.481
Max	1.323	1.088	1.391	1.649	1.391	0.573	0.659	0.588	0.463	0.528	0.989	1.198	0.693	0.718
Min	0.415	0.3	0.308	0.354	0.557	1.286	1.813	1.647	0.831	1.305	0.339	0.454	0.231	0.183
Std. Dev	0.165	0.176	0.185	0.226	0.143	0.317	0.318	0.199	0.215	0.35	0.14	0.184	0.095	0.133

Skew, skewness; std. dev, standard deviation

3.4. Methodology

The estimation of fuel prices pass-through to food prices follows two stages: international crude oil prices (or crude oil prices, for short) pass-through to domestic fuel prices (or fuel prices, for short) and fuel prices pass-through to domestic food prices. In stage 1, changes in crude oil prices are assumed to affect exchange rate, crude oil import cost, and therein, fuel prices. While feedbacks from exchange rate are allowed, the transmission of fuel prices to crude oil prices is restricted to zero, given the negligible economic power of Cote d'Ivoire, Burkina Faso, and Ghana in the world economy. In stage 2, fluctuations in fuel prices are assumed to affect food prices (through transport costs). This second stage considers two dimensions. The first dimension is the macroeconomic transmission of fuel prices to food prices. Although several studies including Ceballos (2017) found that international food prices have negligible impacts on some African economies since crops are usually intended for domestic consumption, international food price is added to the estimation along with exchange rate. Even though most countries produce for domestic consumption, international food or seed donors can be affected by international prices. Also, there still exist some amounts of food that are exported or imported during surpluses or crises. For example, Moctar et al., (2014) recorded that, in Burkina Faso, although maize is generally traded between regions within the country, some amounts of maize are exported to Niger and Mali, and smaller amounts are imported from Côte d'Ivoire, Ghana, and Togo. Thus, world food price is a non-negligible indicator that can be considered in the transmission of fuel prices to food prices. The second dimension is microeconomic. It captures the transmission of fuel prices to food prices in some local markets.

In all stages, estimations are based on a vector error correction model. The estimation is switched to a vector autoregressive when cointegration between series is not confirmed. No structural break is added to the system for a few reasons. First, over the period of study, breaks (or significant policy changes) are located at the beginning of the series. Second, breaks are endogenous to the economy itself. These justifications are supported by Dillon and Barrett (2016). Also, significant changes in fuel pricing are informed in advance by the government. The number of lags in each estimation is chosen based on the sequential modified likelihood ratio test, the final prediction error, Akaike, Schwarz, and Hannan-Quinn information criteria, and in such a way that the optimal selected lag is confirmed by the majority of the criteria, while residuals remain non-autocorrelated.

Stage 1: crude oil pass-through to domestic fuel prices

The error correction model for the first stage can be specified as follows:

$$\Delta fuel_t = \sum_{k=1}^{n} \mu_k \Delta fuel_{t-k} + \sum_{k=1}^{n} \lambda_k \Delta crude_{t-k} + \sum_{k=1}^{n} \gamma_k \Delta fex_{t-k} + \varphi ECT_t + \varepsilon_t \qquad (6)$$

where *fuel* is domestic fuel prices; *crude* crude oil prices; *fex* exchange rate; ECT the error correction term capturing the speeding of adjustment towards the equilibrium; μ_k, λ_k, γ_k,and φ are estimation parameters.

Each series are expressed in logarithm term. The number of lags varies from 1 to 8. For simplicity, results report only 1 lag.
The pass-through elasticity of crude oil prices to domestic fuel prices is estimated from the level values of each variable and in the following way:

$$fuel_t = \theta + \alpha_1 crude + \alpha_2 fex_t + \gamma_t \ (7)$$

$$Crude\ oil\ prices\ pass-through\ elasticity\ to\ fuel\ prices = \hat{\eta}_1 = \alpha_1 Acrude/Afuel \ (8)$$

Where *Acrude* is the average price of crude oil prices, *Afuel* the average price of domestic fuel period over the sample period and γ_t a constant. All pass-throughs are estimated in a similar procedure. Not that (6) and (7) are not linked. They correspond to different estimations as in Dillon and Barrett (2016).

Stage 2: fuel prices pass-through to food prices

The analysis of fuel prices transmission to maize, sorghum, and rice prices takes into consideration the possible impact of other food prices. Common misspecification in the literature is the duplication of food price variables. Estimations that incorporate both general food price level and some specific foods such as staple foods omit the fact that these specific foods are used in the computation of general food price levels. To avoid this redundancy that leads to biased results, general food prices can be recalculated after removing the specific food prices in the computation.

This requires access to all datasets on food prices, which can be challenging. An alternative, more feasible, is to take the residual from the regression of food prices on each specific staple food prices (maize, sorghum, and rice for this study).

The new variable $\widehat{food_i}$ $(i\ is\ a\ subscript\ referring\ to\ prices\ of\ \{maize, sorghum, rice\})$ can be obtained as follows:

$food_t = \omega_{0\_i} + \omega_{1\_it} y + \widehat{food}_{it}$ or $\widehat{food}_{it} = food_t - \omega_{0\_i} - \omega_{1\_it} y$ (9)

where: *food* is general food prices, y the price of the staple food (maize, sorghum, rice) and ω_0, ω_1 the estimated parameters.

In this stage 2 cointegration among variables varies depending on the country and the commodity. Thus, the autoregressive and error correction specifications for the macroeconomic transmission of fuel prices to food prices take respectively the form of:

$$\Delta y_t = c + \sum_{k=1}^{n} \alpha_k \Delta y_{t-k} + \sum_{k=1}^{n} \beta_k \Delta wfood_{t-k} + \sum_{k=1}^{n} \varphi_k \Delta fex_{t-k} + \sum_{k=1}^{n} \mu_k \Delta fuel_{t-k} + \sum_{k=1}^{n} \gamma_k \Delta \widehat{food}_{it-k} + \varepsilon_{1t} \quad (10)$$

$$\Delta y_t = \sum_{k=1}^{n} \theta_k \Delta y_{t-k} + \sum_{k=1}^{n} \omega_k \Delta wfood_{t-k} + \sum_{k=1}^{n} \delta_k \Delta fex_{t-k} + \sum_{k=1}^{n} \lambda_k \Delta fuel_{t-k} + \sum_{k=1}^{n} \rho_k \Delta \widehat{food}_{it-k} + \varphi ECT_t + \varepsilon_{2t} \quad (11)$$

where c is a constant, $\alpha_k, \beta_k, , \varphi_k, \mu_k, \gamma_k, \theta_k, \omega_k, \delta_k, \lambda_k, \gamma_k, \rho_k$ and φ are the estimated parameters, *wfood,* international food prices, $\widehat{food}_i$ other domestic food prices, as specified in equation (9), and ε_1 and ε_2 error terms.

For the second dimension, which is the transmission of fuel prices to food prices in local markets, equations (10) and (11) are repeated for each regional market, excluding $wfood$ and fex.

$$\Delta y_t = c + \sum_{k=1}^{n} \alpha_k \Delta y_{t-k} + \sum_{k=1}^{n} \mu_k \Delta fuel_{t-k} + \sum_{k=1}^{n} \gamma_k \Delta \widehat{food}_{it-k} + \varepsilon_{1t} \quad (12)$$

$$\Delta y_t = \sum_{k=1}^{n} \theta_k \Delta y_{t-k} + \sum_{k=1}^{n} \lambda_k \Delta fuel_{t-k} + \sum_{k=1}^{n} \rho_k \Delta \widehat{food}_{it-k} + \varphi ECT_t + \varepsilon_{2t} \quad (13)$$

The pass-through elasticity of fuel prices, international food prices, exchange rate, and other food prices to maize, sorghum, and rice prices are estimated in a way similar to stage 1. The number of lags varies from 1 to 8. For simplicity, the results report only lag 1.

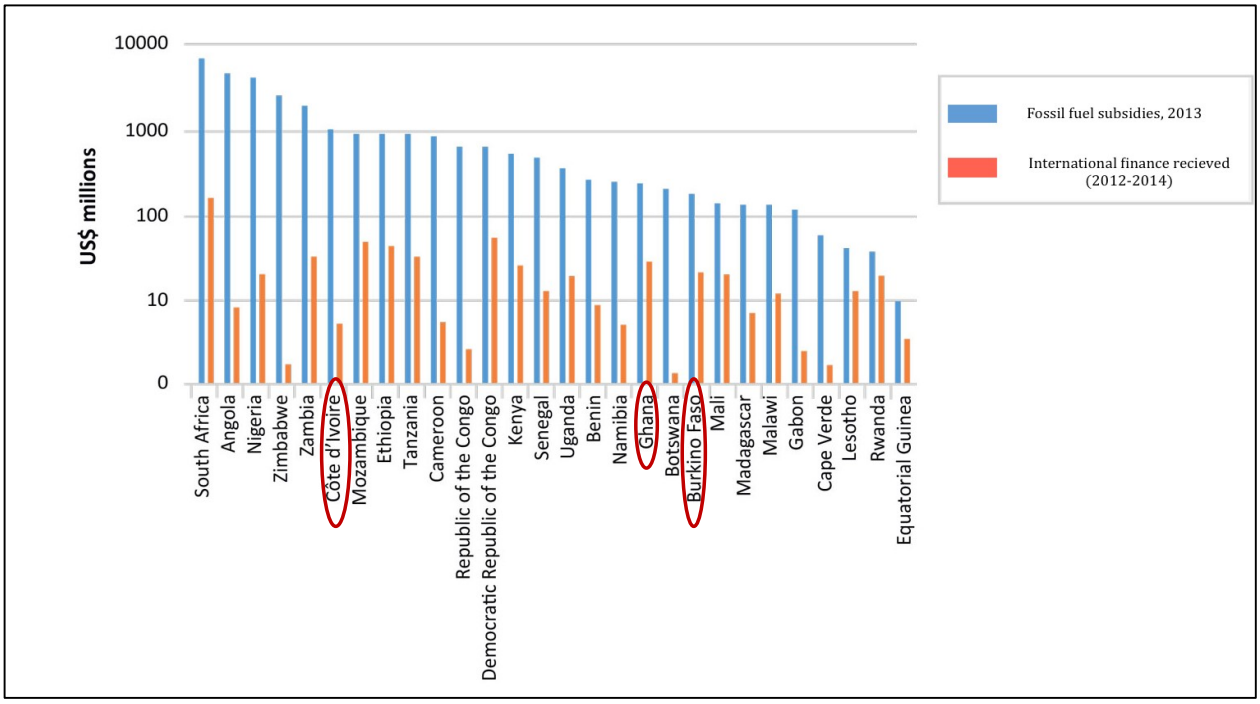
3.5. Results and interpretations

Results from stages 1 and 2 are reported in tables 3.2, 3.3, 3.4 (panels a,b, c). For all estimations, 0 to 3 cointegrating equations exist among series (appendix tables A.3.2, A.3.3, and A.3.4).
In stage 1, the cointegration test provides evidence of a long-term relationship between crude oil prices, exchange rate, and domestic fuel prices for each country. However, the speed of adjustment towards the equilibrium appears low and insignificant, implying that governments actions on domestic fuel prices win over markets' forces. The speed is about 0.4% for Cote d'Ivoire, 1% for Ghana and 0.01% for Burkina Faso. The pass-through of exchange rate is more prominent in the long-run than in the short-run. In all countries, exchange rate has a significant contribution to fuel prices. In Cote d'Ivoire, most long-term variations in fuel prices are attributed to exchange rate.

In the short-run, the transmission of crude oil prices to fuel prices is about 21% in Cote d'Ivoire, 25% in Ghana and 11% in Burkina Faso. Over the sample period, crude oil prices pass-through have been incomplete in each country. The pass-throughs are the highest in Ghana (over 50%), fair in Burkina Faso (44 %) and low in Cote d'Ivoire (less than 20%). The low pass-through in Cote d'Ivoire, as opposed to Ghana and Burkina Faso, is explained by the fuel pricing policy in each country. In theory, the three countries apply an automatic fuel pricing mechanism (Coady et al., 2015) where domestic fuel prices are regularly and systematically adjusted to reflects changes in international crude oil prices and to reduce subsidies (Coady et al., 2010, 2012). However, in practice, only Ghana and Burkina Faso seem to follow this rule, although not strictly (Kojima, 2016, Coady et al., 2015) as government occasionally intervene to protect fuel buyers against sharp increases. Cote d'Ivoire's pricing mechanism is close to an Ad hoc adjustment where fuel prices are set irregularly and often translated into long periods of freezing, supported by government subsidies (Coady et al., 2010, 2012). High subsidies, like in an ad hoc pricing system reduces the full pass-through of international crude oil prices for the protection of fuel buyers, but, at the expenses of budgets. This explains the low impact of crude oil prices to domestic fuel prices in

Cote d'Ivoire. As can be seen from figure 3.3, in 2013, Cote d'Ivoire came first in terms of subsidy, followed by Ghana and Burkina Faso.

Figure 3.3. Fuel subsidies in Cote d'Ivoire, Burkina Faso and Ghana



Data source: IMF, and Whitley (2013)

The second stage investigates the transmission of fuel prices to maize, sorghum, and rice prices at the macroeconomic level and in local markets in each country. Results are presented in tables 3.3 and 3.4 (panels a, b, and c).

At the macroeconomic level, world food prices, exchange, domestic food prices, and fuel prices appear to be cointegrated with maize and rice prices in Cote d'Ivoire, and with rice prices in Ghana. The cointegration of the variables with rice prices is a characteristic of a higher share of rice in total food imports of many West African countries. In Burkina Faso, no cointegration is found among series, despite the existence of pass-throughs. This suggests that international food prices, domestic food prices, exchange, and domestic fuel prices can transmit to maize, sorghum, and rice prices without necessarily moving with these grains in the long-run. Factors such as the degree of trade openness, the volume of domestic production and demand, the type of grains as well as

domestic fuel policy are some factors that can explain the capacity of world food prices, domestic food prices, exchange rate, and fuel prices to cointegrate in the long run.

In all countries, there are negligible impacts of fuel prices, world food prices, domestic food prices, and exchange rate on maize, rice and sorghum prices in the short run. Most immediate changes are explained by the grains' own prices. In the longer horizon, in terms of pass-through throughout the period of study, fuel prices have a more significant transmission to maize, rice and sorghum prices in Ghana, followed by Cote d'Ivoire (for rice) and Burkina Faso (sorghum). While the pass-through of fuel prices to maize prices is relatively low (compared to rice and sorghum) in Ghana, in Burkina Faso and Cote d'Ivoire the result is not significant.

In most countries, world food price has a high and positive pass-through to domestic food prices. In Ghana, however, the pass-through of world food prices to domestic food prices has a little significance. Possible explanations can be attributed to Ghanaian recent satisfactory domestic food policy that has been leveraging the country's food-sufficiency level (although a 100% food security not fully achieved). Ghana has a high promotion of domestic food production and consumption. For the case of rice, although the country has a significant import level, several initiatives have been set to wane down the impacts of international shocks. For example, in May 2008, the country was one the first to launch the National Rice Development Strategy (NRDS) for the period 2009-2018, with the target of doubling domestic production by 2018 (10 percent annual production growth rate), and enhancing quality to stimulate demand for domestically produced rice (FAO 2016). It can also be seen in the results that exchange rate does not have a much impact on Ghanaian domestic food prices. The pass-through of exchange rate to food prices is also not prominent. However, exchange rate has a high and significant contribution to Burkina Faso and Cote d'Ivoire's food prices.

At local markets, results for all countries generally present positive and significant transmission of fuel prices to food prices. The transmission is more pronounced in terms of pass-through than in terms of short-run impacts. The pass-through of fuel prices to food prices in most regions is higher than that of crude oil prices to fuel prices at the national level. In Cote d'Ivoire, although fuel prices in most regions have positive effects on maize and local rice prices, the coefficient is not significant.

This can be explained by the fact that in the selected local markets some farmers do not own cars, and rely on different or remote ways of transports to local markets, such as transportation companies, services from local associations, carts, and wheelbarrow. Also, some farmers or transporters purchase their fuel from some local resellers called "vendeurs d'essence au noir" or "*black market fuel vendors"* (Ivorian Press Agency, 2017) who sometimes sell at prices cheaper than those of gas stations. Another important finding from the analysis of local markets estimates is the presence of deviations in the results (deviation here means that results of the estimates for these markets are irregular and unexpected). These deviations are found in the estimations for Maize in Montagnes (Cote d'Ivoire), Sorghum in Northern (Ghana) and Maize in the Sahel (Burkina Faso). As those regions are located close to borders, the hypothesis of smuggling or arbitrage (to take advantage of prices differences) can strongly be put forward.

Table 3.2. Stage 1. International transmission: crude oil prices pass-through to domestic fuel prices

	Cote d'Ivoire	Burkina Faso	Ghana
	Fuel price	*Fuel price*	*Fuel price*
Speed of adjustment (EC_1)	-0.004	-0.0001	-0.01
	(-0.003)	(-0.004)	(-0.007)
Crude oil price (-1)	0.209***	0.109***	0.246***
	(-0.033)	(-0.027)	(-0.06)
Exchange Rate (-1)	-0.015	0.182	-0.272
	(-0.084)	(-0.112)	(-0.266)
Fuel price (-1)	-0.116	0.071	0.086
	(-0.143)	(-0.089)	-0.102
R-squared	0.594	0.141	0.237
SC	-5.013	-4.176	-3.213
N	138	217	133
Real average price (Local currency/ Litre)	633.077	620.606	1.604

SC: Schwarz criterion; *10% significance level; ** 5% significance level; *** 1% significance level.

Table 3.2(i). Regression results and passthroughs

	Cote d'Ivoire	Burkina Faso	Ghana
	Fuel price	*Fuel price*	*Fuel price*
Crude oil price	0.03***	0.011***	0.612***
	(0.01)	(0.001)	(0.064)
Exchange rate	1.044***	0.496***	0.212***
	(0.043)	(0.029)	(0.102)
Constant	4***	0.689**	-2.405***
	(0.645)	(0.162)	(0.145)
Observations	70	120	105
R-squared	0.996	0.983	0.9
Pass-through elasticity (*crude*)	0.194***	0.438***	0.567***
Pass-through elasticity (*fex*)	0.706***	0.307***	0.432***

*10% significance level; ** 5% significance level; *** 1% significance level

Table 3.3. Stage 2: National perspectives: Domestic fuel prices transmission to food prices, accounting for world food prices effects

	Cote d'Ivoire		Burkina Faso		Ghana		
	$y_t =$		$y_t =$		$y_t =$		
	Maize	Rice	Maize	Sorghum	Maize	Rice	Sorghum
Speed of adjustment (EC_1)	-0.070***	-0.005				-0.032**	
	(-0.039)	(-0.006)				(-0.016)	
Speed of adjustment (EC_2)	-0.040***						
	(-0.014)						
y_{t-1}	-0.172	-0.234	0.448***	0.923***	0.251	-0.556***	0.076
	(-0.183)	(-0.229)	(-0.114)	(-0.037)	(-0.154)	(-0.1)	(-0.155)
$wfood_{t-1}$	-0.355	0.565*	-0.429	0.186	-0.285	-0.215	-0.203
	(-1.133)	(-0.342)	(-0.495)	(-0.156)	(-0.368)	(-0.312)	(-0.567)
fex_{t-1}	1.704	0.817*	-0.502*	-0.215	-0.259	1.536	0.913
	(-1.4)	(-0.439)	(-0.272)	(-0.271)	(-0.529)	(-1.343)	(-2.026)
$fuel_{t-1}$	0.388	-0.002	-0.297	-0.128	-0.028	0.208	-0.351
	(-0.425)	(-0.104)	(-0.220)	(-0.083)	(-0.223)	(-0.201)	(-0.368)
$\widehat{food}_{it-1}$	0.267	0.019	0.186	-0.059	-0.032	0.023	-0.108
	(-0.574)	(-0.154)	(-0.187)	(-0.068)	(-0.078)	(-0.079)	(-0.127)
c			-0.001	0.815	0.007	0.009	0.012
			(-0.006)	(-0.518)	(-0.011)	(-0.010	(-0.019)
R-squared	0.328	0.156	0.199	0.86	0.218	0.41	0.32
SC	-1.159	-3.819	-2.387	-2.348	-1.278	-1.752	-0.29
N	139	127	169	169	133	133	133
Real average price (Local currency/kg)	192.908	356	146.66	152.66	0.662	0.71	0.59

SC: Schwarz criterion; *10% significance level; ** 5% significance level; *** 1% significance level. The error correction term ECT captures the speed of adjustment to the equilibrium of the specification. The number of error correction terms is directly linked to the number of cointegrations among the variables in the specification (equation 6). The existence of two error correction terms above means that the long-term relation between series in the corresponding equations (equation for rice and maize in Cote d'Ivoire, and equation for rice in Ghana) can be captured by two equations.

Table 3.3(i). Regression results and passthroughs

	Cote d'Ivoire		Burkina Faso		Ghana		
VARIABLES	Maize	Rice	Maize	Sorghum	Maize	Rice	Sorghum
World food price	1.888***	0.464***	1.879***	1.748***	-0.108	0.519	-0.016
	(0.699)	(0.127)	(0.471)	(0.461)	(0.241)	(0.148)	(0.134)
Exchange rate	0.687***	0.177***	0.668**	0.917***	-0.165	-0.035	-0.220*
	(1.319)	(0.241)	(0.257)	(0.235)	(0.295)	(0.426)	(0.131)
Domestic fuel price	-0.621	0.337**	-0.143	0.037	0.433***	0.381***	0.02***
	(0.563)	(0.103)	(0.222)	(0.220)	(0.117)	(0.072)	(0.001)
Domestic food price	-1.385***	-0.393***	-0.686***	-0.596***	0.171***	0.079***	0.048
	(0.365)	(-0.063)	(0.172)	(0.173)	(0.055)	(0.032)	(0.037)
Constant	-19.347***	-0.805	-2.277	-4.681	-1.875**	0.868	0.747
	(4.492)	(-1.081)	(3.151)	(2.930)	(0.873)	(0.536)	(0.755)
Observations	69	70	120	120	105	97	105
R-squared	0.479	0.528	0.133	0.152	0.434	0.673	0.212
Pass-through elasticity							
World food price (wfood)	0.489***	0.964***	0.929**	0.65***	-0.106	-0.211	-0.388
Exchange rate(fex)	0.669***	1.177***	0.541**	0.386***	-0.164	-0.102	-1.653*
Domestic fuel price (fuel)	-0.062	0.237**	-0.052	0.197	0.432***	0.447***	0.558***
Domestic food prices($\widehat{food}_i$)	-0.139***	-0.293***	-0.642***	-0.311***	0.171***	0.177***	0.129

*10% significance level; ** 5% significance level; *** 1% significance level

Table 3.4a. Stage 2: Domestic transmission: fuel prices and food prices/ Cote d'Ivoire

	Bandama		Montagnes	
	$y_t =$		$y_t =$	
	Maize	Rice	Maize	Rice
Speed of adjustment		-0.337**	-0.976**	-0.024***
		(-0.156)	(-0.428)	(-0.009)
y_{t-1}	-0.348***	-0.273	-0.034	0.357
	(-0.130)	(-0.245)	(-0.282)	(-0.219)
$fuel_{t-1} =$	-0.838	-0.146	0.678	0.578*
	(-0.563)	(-0.380)	(-0.632)	(-0.335)
$\widehat{food}_{it-1}$	-0.038	-0.956	0.259	0.495
	(-1.161)	(-0.547)	(-0.914)	(-0.407)
c	0.021			
	(-0.022)			
R-squared	0.202	0.202	0.187	0.244
SC	-0.595	-2.771	-0.352	-3.433
N	118	106	139	115
Real average price (Local currency/kg)	139.409	335.374	195.721	352.846

SC: Schwarz criterion; *10% significance level; ** 5% significance level; *** 1% significance level

Table 3.4a(i). Regression results and passthroughs

	Bandama		Montagnes	
VARIABLES	Maize	Rice	Maize	Rice
Domestic fuel price	0.175	0.127	0.185	-0.104
	(0.125)	(0.100)	(0.186)	(0.190)
Domestic food price	1.056	-0.914	-1.056*	-0.626
	(0.374)	(0.315)	(0.518)	(0.632)
Constant	2.389	2.595***	6.84	4.278***
	(7.871)	(6.841)	(1.765)	(1.256)
Observations	69	64	69	70
R-squared	0.29	0.28	0.62	0.2

Pass-through elasticity (*fuel*)	0.705	0.258	0.876	-0.093
Pass-through elasticity ($\widehat{food}_i$)	0.051	-0.002	-0.601*	-0.087

*10% significance level; ** 5% significance level; *** 1% significance level

Table 3.4b. Stage 2: Domestic transmission: fuel prices and food prices/ Burkina Faso

	Mouhoun		Sahel		Centre	
	$y_t =$		$y_t =$		$y_t =$	
	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum
y_{t-1}	-0.005	0.031	0.399**	0.046	0.164	0.157
	(-0.099)	(-0.144)	(-0.159)	(-0.131)	(-0.120)	(-0.133)
$fuel_{t-1} =$	-0.314	-0.226	-0.205	0.065	0.215	0.509
	(-0.332)	(-0.478)	(-0.269)	(-0.364)	(-0.393)	(-0.346)
$\widehat{food}_{it-1}$	0.566*	0.217	0.289	0.528*	0.690**	0.301
	(-0.296)	(-0.421)	(-0.219)	(-0.313)	(-0.342)	(-0.292)
c	-0.005	-0.002	-0.003	-0.003	0.001	-0.003
	(-0.01)	(-0.015)	(-0.008)	(-0.012)	(-0.011)	(-0.011)
R-squared	0.113	0.141	0.122	0.129	0.134	0.16
SC	-1.431	-0.811	-2.067	-1.549	-1.156	-1.573
N	169	169	169	169	167	78
Real average price (Local currency/ kg)	151.147	126.989	175.911	162.914	152	169.547

SC: Schwarz criterion; *10% significance level; ** 5% significance level; *** 1% significance level

Table 3.4b(i). Regression results and passthroughs

	Mouhoun		Sahel		Centre	
VARIABLES	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum
Domestic fuel price	0.226***	0.187***	0.243***	0.238***	0.225***	0.249***
	(0.005)	(0.006)	(0.005)	(0.007)	(0.005)	(0.006)
Domestic food price	0.461	-0.442	-0.832***	-0.695	-0.05	-0.665
	(0.163)	(0.339)	(0.224)	(0.37)	(0.155)	(0.383)
Constant	0.116***	0.106*	0.141***	0.165***	0.108***	0.51
	(0.318)	(0.541)	(0.437)	(0.583)	(0.32)	(0.587)
Observations	120	77	90	72	118	72
R-squared	0.953	0.928	0.967	0.950	0.958	0.955
Pass-through elasticity ($fuel$)	0.769***	0.739***	0.782***	0.778***	0.768***	0.784***
Pass-through elasticity ($\widehat{food}_i$)	0.02	-0.197	-0.415***	-0.326	-0.013	-0.299

*10% significance level; ** 5% significance level; *** 1% significance level

Table 3.4c. Stage 2: Domestic transmission: fuel prices and food prices/ Ghana

	Greater Accra			Upper East			Northern			Ashanti	
	$y_t =$			$y_t =$			$y_t =$			$y_t =$	
	Maize	Rice	Sorghum	Maize	Rice	Sorghum	Maize	Rice	Sorghum	Maize	Sorghum
Speed of Adjustment									-0.163***		
									(-0.031)		
y_{t-1}	0.006	0.051	0.432***	-0.024	-0.279**	-0.103	0.047	-0.3***	0.234*	0.023	-0.269
	(-0.125)	(-0.138)	(-0.125)	(-0.172)	(-0.136)	(-0.117)	(-0.138)	(-0.109)	(-0.129)	(-0.162)	(-0.135)
$fuel_{t-1} =$	0.369	0.178	0.331	0.017	0.085	0.074	0.142	0.197	0.282	-0.178	-0.287
	(-0.230)	(-0.290)	(-0.288)	(-0.355)	(-0.326)	(-0.523)	(-0.343)	(-0.394)	(-0.437)	(-0.229)	(-0.322)
$\widehat{food}_{it-1}$	0.098	-0.051	0.033	0.018	0.019	0.124	0.076	0.131	0.073	-0.072	-0.09
	(-0.085)	(-0.108)	(-0.114)	(-0.105)	(-0.105)	(-0.187)	(-0.110)	(-0.144)	(-0.187)	(-0.075)	(-0.125)
c	0.007	0.003	0.014	0.007	0.014	0.013	0.008	0.009		0.009	0.003
	(-0.011)	(-0.014)	(-0.014)	(-0.019)	(-0.016)	(-0.030)	(-0.017)	(-0.019)		(-0.011)	(-0.015)
R-squared	0.112	0.22	0.226	0.103	0.124	0.258	0.144	0.195	0.25	0.191	0.121
SC	-1.515	-1.152	-1.006	-0.624	-0.909	0.408	-0.801	-0.523	-0.103	-1.58	-0.837
N	133	133	133	133	133	133	133	133	133	133	133
Average real price (Local currency/ kg)	0.662	0.784	0.701	0.668	0.461	0.631	0.732	0.443	0.457	0.803	0.568

SC: Schwarz criterion; *10% significance level; ** 5% significance level; *** 1% significance level

Table 3.4c(i). Regression results and passthroughs

	Greater Accra			Upper East			Northern			Ashanti		
VARIABLES	Maize	Rice	Sorghum	Maize	Rice	Sorghum	Maize	Rice	Sorghum	Maize	Rice	Sorghum
Domestic fuel price	0.137***	0.069***	0.158***	0.038***	0.069***	0.133***	0.032***	0.038***	-0.088***	0.117***	0.487***	0.051***
	(0.018)	(0.046)	(0.030)	(0.045)	(0.024)	(0.029)	(0.052)	(0.029)	(0.020)	(0.044)	(0.059)	(0.026)
Domestic food price	0.939***	0.060**	0.037**	0.019**	0.041***	0.086***	0.014**	0.016**	-0.053***	0.057**	0.22	0.003***
	(0.441)	(0.044)	(0.033)	(0.043)	(0.023)	(0.027)	(0.049)	(0.027)	(0.019)	(0.041)	(0.045)	(0.029)
Constant	4.137***	6.561***	4.344***	7.136***	5.678***	3.297***	7.756***	4.940***	6.041***	9.728***	1.805***	4.752***
	(3.161)	(8.015)	(5.364)	(7.770)	(4.276)	(5.072)	(9.064)	(5.059)	(3.459)	(7.686)	(12.806)	(4.505)
Observations	105	105	105	105	105	103	105	105	105	104	59	105
R-squared	0.362	0.025	0.230	0.007	0.073	0.176	0.004	0.017	0.165	0.068	0.554	0.063
Pass-through elasticity (*fuel*)	0.427***	0.438***	0.510***	0.482***	0.399***	0.406***	0.556***	0.610***	-0.344***	0.285***	0.250***	0.427***
Pass-through elasticity ($\widehat{food}_i$)	0.191***	0.114**	0.165**	0.144**	0.155***	0.313***	0.216***	0.298**	-0.215***	0.108**	0.054	0.191***

SC: Schwarz criterion; *10% significance level; ** 5% significance level; *** 1% significance level

As a summary of this chapter, in general, domestic fuel prices transmit at higher rates to food prices than do international crude oil prices to domestic fuel prices. The degree of transmission of international crude oil prices to domestic fuel prices depends on governments' regulations of fuel prices and capacity to absorb shocks. High absorption of spikes implies high budget burden for the government and can compromise other social expenditures. This difference in terms of pass-through means that poor people (whose income share for food is generally higher than the rich, Ceballos et al., 2017) are not protected against future hikes in fuel prices. Poor people that are highly dependent on fuel (like in Burkina Faso, due to the high number of motorbikes) can face severe exposures to food insecurity from two channels: from high fuel prices (which can jeopardize their food consumption, as will be explored in the next chapter), and from high food prices (primarily triggered by high input costs such as fuel prices).

Besides, exchange rate bolsters international crude oil and food prices spillovers. Of the three countries, Ghana appears better prepared to ward off international food prices shocks. Burkina Faso and Cote d'Ivoire, however, appear in better positions to counter international crude oil price shocks. The analysis also shows suggestive evidence of smuggling or arbitrage in regions located close to borders. This means that a number of people possibly take advantage of price differences between countries. This behavior can considerably limit food availability and place the poor in challenging situations, at least in the short-run.

Having evidenced that the current policies and the pass-through of crude oil prices expose consumers to food insecurity, the last chapter uses a different and more in-depth approach to analyze the immediate impact of fuel prices on households' consumption behavior. It uses a household level survey set in one of the urban cities of Burkina Faso, Ouagadougou.

CHAPTER 4: Fuel prices and households' consumption behavior, the case of Ouagadougou

How do fuel prices impact households' food security at the microeconomic level? To address this research question, this chapter uses a household survey implemented in Ouagadougou, the capital of Burkina Faso, chosen as a case study.

Despite the important contribution of the agricultural sector to growth, food security remains a challenge in Burkina Faso. Agriculture employs around 70% of the labor force and is mainly targeted towards consumption and trade. Cereals (such as maize, rice, millet, sorghum) are the most produced-and-consumed goods. At the international level, cotton is the most traded commodity. However, the national households living standards surveys revealed that a large portion of the population (7 million people, i.e. 43.7% of the population) lives under 1.9 dollars a day and many people are constantly exposed to severe food insecurity (National Statistical Institute, 2014). The most vulnerable are rural households. The country vulnerability to food insecurity is further complicated by exogenous and highly unpredictable events such as weather shocks and international prices volatility. As a landlocked country, draught and rarefaction of rains often shrink harvest, reduce physical access to food in rural areas, and in the same time shrink financial access in urban areas (due to price upsurges). Shocks in international commodity prices such as cotton or crude oil price contribute to harming government budget and driving domestic prices up while limiting the leeway of government policies.

It is well known that unwinding the trap of food insecurity remains a crucial priority for the government of Burkina Faso. Nevertheless, in practice, most efforts have been centered on rural areas. Policy settings often do not take into consideration major cities. This prioritization of remote and rural areas can partially be justified by government limited capacities. Consequently, food insecurity in major cities mostly remains hidden, food policies not effectively targeted, and national aggregates underestimated. Very few comprehensive initiatives have attempted to estimate urban households' vulnerabilities. The Survey on Food Vulnerability in Urban Settings (VAMU, or Vulnérablité Alimentaire en Milieux Urbains, in French) is an example. VAMU was initiated in 2007 and belongs to the Ministry of agriculture. It is implemented in two major cities, namely, Ouagadougou and Bobo Dioulasso. The survey describes urban households' food and nutrition vulnerability to accompany the Early Warning

System in Sahel region or SAP (SAP is an analytical tool that helps to mitigate the drawbacks of natural shocks, FAO, 2006). Its results aim to measure the consequences of future shocks on urban households' food security. It has three main features: households socio-economic characteristics, dietary diversity, and food security scores. Similarity, Martin-Prevel et al. (2012) have measured household food security and dietary diversity score in urban Ouagadougou, but in a specific context: an assessment of the 2008 international fuel and food price shocks. VAMU and other related studies are lacking depth in the analysis of households' food security in urban areas. For example, drivers of food security/insecurity, households' coping capacity or behavioral responses to changes in their purchasing power, etc. are lacking enough investigations. Furthermore, the approaches in these studies are based on structured surveys were respondents are asked to respond to a set of pre-established answers, with fewer options to freely express their opinions.

This study provides an additional analytical approach to food security in the city of Ouagadougou, chosen as a case study. In fact, all energy is Burkina Faso is imported. Ouagadougou, the capital city has a high consumption of fuel, and the number of motorbike users is one of the highest in the region. Motorbike is the most common way of locomotion in the city and Burkina Faso in general. The vast majority of households possess at least a motorbike as primary locomotion. The usage of motorbike does not necessarily dependent on people's living conditions or economic activities. Those who cannot afford to buy a motorbike often receive as a gift from relatives to facilitate their activities. According to the National Statistical Institute (INSD, 2014), in 2007, more than 62% of households had at least one motorbike (the current survey found nearly 90%). The rise in fuel prices can severely affect food consumption, especially of the poor when they highly rely on fuel. This finding was posited in the previous chapter as well as in a large number of researches including Gicheva et al. (2010), Tuttle et al. (2017) who suggest that less financially advantaged households shrink their food expenditure in response to an unexpected upsurge in fuel prices. Cut in food spending can push households to reduce the quantity or quality of their food. Either situation can trigger food distress and result in food insecurity (Tuttle and Beatty, 2017).

The main objective of the study is to measure the contribution of fuel cost to food insecurity at the household level in Ouagadougou. To achieve this goal, the study begins by describing households' socio-economic status and measuring their dietary diversity and food security level. It next investigates the nexus between households' socio-economic characteristics and

their food security conditions. Finally, it assesses households' behavioral responses to different scenarios of fuel price changes before concluding.

4.1. Review of the literature

Food insecurity is associated with several events including slow growth (Timmer, 2005), starvation or famine, especially in less developed areas (Webb and von Braun, 1994; Nord et al, 2007; Vozoris, et al, 2002), inequality (Sen, 1981) and peace Breisinger et al. (2011). The geographical disadvantage is also put forward as a factor than can instigate food insecurity (Gleeson and Carmichael, 2001; Gleeson and Randolph, 2000). People located in areas where less infrastructure (education, road, electrification, construction, etc.) is made available are likely to be highly disadvantaged in terms of employment, social and economic inclusion. This could lead to poor income and persistent financial barrier to food in addition to the physical barrier. Low income can trigger high exposure to food insecurity as income is one the most determinant of food insecurity and hunger (Rose 1999; Gicheva et al., 2010; Tuttle et al., 2017). The strong linkage between income and food security was also posited by authors like Tingay et al. (2003) in their study of London city, and generalized in the UK context. Some factors indirectly linked to income can also lead to food insecurity. For example, Gulliford et al. (2005) and Nolan et al. (2006) have respectively found that unemployed father or households poor saving capacity are associated with food insecurity. The FAO (2008) and authors like McMichael (2011) and Eriksen (2008) among many others, have also highlighted the nexus environment and food security.

The contribution of fuel prices and energy in general to food security has received more attention and since the 2008 global financial crisis and its knock-on effects on energy and food prices especially in poor countries (Ruel et al, 2009; Arze et al, 2011). Von (2008), Ahmed et al. (2007) and Quisumbing et al. (2008) have stressed on the fact that fuel and food crises are closely intertwined, and their amplifying knock-on effects mostly affect the same type of people, namely landless, poor and net food buyers. These types of people usually correspond to the urban population, in the sense that they are not generally involved in the agricultural sector, they highly rely on income, and spend more than they produce. According to FAO (2008), 97% of world urban households are net food buyers (the value of their produced food is inferior to that of their consumed food). In a recent study, Tuttle and Beatty (2017) have incorporated asymmetrical issues in the analysis of energy prices transmission to food security among low-income households. Their finding suggests that unexpected rise in energy prices

such as fuel, natural gas, and electricity trigger food access concerns, while unexpected drop would have the opposite effect. Such linkage between energy prices and food security, especially among less advantaged households was analyzed by Cullen et al., (2005), Bhattacharya et al. (2003) and Beatty et al. (2011) who evidence that low-income households adjust their food quantity and quality to accommodate unexpected increases in energy prices. Also, for Gicheva et al. (2010) households downgrade the quality of food they consume to respond to gasoline prices shocks.

The ultimate purpose of measuring and controlling food security is to improve food security governance. The FAO (2011) defines food security governance as the formal and informal rules and processes through which interests are articulated, and decisions relevant to food security in a country are made, implemented and enforced on behalf of members of society. The following four conditions need to be met to ensure good food security: well-defined planning, decision process, and policies implementation strategy; transparency, effectiveness and accountability; strict application of rule of law and equality in the process of resources allocation; and coherent synergy between institutions. This ideal governance requires an accurate measurement of food security scales at country levels. That is why several measurements have been proposed to measure food security by authors like Webb et al. (2006); Swindale and Bilinsky (2006) Frongillo (1999), Barrett (2010) and Grebmer et al. (2012). The most comprehensive approach is the experience-based food security scales of households or EBFSS. EBFSS is composed of a set of qualitative questions related to households' experience of different aspects and scales of food security. It has been found to have a sound theoretical foundation (Radimer et al., 1992), a robust method, a good psychometric, and effective prediction capacity in a spectrum of socio-economic and cultural circumstances (Becquey et al., 2010; Munoz-Astudillo et al., 2010; Vianna et al., 2012; Usfar et al., 2007; Perez-Escamilla et al., 2004, 2007, 2009). EBFSS was first comprehensively applied in 1995, in the United States to measure and monitor food situation (Hamilton et al., 1997) through the US Household Food Security Survey Module (HFSSM). Since then, the approach has been widely applied in countries contexts in both low and middle-income countries (Pérez-Escamilla 2012; Webb et al., 2002; Coates et al., 2007; Frongillo and Nanama 2004).

4.2. Study area and methodology

The study has two features, a qualitative/explorative analysis, and a quantitative one. Both approaches use the survey dataset.

The survey is implemented in the capital city Ouagadougou where the dependency on gasoline is among the highest in the region. Each of the 5 boroughs of the city (depicted in the graph below) is included in the sample and used as a stratum. These boroughs are Nongremassom, Sig-Nonghin, Boumiougou, Bogodogo, and Baskuy. Since December 2nd, 2012, the city has been re-divided into 12 boroughs and 55 sub-boroughs to improve access to government services. However, the National Statistical Institute and most studies use the former division for sampling. Also, at the time of the consultation with the National Statistical Institute, the 2012 database was not made available.

The questionnaire is primarily administered to households' heads. A household is defined as one or more people living in the same lodging and sharing meals (Haviland, 2003). In the context of Africa and Burkina Faso, the definition of a household is closer to that of the United Nations. It is defined as a set of arrangements made by people, individually or in groups, to provide themselves with food or other essentials for a living (UNDESA, 1980). People living alone are identified as individual households. In case of unavailability of the household head, questions are administered to any adult in charge of houses expenses and who is more aware of the household conditions.

The size of the sample was calculated using Cochran's (1963) formula:

$$n_o = \frac{Z^2 pq}{e^2}$$

Where n_o is the sample size, Z the Z-score corresponding to the confidence level, p is the estimated proportion of an attribute present in the population, q=*1-p*, and e the level of precision. As the variability of characteristics from one person to another is unknown, the maximum variability is assumed and set to 0.5 (p=0.5). A confidence level of 95 (Z=1.96) and +/-5 precision (e=0.05) are also selected. Substituting these values in the equation above, a minimum sample size of 385 is derived. To account for possible outliers or unreliable information that will need to be dropped, the survey reached 427 households, with a response

rate of 94%. This high response rate is explained by the importance given by respondents to the topic. The vast majority have a high reliance on fuel prices and are strongly willing to cooperate for a better knowledge of their conditions.

Figure 4.1 Area of study

Note: red lines: areas repartitions. Source: Research Institute for Development

Stratified random sampling was applied to select the number of households. The National Statistical Institute's database was used for sampling (INSD, 2008). The database covers the whole city of Ouagadougou and each of the 5 boroughs. The selection probability of the number of households to survey in each borough is equal to the size of the borough in the total population of Ouagadougou. Complementarily, for areas difficult to locate, a geographical sampling helped to generate the survey locations based on random generations of longitude and latitude. Before launching the survey, few visits were undertaken to institutions such as the Ministry of Agriculture, the Center of Digital Documentation on Food Security, the Ministry of Environment, the Ministry of Energy, the National Statistical Institute. The purpose of these visits was to collect relevant files, reports, and statistics that could help to improve the

questionnaire as well as the interpretations of the results. Several pre-tests were also conducted to correct possible mistakes in the questionings, and to ensure a reasonable timing of the interviews. To ensure the quality of the data, three complementary approached were used. First, questions were asked in the most spoken and easily understandable languages (French, Moré or Dioula. The last two are local languages). Second, questions were repeated or reformulated to obtain the most accurate answers from respondents. Last, respondents' contacts were asked for possible clarifications if needed after the interview. As people found the topic appealing, the vast majority was willing to share their contacts.

Components of the questionnaire include households' characteristics, socio-economic status, food security and dietary diversity, and fuel consumption questions. Questions related to fuel consumption have been incorporated in the food security section of the chapter to assess the possible contribution of fuel prices to the household food security status. The last component of the questionnaire assesses respondents' behavior following different scenarios of fuel price changes. Many questions were open with no pre-established answers to obtain the most reliable and accurate attitude of respondents. The transcripts were coded, categorized, and integrated into the dataset. The final dataset has been weighted to adjust for sampling errors, non-responses, and post-stratifications.

Contingency tables presented in this chapter link social and economic characteristics of respondents to some of the important indicators used for the analyses. For these tables, two statistics are computed for each row and each group of cells. The purpose of computing these statistics is to assess the randomness and dependency in the data, which are crucial when analyzing, making inferences, and interpreting the results. For each row, the *t-student* test (William, 1908) for the mean difference across columns reflect the significance level of differences of rows across columns. The null hypothesis is that row *r* is not significantly different across column *c,* considering the weighted dataset (as specified earlier, the data has been weighted to reflect the characteristics of the population). The general specification of the t-paired statistic is given by:

$$t = \frac{(\sum D)/N}{\sqrt{\frac{\sum D^2 - \frac{(\sum D^2)}{N}}{(N-1)N}}} \qquad (1)$$

where D is the difference across column *c* of row *r* and N the number of observations.

In addition to the *t-paired* statistics, Pearson chi-square test (Pearson, 1900) is also implemented. Pearson χ^2 test is applied to contingency tables with various dimensions. In a straightforward sense, it is a test of independence among groups of cells in a crosstabulation. It compares the significance of the difference between the observed values and the expected ones (often proxied by the mean). Computing Pearson χ^2 statistics and comparing it to the Chi-square distribution allows determining whether the actual cell counts are significantly different from the expected ones. A significant estimate provides evidence of dependency among cells.

The calculation is straightforward and intuitive:

$$\chi^2 = \sum \frac{(f_o - f_e)^2}{f_e} \quad (2)$$

where f_o is the observed frequency and f_e the expected frequency. Many software provide many ways to compute both t-student and χ^2 statistics.

The combination of t-statistics and χ^2 allows drawing a general positive conclusion on the appropriateness and quality of the data for the vast majority of cases. For a few cases such as where the distribution is concentrated in a particular column, results are fairly significant. This makes sense given the uneven repartition of populations characteristics.

To complement and assess the results from the qualitative/explorative data analysis, a quantitative analysis is applied. The approach is essentially econometric. Two sets of analyses are carried out. The first set investigates the factors that explain the probability to move across food security scales. The second analysis measures the drivers of food and fuel consumption.

4.2.1. Factors explaining the switch between food security categories

As will be detailed later in this chapter, households' food security has been scaled into four categories: food secure, food insecure without hunger, food insecure with moderate hunger and food insecure with severe hunger. To measure the risk/probability to switch across these scales and to capture the explanatory factors, given the type of the dependent variable (the four scales of food security), the suitable methodology is the ordered logit model which has firstly been considered by McCullagh (1980). Studies such as Mallick and Rafi (2010) also applied an ordered logit model in their analysis of female-headed households food security in Bangladesh.

The model is an extension of the logistic regression to cases when the dependent variable is categorical (with more than two categories) and ordered in a meaningful way. Let *Y* the dependent categorical variable (in this study, food security scales). *Y* is a function of an unobserved, and continuous variable *Y**, called latent variable. *Y** has various threshold points and the value of the observed variable *Y* depends on whether or not *Y** crosses the threshold point. More formally if *k* and *m* are two scalars:

$$Y_i = 1 \ \ if \ \ Y_i^* \leq k_1 \quad (3)$$

$$Y_i = j \ \ if \ \ k_{j-1} \leq Y_i^* \leq k_j \quad (4)$$

$$Y_i = m \ \ if \ \ Y_i^* \geq k_{m-1} \quad (5)$$

Where the latent variable Y_i^* takes the form of:

$$Y_i^* = \sum_{k=1}^{K} \alpha_k X'_{ki} + \epsilon_i \quad (6)$$

The probability that observation *i* moves to alternative *j* is given by:

$$p_{ij} = p(Y_i = j) = p(k_{j-1} \leq Y_i^* \leq k_j = F\left(k_j - \ \alpha X'_i\right) - F\left(k_{j-1} - \ \alpha X'_i\right) \quad (7)$$

F is a cumulative distribution function (cdf), *X* a set of regressors and ϵ_i the error term assumed normally distributed.

Note that the coefficients on regressors in *X{x1,x2…xn}* are not directly interpreted as the impact on the dependent variable *Y*. Only the sign is interpretable. For example, in case of ascendant *Y* (worse to better) a positive coefficient on *x1* implies that higher *x1 (*or changing from the base category, if *x1* is a dummy variable) increases the probability to move to better scale of *Y*.

To obtain the individual impacts of the components of *X*, the marginal effect is computed in the following way:

$$\frac{\partial p_{ij}}{\partial x_{ri}} = \left\{F'\left(k_{j-i} - \ \alpha X'_i\right) - F'\left(k_j - \ \alpha X'_i\right)\right\}\alpha_r \quad (8)$$

r is an under script referring to the estimated parameter α.

For robustness check purpose, an ordered probit model is also estimated. Both ordered logit and probit yield the same concept and interpretation. The only difference is the expression of *F*, the cumulative distribution function. In an ordered logit, the cdf function is derived from the logistic distribution and is computed in the following way:

$$F(x'\alpha) = \frac{exp(x'\alpha)}{1+exp(x'\alpha)} \qquad (9)$$

The cumulative distribution function in an ordered probit model is similar to that of the probit model and refers to the standard normal distribution function:

$$F(x'\alpha) = \Phi(x'\alpha) = \int_{-\infty}^{x'\alpha} \Phi \, dz \qquad (10)$$

The list of regressors selected for the analysis is detailed in table 4.21. Note that the selected regressors are the most relevant ones given the context of the country and the fact that too many regressors can jeopardize the quality of the study.

4.2.2. The drivers of food and fuel consumption

A spate of factors determines households' food and fuel consumption. The purpose of this section is first, to assess the key findings from the qualitative approach and also to identify potential significant drivers that can play important roles in the trade-off between fuel consumption and food consumption (or food security). Two complementary approaches are implemented. The first approach is an Ordinary Least Squared (OLS), which can be specified as:

$$\log(y) = \sum_{i=1}^{k} \alpha_i x_i + \varepsilon \quad (11)$$

Where *y* is the dependent variable (in this study, weekly fuel consumption, and weekly food consumption, in local currency). The logarithm is taken for scaling purpose; *x* is a regressor, *i* the regressor id and ε the error term assumed normally distributed. To circumvent possible biases caused by the presence of heteroskedasticity, the study uses a robust OLS.

OLS estimates the average relationship between the dependent variable and the set of regressors. However, the model does not capture possible outliers that could exist at different points in the data distribution. Also, the coefficients of OLS regressors are identical across

observations. To overcome this issue, quantile regression is applied. In addition to dealing with the issue of possible outliers in the sample, quantile regression allows assessing the drivers of food and fuel consumption at different percentiles. For example, it measures the determinants of fuel/food consumption among the 25% lowest food/fuel consumers, among the median or the 75th percentile. This distinction gives the advantage of comparison.

Quantile regression minimizes (via the simplex method) the non-differentiable objective function *Q*:

$$Q(\alpha_q) = \sum_{i:y_i \geq x_i'\alpha}^{N} q\left|y_i - x_i'\alpha_q\right| + \sum_{i:y_i < x_i'\alpha}^{N} (1-q)\left|y_i - x_i'\alpha_q\right| \qquad (12)$$

Where q is the requested quantile ($q \epsilon [0,1]$) that split the data in into proportion q below and $1\text{-}q$ above. N is the sample size.

The list of regressors selected applied to equations (11) and (12) is detailed in table 4.21.

Table 4.1. Data outline

Strata	**Number of Households (population)**	**Share in total population**	**Minimum target (Cochrane)**	**Sampled**	**Non-respondents**	**Respondents**	**Share in sample (respondents)**
Boulmiougou (BOU)	35857	20.77	79.95	104	6	98	24.32
Baskuy (BAS)	37814	21.90	84.31	95	4	91	22.58
Bogodogo (BOG)	48626	28.16	108.42	114	6	108	26.80
Sig-noghin (SIG)	24507	14.19	54.64	63	6	57	14.14
Nongremassom (NON)	25869	14.98	57.68	51	2	49	12.16
Total	172673	100	385	427	24	403	100

Part A: Qualitative analysis

This section is purely qualitative. It uses charts and tables derived from the survey and the transcription of households' responses to analyze the nexus between food consumption and fuel consumption.

4.3. Households socio-economic characteristics

The description of households' characteristics and socio-economic status in each of the strata and the entire city reveals that about 62 % of respondents are less than 40 years of age, which portrays the younger age of the population. The majority is between the ages of 20 and 40. Only 1.9% is less than 20. About 55.5% are married monogamous and 30.1% single. Baskuy and Nongremassom have the highest number of monogamous couples (61.8% and 61.9%, respectively). Polygamy accounts for 6.3 % of all surveyed households. The lowest percentage of couples under polygamy is in Bogodogo, the center of Ouagadougou (3.9%). With a rate of 4.8%, divorce is not a recurrent issue in Ouagadougou, even in the center Bogdogo. The divorce rate in Bogodogo is 1%. Boulmiougou and Nongremasson, in contrast, with a share of 9.4% and 8.1 % respectively have the highest polygamous couples. Most households have between 2 and 5 members (37.9%) followed by 6 to10 members (36.8%), and 11 to 15 (15.2%). Some households have more than 15 members and account for 8.4%. In terms of literacy and education, at least 71% of respondents in each borough are literate. The city average literacy approaches 80%, and the Sig-noghin has the highest rate (92.8%). Only 30.4% of students reach the university and the majority stop in high school. The only exception is the center Bogodogo, where nearly 44% of respondents have a university level. Although sig-noghin has the highest literacy rate, the borough is the third in tertiary education, after Bogodogo (43.9%) and Boulmiougou (39%).

Table 4.2. Social characteristics

	BOROUGHS							
	BOU (%)	**BAS (%)**	**BOG (%)**	**SIG (%)**	**NON (%)**	**Total (%)**	**Obs.**	**Diff-mean (t-test)**
Gender								
Female	50.6	54.2	47	51.7	41.2	49.8	213	-0.555***
Male	49.5	45.8	53	48.3	58.8	50.2	202	-0.493***
	Pearson $\chi^2(4)$ = 2.5413 Pr = 0.63							
Age								
<20	1.9	1.2	2.8	1.7	2.2	1.9	8	-1***
[20-30[	33.7	20.1	43.2	38.5	20.2	32.4	131	-0.702***
[30-40[	28.2	26.3	25.4	17.6	46.7	27.3	110	-0.746***

[40-50[	11.5	25.1	12.3	24.8	8.5	16.4	66	-0.863***
[50-60[	16.7	15.5	12.9	12.2	6.1	13.8	56	-0.89***
60+	8	11.9	3.5	5.4	16.3	8.2	33	-0.94***
			Pearson $\chi^2(20)$ = 44.5204 Pr = 0.001					
Marital status								
Single	30.6		37.1	36.6	27.8	30.1	121	-0.717***
Married/monogamous	51.6	61.8	55.4	49.2	61.9	55.5	224	-0.962***
Married/polygamous	9.4	5.3	3.9	5.2	8.1	6.3	25	-0.962***
Divorced/widow	4.3	9	1	7.4	2.2	4.8	19	-0.89***
Concubine	4.2	5.4	2.7	1.7	0	3.3	13	-0.992***
			Pearson $\chi^2(4)$ = 3.7545 Pr = 0.440					
Household size								
Single (1 member)	1.9	3.2	1.8	0	0	1.7	7	-1***
2-5 members	40.7	35.2	39.4	33.3	38.7	37.9	153	-0.645***
6-10 members	29.7	35.3	38.1	49	39.3	36.8	148	-0.655***
11-15 members	19.6	14.3	14.9	14.4	5.9	15.2	61	-0.585***
> 15 members	8.1	11.9	5.8	3.3	16.1	8.4	34	-0.937***
			Pearson $\chi^2(16)$ = 19.3500 Pr = 0.251					
Literacy								
No	26.7	13.2	27.3	7.2	28.9	21.2	85	-0.813***
Yes	73.3	86.8	72.7	92.8	71.1	78.9	318	-0.235***
			Pearson $\chi^2(4)$ = 15.7427 Pr = 0.003					
Education level								
Elementary	28.2	28.7	16.9	18.7	19.6	23.4	94	-0.726***
Secondary	35.8	55.2	39.3	53	57.8	46.3	187	-0.49***
University	36	16.1	43.9	28.3	22.6	30.4	123	-0.04

Boulmiougou (BOU); Baskuy (BAS); Bogodogo (BOG); Sig-noghin (SIG);Nongremassom (NON)
Pearson χ^2(n), n: degree of freedom, Pr: probality

Most respondents' revenue and spending do not exceed 200,000 Cfa in each borough. There is a high concentration of spending between 50,005 and 100,000 Cfa (47.7% of respondents have their spending within this range). The exceptions are poor households (income between 50,005 and 100,000 Cfa) and some rich whose spending are generally higher than their income. For poor households, Family or friends' help are some factors that can explain this situation. As for richer households, debt could be an explaining factor.

In terms of economic activity, housing, and locomotion, there is a concentration in a particular area. Trade and transport employ most respondents (26.1%), followed by small crafts. Salaried from both the public and private sectors represent around 10% of respondents. Students and job seekers together account for 20.8%. Hard-wall is the most common accommodation type and is tenanted by 50-70% of households in each borough. Poor construction represents 10.6% of

accommodations, and a small portion of households (4.1%) live in villas. The most preferred locomotion is a motorbike. Around 85-90% of respondents use motorbike as a mean of locomotion. This high rate explains the strong dependency on fuel and high sensitivity to fuel prices changes in Ouagadougou and provides a substantial justification for the study. Only 4 % do not own any locomotion. Those who do not have any personal locomotion usually pay for their transportation (and are therefore affected by fuel price changes), as they usually borrow motorbikes from family members/friends or use public transportation. A few respondents possess a car (1.9%), and some have both cars and motorbikes (5.1%).

Table 4.3. Economic characteristics

	BOROUGHS							
	BOU (%)	**BAS (%)**	**BOG (%)**	**SIG (%)**	**NON (%)**	**Total (%)**	**Obs.**	**Diff-mean (t-test)**
Monthly revenue								
<50,000	12.9	11.7	22.2	5.2	26.6	15.6	63	-0.742***
[50,005-100,000]	42.4	20.9	36.2	33.0	10.4	31.4	127	-0.757***
[100,005-150,000]	17.9	32.6	20.0	28.9	26.0	24.1	97	-0.84***
[150,005-200,000]	11.9	14.6	13.8	18.6	5.2	13.4	54	-0.91***
[200,005-250,000]	3.0	3.2	4.0	5.2	15.6	4.8	19	-0.964***
250,0000+	11.9	17.1	4.0	9.3	16.2	10.7	43	-0.997***
Pearson $\chi^2(32) = 35.5950$ Pr = 0.303								
Monthly expenses								
<50,000	10.6	4.9	22	14.3	16.2	13.60	55	-0.768***
[50,005-100,000]	62.5	45.3	42.6	45.8	31.2	47.7	192	-0.624***
[100,005-150,000]	13.3	25.3	14.8	22.2	26	18.9	76	-0.823***
[150,005-200,000]	5.3	12.4	13.1	13.3	5.2	10.3	42	-0.937***
[200,005-250,000]	0	4.9	2	0	10.4	2.6	11	-1.002***
250,0000+	8.3	7.3	5.5	4.4	11	6.9	28	-1.007***
Pearson $\chi^2(32) = 43.7942$ Pr = 0.080								
Function								
Student	15.3	6.5	18.9	19.2	13.9	14.6	62	-0.875***
Salaried/private sector	6.8	10.7	10.8	10.2	18.5	10.3	44	-0.915***
Salaried/public sector	8	8.7	12.3	10.9	20.2	10.8	46	-0.913***
Small craft	16	24	9.1	10.5	18.5	15.6	67	-0.868***
Trade/transport	22.8	27.9	32	26.8	14.6	26.1	111	-0.769***
Agriculture/livestock	3.1	1.2	0.9	1.9	0	1.6	7	-1.009***
Job seeker	9.3	3.4	7.6	5.2	2	6.2	26	-0.965***
Others	18.7	17.7	8.4	15.4	12.4	14.8	63	-0.88***
Pearson $\chi^2 28) = 39.9570$ Pr = 0.067								
Habitation								
Poor construction	7	6.6	23	1.7	12.2	10.6	45	-0.913***
Hard wall	53.8	70.8	52	61.4	67.4	59.6	254	-0.426***

Mini-villa	16.6	10.9	14.8	22.9	16.3	15.7	67	-0.868***
Villa	22.6	11.8	10.2	14.1	4.1	14.8	63	-0.89***
	Pearson χ^2 (12) = 21.2742 Pr = 0.047							
Locomotion								
No personal locomotion	2.1	5.8	5.5	3.5	2.2	4	17	-0.985***
Motorbike	92.9	84.8	90	86.1	89.6	89	380	-0.136*
Motorbike and car	4.1	4.2	3.6	10.4	6.3	5.1	22	-1.004***
Car	1	5.3	0.9	0	2	1.9	8	-0.97***
	Pearson χ^2(12) = 12.9429 Pr = 0.373							

Boulmiougou (BOU); Baskuy (BAS); Bogodogo (BOG); Sig-noghin (SIG);Nongremassom (NON)
Pearson χ^2(n), n: degree of freedom, Pr: probality

4.4. Dietary diversity and food security

This section represents the preliminary stage of the study. It assesses household dietary diversity and food security level using the experience-based household food security scale.

4.4.1. Dietary diversity

In food security context, dietary diversity is considered as an important factor explaining households and individuals' capacity to access food. It is a "qualitative measure of food consumption that reflects household access to a variety of foods and is also a proxy for nutrient adequacy of the diet of individuals" (FAO, 2011). Households Dietary Diversity Score (HDDS) provides a measurement of households' capacity to access a wide range of foods. According to the FAO (2011), a more diversified diet is linked to several positive outcomes on households and individuals' conditions. Such outcomes include birth weight, better hemoglobin concentration, improved health condition health. Thus, higher dietary diversity can be associated with better food security (Hoddinot and Yohannes, 2002).

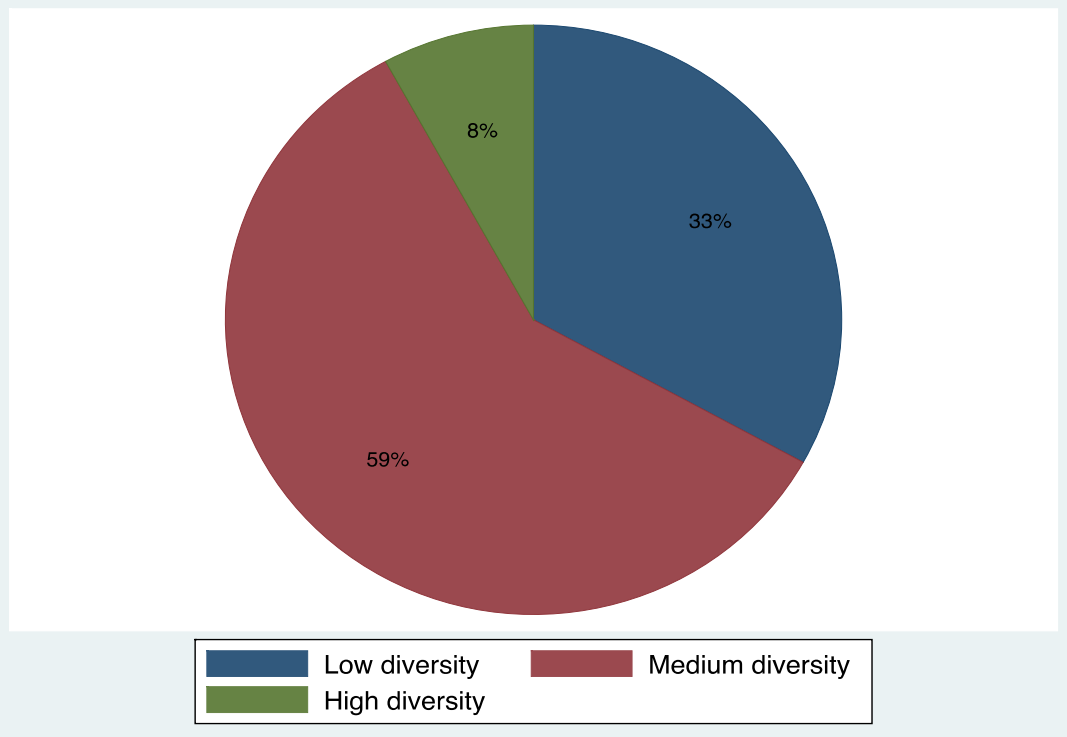
In HDDS measurement, all nutrients necessary for a balanced diet are classified in different categories. Respondents are questioned on the frequency of their consumption for each type of food they might consume in the day. The selection of food types and groups is drawn from the Food and Nutrition Technical Assistance (FANTA) and adapted to each country's reality. Table 4.4 presents each food type and group included in the questionnaire. The computation of the score is straightforward. For each group, respondents are asked whether they consume each particular food type in the day. A score 0 is attributed to negative answers and 1 for positive ones. Respondents with the highest score have the most diversified dietary, and the ones with the least diversified dietary have the lowest score. For categorization purpose, the 40% lowest score is referred to as *low diversity*, the next 30%, *medium diversity*, and the last 30%, *high diversity*.

Table 4.4. Types of foods included in dietary diversity measurement

Food Group	**Example of Food Type**
Staple foods (cereals, roots, and tubers)	Maize, millet
	Cassava, yam, plantain, other tubers etc.
Pulses and likewise	Nut/pulses (beans, cowpea, pea, lentils, etc.)
Vegetables and green leaves	Cabbage, tomato, spinach, eggplant, okra, etc.
Fruits	Mango, orange, banana etc.)
Animal proteins	Meat, poultry, fish and seafoods, egg etc.
Milk products	Milk, milk products
Sugars	Sugar, honey, other sugars, etc.
Oils	Oils and fats

Results from the estimation show that only 8% of surveyed have a high dietary diversity. Most households have a medium diversity. The percentage of households with medium food diversity is around 60%.

Figure 4.2 Households dietary diversity



Across economic and social characteristics, the majority of households has a medium dietary diversity. The proportion of females with low diversity is slightly higher than that of males (34.8% against 31.3%). Dietary is more diversified at a younger age and is a decreasing function of age. This could be explained by incrementing responsibility, spending, and family burden that undermine the capacity to have a more balanced diet. After 60 years of age, the score improves. Retirement and support from children can be some explanatory factors. Across marital status, married polygamous are found to have the highest share among households facing low dietary diversity (38.7%) and the lowest share among those with the most diversified dietary (3.9%). Singles, concubines and married monogamous have, on the contrary, relatively better dietary. Family size, with all financial burden that could be tied to it, is negatively correlated with food diversity. Households with higher members have a lesser capacity to reach more diversified dietary. The optimal household size is 2-5 members as only 28.3% have low dietary diversity. In term of literacy and education, while the former presents mixed results, the latter clearly shows that being more educated improves the ability to have more diversified consumption. 10% of respondents who were able to reach university level have a highly diversified dietary in their household, against 7.6% for secondary education and 4.8% for elementary level.

Table 4.5. Dietary diversity across households' characteristics

	Low diversity (%)	**Medium diversity (%)**	**High diversity (%)**	**Diff-mean (t-test)**
Gender				
Female	34.8	57.3	8	0.27***
Male	31.3	60.7	8	0.328***
Total	33	59	8	
Observations	133	238	32	
	Pearson $\chi^2(2) =$ 0.8093 Pr = 0.667			
Age				
<20	37.1	49.4	13.5	-0.18***
[20-30[	30.5	57	12.5	0.12***
[30-40[	32.4	61.5	6.1	0.077*
[40-50[	34.1	58	7.9	-0.037
[50-60[	39.5	58.7	1.8	-0.065*
60+	31.3	63.3	5.4	-0.117***
Total	33	59	8	
Observations	133	238	32	
	Pearson $\chi^2(10) =$ 7.6376 Pr = 0.664			
Marital status				
Single	33.3	56.3	10.4	0.107***
Married/monogamous	32.4	60.3	7.3	0.35***
Married/polygamous	38.7	57.5	3.9	-0.137***

Divorced/widow	34.2	60.2	5.6	-0.065*
Concubine	28.8	62.1	9.1	-0.167***
Total	33	59	8	
Observations	133	238	32	
	Pearson $\chi^2(8)$ = 5.9876 Pr = 0.649			
Household size				
Single (1 member)	0	70.4	29.6	0.107***
2-5 members	28.3	62.3	9.4	0.35***
6-10 members	40.2	53	6.8	-0.137***
11-15 members	31.9	60.4	7.7	-0.065*
> 15 members	31.7	65.5	2.8	-0.167***
Total	33	59	8	
Observations	133	238	32	
	Pearson $\chi^2(8)$ = 16.5011 Pr = 0.036			
Literacy				
No	40.6	50.2	9.2	0.002
Yes	31	61.3	7.7	0.596***
Total	33	59	8	
Observations	133	238	32	
	Pearson $\chi^2(2)$ = 1.4365 Pr = 0.488			
Education level				
Elementary	39	56.2	4.8	0.019
Secondary	27.1	65.4	7.6	0.254***
University	30.9	59.1	10	0.704***
Total	31	61.3	7.7	
Observations	125	247	31	
	Pearson $\chi^2(4)$ = 9.1453 Pr = 0.058			

Pearson χ^2(n), n: degree of freedom, Pr: probality

Except for a few cases, table 4.6 provides evidence that household dietary diversity improves with monthly revenue and is associated with the type of accommodation. Salaried from the public sector have the highest share among highly diversified dietaries (16.1%). None of the respondents from the agriculture and livestock sector has a high-quality consumption. Furthermore, they have the highest share of households with a low score (51.8%). Job seekers are neither better off nor worse off in terms of dietary diversity. Education level and family supports can be put forward as an explanatory factor. Finally, the type of locomotion does not provide any clear evidence on the link to dietary diversity except that 61.3% of respondents with no locomotion have a low diversity score.

Unlike the vast majority of dietary diversity measurement surveys, which are solely composed of yes/no questions, the inclusion of respondents opens comments in this study showcase an important feature that needs close consideration in the DDS measurement interpretations. These comments helped to identify potential drivers of foods preferences among the population. In

fact, although many households mentioned financial constraints, some made a striking comment, similar to one of the respondents who stated: *"it is not that I cannot afford to buy cheese, or milk, or fruits for our daily consumption. We are just not used to it. It is not a part of our habit and culture"*. This appealing comment can be applied to many other mixed results found in the results above. Thus, DDS should be interpreted with cautious. A low DDS score should not strictly be correlated with a high poverty level, as factors such as cultures, values, mindsets can play an essential role in explaining households' consumption habit.

Table 4.6. Dietary diversity across economic characteristics

	Low diversity (%)	**Medium diversity (%)**	**High diversity (%)**	**Diff-mean (t-test)**
Monthly revenue				
<50,000	33.6	58.9	7.5	0.081***
[50,005-100,000]	29.9	59.3	10.7	0.063*
[100,005-150,000]	31.3	63.6	5.2	-0.02
[150,005-200,000]	48	49.7	2.3	-0.091***
[200,005-250,000]	53.2	34.3	12.5	-0.145***
250,0000+	17.4	78.9	3.8	-0.183***
Total	33.8	58.8	7.4	
Observations	134	241	28	
	Pearson $\chi^2(16) = 34.9411$ Pr = 0.004			
Monthly expenses				
<50,000	24.6	64.3	11.1	0.055*
[50,005-100,000]	37.3	55.8	6.9	0.198***
[100,005-150,000]	40.1	54.1	5.8	-0.007***
[150,005-200,000]	32.2	61.6	6.2	-0.115***
[200,005-250,000]	0	86.2	13.8	-0.18***
250,0000+	26.5	61.0	12.5	-0.185***
Total	32.7	60.4	6.9	
Observations	132	243	28	
	Pearson $\chi^2(16) = 18.1559$ Pr = 0.315			
Function				
Student	37.4	59.1	3.5	-0.0501*
Salaried/private sector	29.5	68.4	2.2	-0.0902***
Salaried/public sector	20.4	63.5	16.1	-0.087***
Small craft	32.8	58.5	8.6	-0.042
Trade/transport	41.1	50.8	8.1	0.05*
Agriculture/livestock	51.8	48.2	0	-0.185***
Job seeker	33.5	62.5	3.9	-0.1403***
Others	24.3	63.6	12.1	-0.057*****
Total	33	59	8	
Observations	133	238	32	
	Pearson $\chi^2(14) = 16.3798$ Pr = 0.291			
Habitation				

Poor construction	33.8	61.3	4.9	-0.0902***
Hard wall	35	57.2	7.8	0.395***
Mini-villa	30.9	59.4	9.7	-0.042
Villa	26.6	64.3	9.1	-0.065***
Total	33	59	8	
Observations	133	238	32	
	Pearson $\chi^2(3) = 6.9440$ Pr = 0.074			
Locomotion				
No personal locomotion	61.3	38.7	0	-0.16***
Motorbike	32.6	58.7	8.7	0.686***
Motorbike and car	21.3	74.4	4.3	-0.147***
Car	27	73	0	-0.18***
Total	33	59	8	
Observations	133	238	32	
	Pearson $\chi^2(6) = 5.9589$ Pr = 0.428			

Pearson χ^2(n), n: degree of freedom, Pr: probality

From the analysis above, it turns out that low dietary diversity is found to be more predominant among the following respondents: (i) Females, (ii) polygamic couples, widowed and divorcees, (iii) high household size (2-5 members appear to be the optimal size), (iv) people with lower education; (v) From the economic aspect, salaried from the private sector have less dietary diversity as opposed to those in the public sector; (vi) finally, agriculture/ and livestock. The finding also considers that habit and culture are some parameters that can bias the interpretation and policy implications.

Dietary diversity does not solely characterize food security or living condition in general. As comments above suggest, unperceived factors such as culture and habit can play an essential role in determining households' food choice. Therefore, different complementary approaches need to be explored to analyze households' conditions. The next section examines households' food security status using the experience-based food security scale, given its proven robustness.

4.4.2. Food security

Several approaches to measure food security at household and individual levels have been implemented across countries and regions. One of the most comprehensive methods was developed by Hamilton et al. (1997) in the context of households' experience-based food security. The measurement was applied to U.S households (U.S. Household Food Security Survey Module) and revised in 2000. In 2006, FANTA (see Coates et al., 2007), adapted the approach to make its implementation fast and less costly for developing countries. This study favors Hamilton et al. (1997) and its 2000 revised version due to the underlying statistically

robust approach used. Also, authors like Webb et al. (2002), Coates et al. (2007), and Frongillo and Nanama (2003) have demonstrated through field validation that the approach remains effective in very different developing countries contexts. Furthermore, FANTA (see Coates et al., 2007) has pointed out the strong correlation between Hamilton et al. (1997) (and the 2000 revised version) measurement and other indicators of poverty and food consumption, making FANTA's approach a complementary instead of a substitute to other food security measurements. The study uses the 18-questions and 12 months scaling of food security. Unlike the 30 days measurement, the 12 months approach covers periods of possible poor harvests and food access distress (triggered by high market prices) and is, therefore, closer to households' conditions. Also, Bickel et al. (2000) posited that the 12 months measurement covers a broader range of severity levels of food insecurity and hunger. The list of questions incorporated in the measurement is presented below.

Table 4.7. Component of food security measurement scale

1)	In the last 12 months, did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?
2)	In the last 12 months, did you or other adults in your household ever not eat for a whole day because there wasn't enough money for food?
3)	In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money to buy food?
4)	In the last 12 months, were you ever hungry but didn't eat because you couldn't afford enough food?
5)	Sometimes people lose weight because they don't have enough to eat. In the last 12 months, did you lose weight because there wasn't enough food?
6)	In the last 12 months, did you ever cut the size of any of the children's meals because there wasn't enough money for food?
7)	In the last 12 months, did any of the children ever skip a meal because there wasn't enough money for food?
8)	In the last 12 months, were the children ever hungry but you just couldn't afford more food? In
9)	In the last 12 months, did any of the children ever not eat for a whole day because there wasn't enough money for food?
10)	"I worried whether our food would run out before we got money to buy more." Was that often, sometimes, or never true for you in the last 12 months?

11)	“The food that we bought just didn't last, and we didn’t have money to get more.” Was that often, sometimes, or never true for you in the last 12 months?
12)	“We couldn’t afford to eat balanced meals.” Was that often, sometimes, or never true for you in the last 12 months?
13)	“We couldn’t feed the children a balanced meal because we couldn’t afford that.” Was that often, sometimes, or never true for you in the last 12 months?
14)	“The children were not eating enough because we just couldn’t afford enough food.” Was that often, sometimes, or never true for you in the last 12 months?
15)	"We relied on only a few kinds of low-cost food to feed the children because we were running out of money to buy food.” Was that often, sometimes, or never true for you in the last 12 months?
16)	"Did you ever run short of money and try to make your food or your food money go further?"
17)	"Did you ever run out of the foods that you needed to make a meal and didn’t have money to get more?"
18)	"Did you ever serve only a few kinds of low-cost foods—like rice, beans, macaroni products, bread or potatoes— for several days in a row because you couldn’t afford anything else?"

Several approaches to measure food security at household and individual levels have been implemented across countries and regions. One of the most comprehensive methods was developed by Hamilton et al. (1997) in the context of households’ experience-based food security. The measurement was applied to U.S households (U.S. Household Food Security Survey Module) and revised in 2000. In 2006, FANTA (see Coates et al. 2007), adapted the approach to make its implementation fast and less costly for developing countries. This study favors Hamilton et al. (1997) and its 2000 revised version due to the underlying statistically robust approach used. Also, authors like Webb et al. (2002), Coates et al. (2007), and Frongillo and Nanama (2003) have demonstrated through field validation that the approach remains effective in very different developing countries contexts.

Furthermore, FANTA (see Coates et al., 2007) has pointed out the strong correlation between Hamilton et al. (1997) (and the 2000 revised version) measurement and other indicators of poverty and food consumption, making FANTA’s approach a complementary instead of a substitute to other food security measurements. The study uses the 18-questions and 12 months scaling of food security. Unlike the 30 days measurement, the 12 months approach covers

periods of possible poor harvests and food access distress (triggered by high market prices) and is, therefore, closer to households' conditions. Also, Bickel et al. (2000) posited that the 12 months measurement covers a broader range of severity levels of food insecurity and hunger. The list of questions incorporated in the measurement is presented below.

Table 4.8. Overview of responses

Questions	Never	Happened	% of all respondents		% of "happened" responses	
			Often	Sometimes	Often	Sometimes
1) In the last 12 months, did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?	50.1%	49.9%	13.9%	36.0%	27.9%	72.1%
2) In the last 12 months, did you or other adults in your household ever not eat for a whole day because there wasn't enough money for food?	82.1%	17.9%	5.5%	12.4%	30.6%	69.4%
3) In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money to buy food?	49.9%	50.1%	10.9%	39.2%	21.8%	78.2%
4) In the last 12 months, were you ever hungry but didn't eat because you couldn't afford enough food?	68.2%	31.8%	6.7%	25.1%	21.1%	78.9%
5) Sometimes people lose weight because they don't have enough to eat. In the last 12 months, did you lose weight because there wasn't enough food?	77.2%	22.8%	22.8%			22.8%
6) In the last 12 months, did you ever cut the size of any of the children's meals because there wasn't enough money for food?	75.6%	24.4%	6.4%	18.0%	26.3%	73.7%
7) In the last 12 months, did any of the children ever skip a meal because there wasn't enough money for food?	81.6%	18.4%	3.9%	14.5%	21.4%	78.6%
8) In the last 12 months, were the children ever hungry but you just couldn't afford more food? In	91.9%	8.1%	2.1%	6.0%	25.8%	74.2%
9) In the last 12 months, did any of the children ever not eat for a whole day because there wasn't enough money for food?	96.3%	3.7%	1.3%	2.4%	35.7%	64.3%
10) "I worried whether our food would run out before we got money to buy more." Was that often, sometimes, or never true for you in the last 12 months?	42.4%	57.6%	22.6%	35.0%	39.2%	60.8%
11) "The food that we bought just didn't last, and we didn't have money to get more." Was that often, sometimes, or never true for you in the last 12 months?	52.1%	47.9%	16.6%	31.3%	34.7%	65.3%
12) "We couldn't afford to eat balanced meals." Was that often, sometimes, or never true for you in the last 12 months?	38.7%	61.3%	34.5%	26.8%	56.3%	43.7%
13) "We couldn't feed the children a balanced meal because we couldn't afford that." Was that often, sometimes, or never true for you in the last 12 months?	53.1%	46.9%	23.3%	23.6%	49.7%	50.3%
14) "The children were not eating enough because we just couldn't afford enough food." Was that often, sometimes, or never true for you in the last 12 months?	69.0%	31.0%	13.4%	17.6%	43.2%	56.8%
15) "We relied on only a few kinds of low-cost food to feed the children because we were running out of money to buy food." Was that often, sometimes, or never true for you in the last 12 months?	56.1%	43.9%	20.8%	23.1%	47.5%	52.5%
Average	65.6%	34.4%	13.7%	22.2%	34.4%	62.8%

Source: author. Questions 5) is a yes / no questions as weight loss is assumed not a recurrent event in a single year, and a single positive answer is enough to capture the level of severity of food insecurity. The percentage for this question is placed in column "sometimes". Also, the share of respondents in the last two columns is a function of the total number of respondents instead of the total number of "happened" (which would in that case give a 100%, and will not reflect the reality.

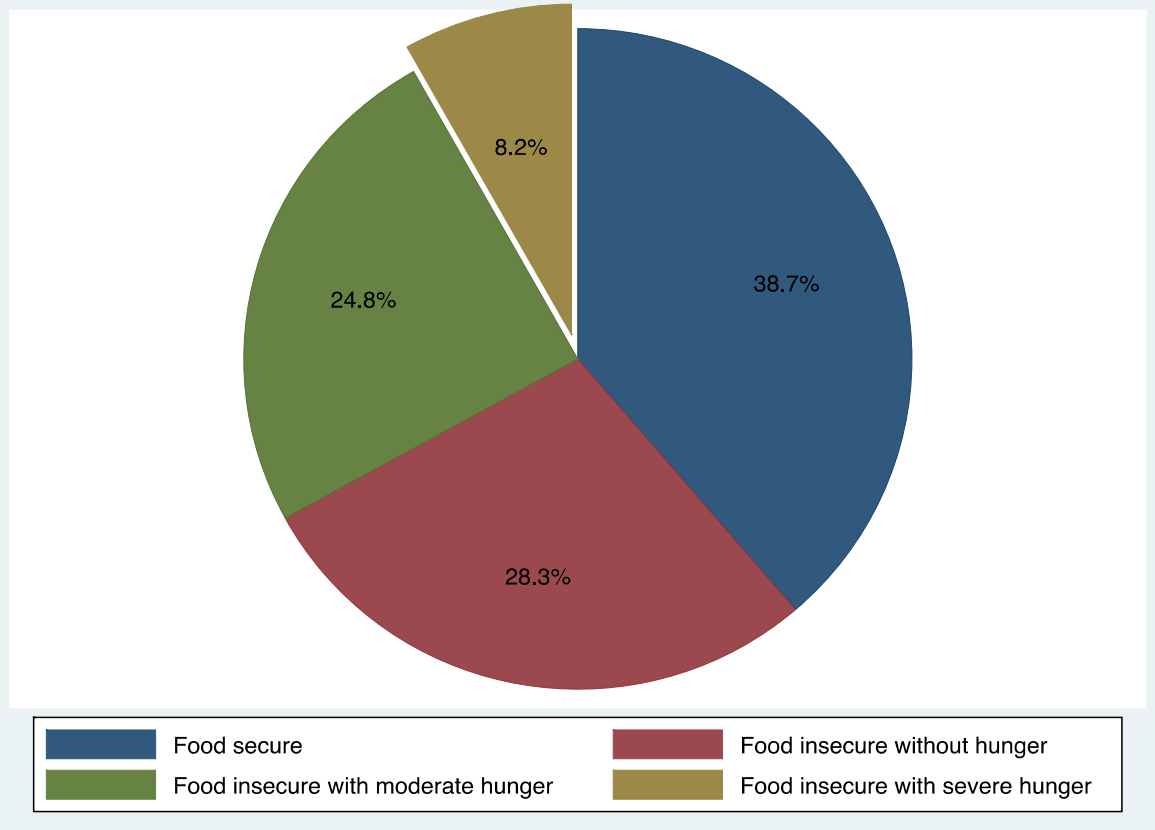
The scaling of food security status takes into consideration all the answers provided in the previous table. An affirmative answer to a single or some of the questions does not directly translate into a specific category of food security status. To obtain the categorization of food security, the dummies 0 and 1 (for no and yes answers, respectively) are summed up and the total scaled, following table 4.9.

Table 4.9. Food security scaling

Households with children (number of "yes")	**households with no children (number of "yes")**	**Food security status**
0	0	Food secure
1	1	
2	2	
3	3	Food insecure without Hunger
4	4	
5		
6	5	
7		
8	6	Food insecure with moderate hunger
9	7	
10		
11	8	
12		
13	9	Food insecure with severe hunger
14	10	
15		

Figures 4.3 presents an overview of food security status among respondents in the city, based on food security categorization above. Results show that 8.2 % of households experience severe food insecurity. This figure does not deviate much from VAMU 2016 survey which reveals that around 7.4% of households in urban Ouagadougou experience severe food insecurity. 38.7% of surveyed are food secure. Excluding this rate from the total sample, 61.3% face food distress, which is quite high and poses to be a severe issue, the more so as food is available in the urban area.

Figure.4.3. Food security status



As in the previous section, the analysis of food security status with respect to social an economic characteristic is presented in tables 4.10 and 4.11.

Females appear to be less food secure than males. 9.7% of females experience severe food security against 7% of males. A higher proportion of males (41.2%) are food secure as opposed to 36.1% of females. In terms of age, results are mixed except that 20 to 40 years is the age range where food insecurity appears to be less severe. The share of food-secure households tends, however, to increase with the age of the head. The highest proportion of food secure is found among respondents over 60 years of age (53.6%). Only 2.9% of them have a severe food security level. This confirms the findings from the DDS analysis and provides evidence that family supports can play important roles in determining elderlies' living conditions. Divorcees and Widowed have the highest proportion of severe food insecurity (18.3%). Married polygamous, although having a low dietary diversity (previous section), their share in the severe food insecurity category is close to the sample average (7.7%). The size of respondents' households plays an essential role in food security status. Single households have 13.7% chance to fall into the category of severe food insecurity. As the number of members increases, chances of becoming food secure goes down and that of turning to severe food insecurity generally

increments. As in DDS measurement, the optimal household size is 2-5 members. Households composed of 2 to 5 members have the highest proportion of food secure (47.6%) and the lowest share of food severe hunger (4.7%). Higher education and literacy are strongly consistent with higher food security and less severe hunger.

Table 4.10. Food security across households' characteristics

	Food secure (%)	**FI/without hunger (%)**	**FI/moderate hunger (%)**	**FI severe hunger (%)**	**Diff-mean (t-test)**
Gender					
Female	36.1	28.3	26	9.7	-0.143***
Male	41.2	27.9	24	7	-0.081**
Total	38.7	28.1	25	8.3	
Observations	156	113	101	33	
	Pearson $\chi^2(3) =$ 4.6076 Pr = 0.203				
Age					
<20	38.9	23.2	23.8	14.1	-0.593***
[20-30[	33.6	34.9	25.7	5.7	-0.29***
[30-40[	36.7	29.1	25.5	8.6	-0.334***
[40-50[	44.7	19.1	21.6	14.6	-0.451***
[50-60[	38.2	20.1	32.8	8.9	-0.478***
60+	53.6	29.9	13.7	2.9	-0.528***
Total	38.7	28.1	25	8.3	
Observations	156	113	101	33	
	Pearson $\chi^2(15) =$ 19.0001 Pr = 0.214				
Marital status					
Single	40.2	31.2	23.7	4.9	-0.305***
Married/monogamous	38.5	26.1	26.3	9.1	-0.059*
Married/polygamous	33.2	32.9	26.2	7.7	-0.55***
Divorced/widow	48.8	22.6	10.4	18.3	-0.478***
Concubine	22.4	31.2	32.7	13.8	-0.58***
Total	38.7	28.1	25	8.3	
Observations	156	113	101	33	
	Pearson $\chi^2(12) =$ 12.8282 Pr = 0.0382				
Household size					
Single (1 member)	45.4	28	12.8	13.7	-0.595***
2-5 members	47.6	26.4	21.2	4.7	-0.233***
6-10 members	36.7	28.8	25.3	9.2	-0.243***
11-15 members	29.2	23.8	34.1	12.9	-0.173***
> 15 members	22.6	39.8	26.2	11.5	-0.526***
Total	38.7	28.1	25	8.3	
Observations	156	113	101	33	
	Pearson $\chi^2(12) =$ 17.9809 Pr = 0.116				
Literacy					

No	31.4	24.3	28.4	15.9	-0.401***
Yes	40.6	29.1	24	6.3	0.176***
Total	38.7	28.1	25	8.3	
Observations	156	113	101	33	
	Pearson $\chi^2(3)$ =12.1476 Pr = 0.007				
Education level					
Elementary	25.1	22	41.1	11.9	-0.364***
Secondary	38	33.4	22.4	6.2	-0.128***
University	56.5	28	13.5	2.1	0.32***
Total	40.6	29.1	24	6.3	
Observations	164	117	97	25	
	Pearson $\chi^2(6)$ = 13.6980 Pr = 0.033				

FI: food insecurity; Pearson χ^2(n), n: degree of freedom, Pr: probality

As intuition would suggest, respondents' monthly income is highly and positively correlated with food security. The higher the income, the more food secure the household becomes. Highly food-insecure households are the ones who earn less than 150,000 CFA. Their proportion is between 7% and 16 %. In terms of monthly expenses, results are quite similar. Higher expenses are generally associated with better food security. High expenses can be seen as an indication of better revenue and better living condition.

A large proportion of respondents working in the agriculture/livestock are food insecure with moderate hunger (46. 8%). Only 16.1% are food secure. Respondents in trade and transport have a high proportion of severely food insecure (12.8%). Job seekers, small craft, with a share of 28.9% and 20.8%, respectively are among the least food-secure households. Only students, and salaried from both private and public sectors are relatively better off. The highest share of food secure among students is explained by the fact that most respondents are single, and the current government policy in favor of students (scholarship/bursaries, discounted meals etc.) place them in a relatively good condition, although enough needs to be done. Also, many students receive supports from relatives. The type of accommodation is an indication of living standards. Households living in impoverished accommodations are the most vulnerable. The majority are food insecure with moderate hunger (52.7%). They also have the highest proportion of severe hunger (17.1%). Regarding the type of locomotion owned by respondents, the highest proportion of food insecure with severe hunger is found among motorbikes owners (9%), and the highest share of food-secure households are found among car owners.

Combining the analyses from dietary diversity and food security, female heads, widowed and divorcees, low educated, households head working in the agricultural/livestock, trade and

transport, and small craft sector are the most exposed to high food insecurity. Polygamic couples are highly exposed to low food diversity. The optimal family size that could set the conditions for better food security is 2 to 5 members. Finally, as motivated by this research, motorbikes owners (who are not necessarily wealthy, as opposed to car owners) are exposed to severe food insecurity.

The next section measures the contribution of fuel costs to households' food security. Although all social and economic characteristics of households are considered in the analysis, closer attention will be given to the identified group above.

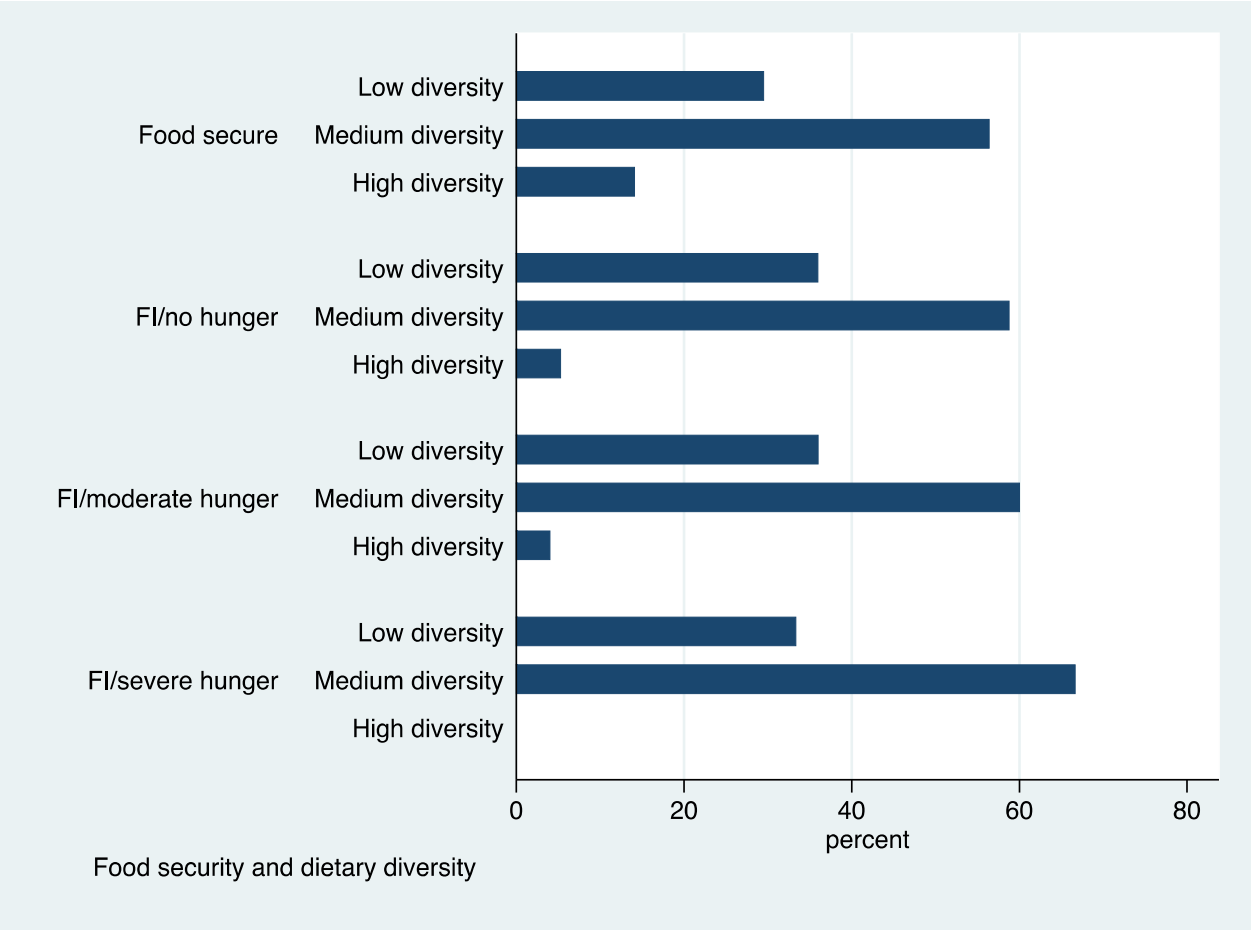
Table 4.11. Food security status across households' economic condition

	Food secure (%)	**FI/without hunger (%)**	**FI/moderate hunger (%)**	**FI severe hunger (%)**	**Diff-mean (t-test)**
Monthly revenue					
<50,000	22.7	35.8	30.2	11.3	-0.333***
[50,005-100,000]	37.3	29.6	25.9	7.3	-0.348***
[100,005-150,000]	38.0	20.3	25.6	16.1	-0.431***
[150,005-200,000]	53.3	21.2	25.6	0	-0.502***
[200,005-250,000]	77.1	18.0	4.9	0	-0.555*
250,0000+	59.6	36.6	3.9	0	-0.583*
Total	43.3	25.2	23.4	8.2	
Observations	174	102	94	33	
	Pearson $\chi^2(24) = 35.6534$ Pr = 0.059				
Monthly expenses					
<50,000	27.6	34.7	26.5	11.2	-0.358***
[50,005-100,000]	38.7	25.1	25.8	10.4	-0.213***
[100,005-150,000]	44.5	21.1	28.8	5.5	-0.412***
[150,005-200,000]	46.3	32.9	17.9	2.9	-0.527***
[200,005-250,000]	58.3	41.7	0	0	-0.592*
250,0000+	65.4	28	6.6	0	-0.597*
Total	44.1	25	23.2	7.7	
Observations	178	101	93	31	
	Pearson $\chi^2(8) = 16.4985$ Pr = 0.036				
Function					
Student	44.9	28.2	21.4	5.5	-0.464***
Salaried/private sector	54.3	27.7	13.3	4.6	-0.503***
Salaried/public sector	47.5	26	22	4.5	-0.501***
Small craft	20.8	20.9	42.8	15.5	-0.456***
Trade/transport	34.1	30.3	22.8	12.8	-0.357***
Agriculture/livestock	16.1	37.2	46.8	0	-0.598***
Job seeker	28.9	32.9	29.9	8.3	-0.553***
Others	48.4	30.3	19.3	2.1	-0.468***

Total	38.7	28.1	25	8.3	
Observations	156	113	101	33	
	Pearson $\chi^2(7)$ = 13.1978 Pr = 0.067				
Habitation					
Poor construction	13.2	17	52.7	17.1	-0.501***
Hard wall	34.6	29.5	25.9	10	-0.0148
Mini-villa	47.6	34.7	14.2	3.5	-0.4565***
Villa	65	23.1	11.9	0	-0.478***
Total	38.7	28.1	25	8.3	
Observations	156	113	101	33	
	Pearson $\chi^2(9)$ = 25.4000 Pr = 0.003				
Locomotion					
No personal locomotion	12.2	36.6	43.6	7.6	-0.573***
Motorbike	37.6	27.9	25.6	9	0.275***
Motorbike and car	87.5	12.5	0	0	-0.56***
Car	60.4	30.5	9.1	0	-0.593***
Total	38.7	28.1	25	8.3	
Observations	156	113	101	33	
	Pearson $\chi^2(9)$ = 22.6794 Pr = 0.095				

FI: food insecurity; Pearson χ^2(n), n: degree of freedom, Pr: probality

Figure 4.4. Additional facts from the data: *high food security is generally associated with better dietary diversity*



Note. FI: food insecurity

Figure 4.5 Additional facts from the data: *females when salaried from the private sector seem better off*

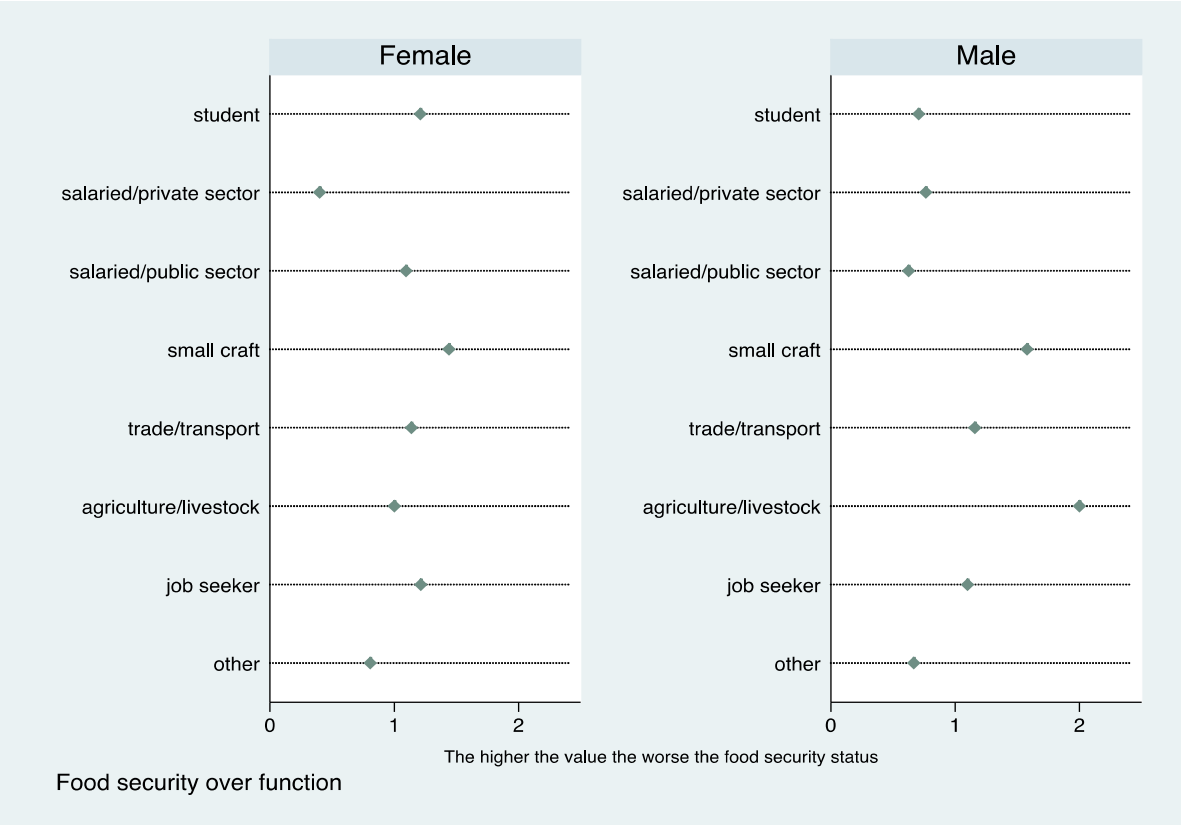
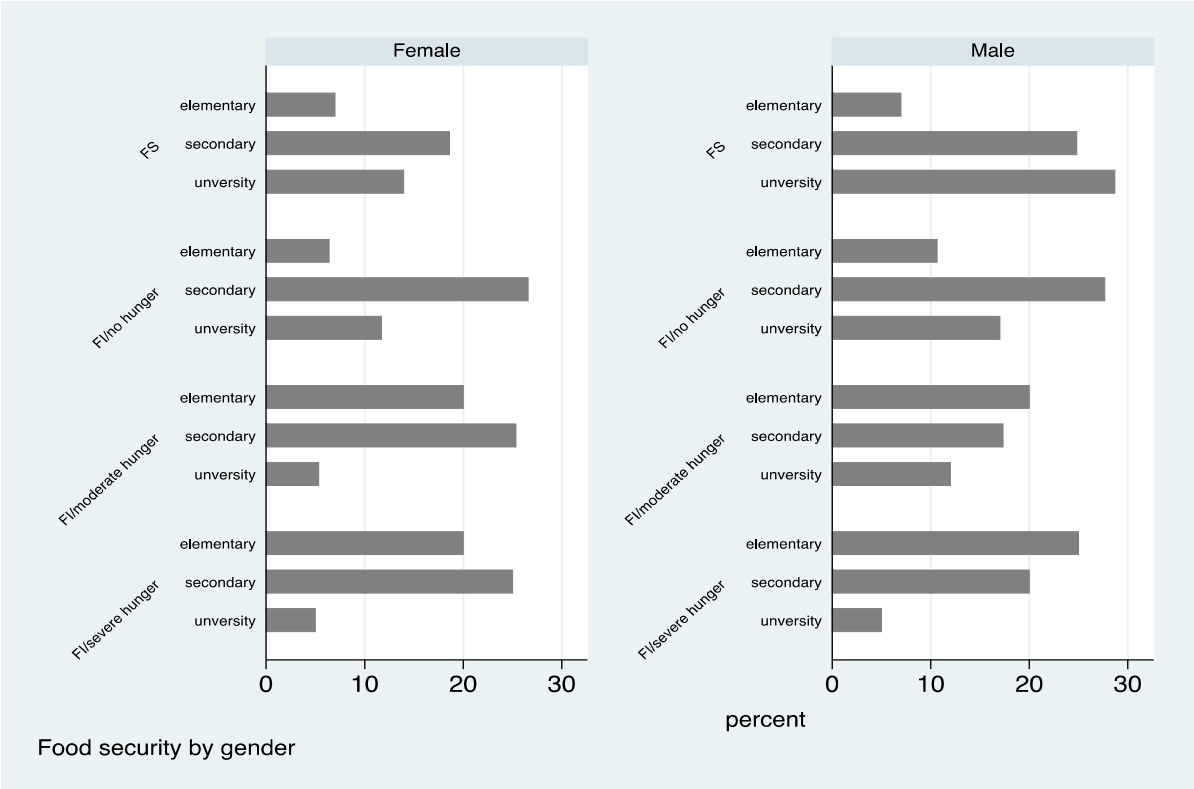


Figure 4.6 Additional facts from the data. *Education improves the food security status although males outweigh females*



4.5. Fuel cost and food security

This section is an extension of the previous one. It assesses the extent to which fuel prices contribute to food security deterioration. Around 90% of households possess at least one motorbike, and 61% face different levels of food insecurity. This implies that a significant proportion of motorbike owners can be affected by food insecurity. To investigate this issue more in-depth, questions on food security have been completed with a series of questions that could help to capture, on the one hand, households' consumption of fuel and, on the other hand, the possible link to food security measurement.

The analysis starts with an overview of the contribution of food and fuel prices to respondents' expenses and the share of those expenses in their income. Results are presented in table 4.12. In general, food expenses have a large share among lower and middle-class households' expenses. The share of food expenses is more significant than that of fuel prices and generally starts decreasing with changes in expenses category. The lowest income classes' spending on food is higher than their total monthly expenses and income. This result is an indication of the possible contribution of relative and friends. A separate analysis of income sources (information available in the dataset) shows that for the 25% percentile income class (lowest income category) around 25 % to 60% of their income is not coming from their activity. The similar downward trend can be observed for fuel prices share in total expenses except that after crossing 200,000 CFA, the share tends to grow, although not exceeding that of food prices. This U-shape pattern can be interpreted by the rising spending and demand for locomotion that follows income increment. In fact, as will be discussed in the latest part of the study related to households' consumption behavior in responses to different scenarios of fuel prices changes, many respondents would choose to increase their locomotion (for luxury or visits to friends and relatives) if fuel prices become more affordable.

Irrespective of the income class, fuel spending represents around 30% to 50% of food spending. Given the percentage of households facing food distress, this range is mattering in the measurement of drivers of food insecurity. For example, for the lowest income class, 102% of their spending is dedicated to food, while 45% for fuel. 100% of them have personal locomotion, but only 15% use public transportation at least once a month (columns locomotion). This high discrepancy is an indication of a non-optimal income and spending allocation and a high dependency on fuel purchases that can play an essential role in food purchases. At any income and spending levels, the vast majority of respondents use less public transportation. The highest income and expenses category do not use at all.

Table 4.12. Overview on fuel and fuel consumption

Expenses and income		Locomotion		Fuel consumtion (1000 cfa)				Food consumption (1000 cfa)			
HH head monthly expenses (Cfa)	Share in sample	Using a personal locomotion	Using public transport at least once/month	Monthly average fuel expenses	Min	Max	Share of fuel in average expenses	Monthly average food expenses	Min	Max	Share of food in average expenses
≤ 50,000	13.5%	100%	15.6%	11.3	2	30	45%	4	4	88	102%
[50,005-100,000]	47.2%	97.4%	17.9%	15.4	2	120	21%	4	4	216	55%
[100,005-150,000]	18.7%	96.2%	12.8%	19.7	6	50	16%	14	14	140	47%
[150,005-200,000]	10.3%	81.8%	18.1%	21.5	5	52	12%	28	28	120	37%
[200,005-250,000]	2.6%	49.7%	17.4%	50.0	10	100	22%	62	62	229	54%
+250,000	6.8%	68.4%	12.0%	63.3	5	300	16%	49.7	31	320	30%
HH head monthly revenue (Cfa)	Share in sample	Using a personal locomotion	Using public transport at least once/month	Monthly average fuel expenses	Min	Max	Share fuel in average expenses	Monthly average food expenses	Min	Max	Share of food in average income
≤ 50,000	14.30%	100%	16.5%	10.6	2	25	43%	30.3	5.6	80	121%
[50,005-100,000]	28.80%	98.2%	19.7%	15.4	4	60	21%	32.5	4	88	43%
[100,005-150,000]	22.10%	98.4%	8.3%	16.0	2	50	13%	49.1	16	216	39%
[150,005-200,000]	12.30%	95.2%	16.7%	19.1	5	48	11%	64.7	28	120	37%
[200,005-250,000]	4.40%	90.1%	26.0%	13.1	5	20	6%	50.4	8.4	140	22%
+250,000	9.90%	59.5%	5.1%	58.6	14	200	16%	108.3	28	160	31%

Source: author. Cfa is the local currency

To further investigate the potential contribution of fuel prices to food insecurity, as suggested above, the next section uses different analytical approaches and further digs into the data.

4.5.1. To what extent fuel prices contribute to instigating food insecurity?

As agriculture is generally not present in urban areas, financial access to food remains one of the chief determinants of food insecurity. Financial capacity does not solely depend on income, but also expenses. Income is known to be rigid. Therefore, efficiently coping with expenses can help to improve living standards. For that reason, among the several expenses, households possibly face, priority has been given to fuel prices in this study, considering the high consumption and dependency on fuel among the population. Also, the previous section showed that fuel spending represents around 30% to 50% of that of food.

This section assesses respondents' opinion regarding the role of fuel in their expenses. It is built as an extension of food security measurement in section 4.4.2. The approach used is as follows. For each of the questions on food security measurement, when the respondent gives a *yes* answer, the following question is asked: *Do you think fuel prices has some responsibilities?* Four possible of cases are derived from the answers: *1) no responsibility, 2) low responsibility, 3) fair responsibility, 4) high responsibility, and 5) Don't know/difficult to say.*

To determine the total score for each individual, a score 0 is attributed to the answer *1) no responsibility* and 1 if the answer falls in either of the categories *2) low responsibility, 3) medium responsibility, 4) high responsibility*; and a similar approach to food security measurement adopted.

Table 4.13. Fuel prices and food security: scaling

Role of fuel prices to food insecurity (number of "yes")	Level of responsibility of fuel prices
0	No responsibility
1	
2	
3	Low responsibility
4	
5	
6	
7	
8	Medium responsibility
9	

10	
11	
12	
13	
14	High responsibility
15	

The description of the respondents' opinion is presented in the next table. For the majority of those who experienced some or all trigger factors of food insecurity, fuel prices had a medium contribution. 30% to 50% of responses is attributed to a fair contribution of fuel prices to food distress (either food insecurity with no hunger, food insecurity with moderate hunger or food insecurity with severe hunger).

A low proportion of respondents mentioned that fuel prices have no responsibility in their experience of food distress. Only for questions 12 to 15, the share is significantly high (32% to 35%). Most of these questions are related to children experiences of food distress. In fact, children are usually affected by food insecurity when parents experience severe food insecurity. Parents prioritize children needs over theirs. Around 34% of respondents find that their incapacity to afford balanced meals was not due to fuel prices, and another 34% think it was fairly due to fuel prices. The no responsibility attributed to fuel prices for some respondents can perhaps be explained by factors such as habit or culture that can drive their willingness to eat balance. An average of 18.2% of respondents finds that fuel prices have a high responsibility for their food distress. This average rate is consistent and does not primarily differ across the questions.

As a summary, among all respondents who ever experienced any of the food insecurity measurement questions, an average of 12.1% (with a high deviation) think that fuel price is not the cause. 15.7% believe that fuel prices have a low responsibility, 37.1% give a fair contribution of fuel prices, and 18.2% think fuel prices are mainly responsible. Finally, 18.2% either do not know. Combining the three scales of responsibility (low, fair, and high), for 71% of respondents who experienced food distress, fuel prices play somewhat a role.

Table 4.14. food security measurement and fuel prices

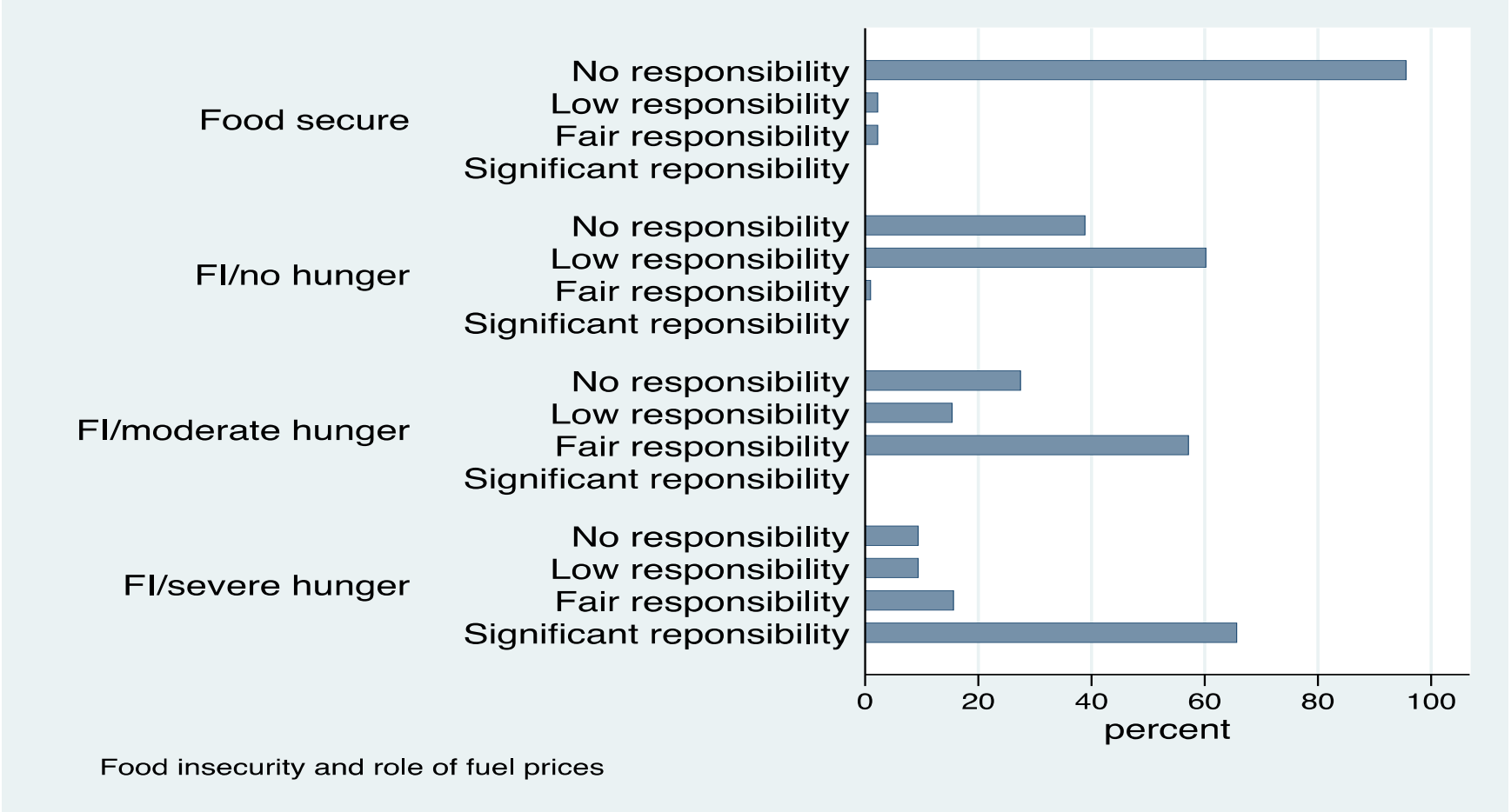
Questions	Happened	Scale of responsibility of fuel prices				
		No responsibility	Low responsibility	Fair responsibility	High reponsibility	Do not know
1) In the last 12 months, did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?	49.9%	3.2%	16.4%	40.7%	14.8%	24.9%
2) In the last 12 months, did you or other adults in your household ever not eat for a whole day because there wasn't enough money for food?	17.9%	2.9%	17.1%	38.6%	15.7%	25.7%
3) In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money to buy food?	50.1%	4.2%	14.7%	37.7%	18.9%	24.6%
4) In the last 12 months, were you ever hungry but didn't eat because you couldn't afford enough food?	31.8%	4.9%	11.4%	41.5%	17.1%	25.2%
5) Sometimes people lose weight because they don't have enough to eat. In the last 12 months, did you lose weight because there wasn't enough food?	22.8%	2.3%	17.4%	30.2%	24.4%	25.6%
6) In the last 12 months, did you ever cut the size of any of the children's meals because there wasn't enough money for food?	24.4%	4.5%	20.2%	38.2%	18.0%	19.1%
7) In the last 12 months, did any of the children ever skip a meal because there wasn't enough money for food?	18.4%	3.1%	13.9%	38.5%	18.5%	26.2%
8) In the last 12 months, were the children ever hungry but you just couldn't afford more food?	8.1%	3.3%	20.0%	50.0%	16.7%	10.0%
9) In the last 12 months, did any of the children ever not eat for a whole day because there wasn't enough money for food?	3.7%	7.1%	21.4%	35.7%	28.6%	7.1%
10) "I worried whether our food would run out before we got money to buy more." Was that often, sometimes, or never true for you in the last 12 months?	57.6%	5.1%	11.5%	33.0%	18.4%	32.1%
11) "The food that we bought just didn't last, and we didn't have money to get more." Was that often, sometimes, or never true for you in the last 12 months?	47.9%	3.9%	13.3%	30.4%	19.9%	32.6%
12) "We couldn't afford to eat balanced meals." Was that often, sometimes, or never true for you in the last 12 months?	61.3%	35.2%	13.7%	34.8%	16.3%	0.0%
13) "We couldn't feed the children a balanced meal because we couldn't afford that." Was that often, sometimes, or never true for you in the last 12 months?	46.9%	34.1%	14.0%	34.6%	16.8%	0.6%
14) "The children were not eating enough because we just couldn't afford enough food." Was that often, sometimes, or never true for you in the last 12 months?	31.0%	34.8%	16.1%	34.8%	13.6%	0.9%
15) "We relied on only a few kinds of low-cost food to feed the children because we were running out of money to buy food." Was that often, sometimes, or never true for you in the last 12 months?	43.9%	32.3%	13.8%	37.1%	16.2%	0.6%
Average	34.4%	12.1%	15.7%	37.1%	18.2%	18.2%

4.5.2. How do fuel prices responsibility scales relate to food insecurity across households' characteristics?

The next figures analyze the relation between each indicator of food security and the scale of responsibility attributed to fuel prices in different patterns of the sample. There are three features in the figures. The first figure (4.7) presents a general overview of the two indicators. Figures 4. 8 to 4.12 select the five categories of the sample identified as containing the most prone to food insecurity and low dietary diversity. These categories are gender, marital status, household size, education, economic activity. Finally, the third group of pictures is added to analyze two other categories of the sample. These are income and expenses.

The overview of the two indicators shows that more than 60% of respondents experiencing severe food insecurity find that fuel prices have a significant contribution to their food insecurity. Less than 20% give either no responsibility, low or fair responsibility to fuel prices. For respondents experiencing moderate food insecurity and food insecurity with no hunger, no significant responsibility of fuel prices is attributed. Fuel prices have either no, low, or fair responsibility on their situation. For food-secure respondents, the small percentage distributed between low and fair responsibility of fuel prices is derived from the fact that for a very few questions on food security measurement, they provided a yes answer. For these answers, no major responsibility is given to fuel prices.

Figure 4.7. Food security and the role of fuel prices: an overview



The next tables identify the characteristics of households identified as being highly prone to severe food insecurity. In terms of gender, section 4 revealed that females head are more exposed to higher food insecurity than men. As for the contribution of fuel prices, men outpace women in all scales of food insecurity. While around 50% of men point out fuel prices as having a significant role in their conditions, 21% of women reveal the same. For females who experience moderate food insecurity or food insecurity with no hunger, less than 10% significantly blame fuel prices.

From the education level perspective, section 4 suggests that lower education level is associated with lower dietary diversity and high food insecurity. In this part, results do not deviate a lot. Among food-secure respondents who provided a positive answer to a maximum of 2 questions related to their experience of food insecurity (see table. 4.7 on food security measurement), the majority of those who find that fuel price is not the reason have a university level. They are followed by household heads with secondary and primary education. Among households experiencing moderate food insecurity, 25% of those who attribute responsibility to fuel price have a university level, and 50% a secondary education. On the other hand, less than 5% think that fuel prices have no responsibility. Although, around 5% of respondents experiencing severe food insecurity think fuel prices are not the reason, when comparing all three levels of education across the figure, the ones with higher education level put lesser responsibility on fuel prices than those with lower education.

Regarding marital status, a high percentage of monogamous couples (more than 70%) experiencing severe food insecurity give a significant contribution to fuel prices. Also, in each level of food insecurity, a significant share of monogamous couples give some responsibilities to fuel prices. Section 4 revealed that polygamous couples, widowed and divorcees are the most exposed to low food diversity and high food insecurity. Figure 4.10 shows that they have the least share among those who think fuel price has some responsibilities on their food security status. This can be explained that the fact that polygamic couples are more worried about other expenses such as food and utilities than fuels, although fuel can play some role.

The finding that the ideal family size of 2 to 5 members is optimal in the sense that they are the least exposed to severe food insecurity and low dietary diversity remains in this section. In each category of food insecurity, none of the households with 2-5 members gives a significant contribution to fuel prices. The only exception is for severely food-insecure households, where

their rate is about 15%. Single households appear to have similar patterns as 2 to 5-member households. Beyond this range, most fuel prices have a non-neglectable contribution to food insecurity level, at least for a reasonable share of households.

Across economic activities, employed from the trade and transport sector are the ones who give the greatest responsibility to fuel prices among severely food-insecure households (which is plausible given their high reliance on fuels). They are followed by small craft, private, public employed, and students. Among severely food-insecure and moderately food-insecure households, employed from trade and transport sectors and small craft are on the top of complaints. As in 4.4.2, salaried from public sectors appear to be better off, and blame less fuel prices. The existence of fuel consumption advantages for public sector salaried such as subsidies, or coupon can be the explanation.

After analyzing the characteristics of households that are more prone to high food insecurity and low food diversity, as detected in section 4, figures 13 and 14 look at income and expenses of the head, respectively. Incorporating the two variables can help to measure the applicability of the interpretations on income to that of expenses, given that the two variables can have different implications in terms of saving capacity. As can be thought, respondents with income below the average range of [200,005-250,000] are the ones who usually give a high responsibility to fuel prices regarding the deterioration of their food conditions. Around 45% and 25% of severely food-insecure respondents whose income are between [100,005-150,000] and lower than 50,000 Cfa give a high responsibility to fuel prices. In terms of expenses, the interpretation remains the same, plus, all severely food-insecure respondents whose income is below the medium income give a significant role to fuel prices. Respondents with high expenses or income complain less about fuel prices and their conditions appear to be better off. An important aspect of the analysis is that although the scale of responsibility attributed to fuel prices seems to be negatively correlated with income and expenses, the percentage of responses in a particular scale is not necessarily negatively correlated with expenses or income. This means that respondents with the lowest income or expenses appear to be the ones who put the most responsibility on fuel prices. However, considering the scale *significant responsibility* among severely food-insecure households, the most impoverished household heads are not necessarily the ones who have the highest share within this scale. To be more precise, for example, in figure 13 among severely food-insecure households, those whose income is below

the average give a significant responsibility to fuel prices. However, inside that scale, 45% have an income between [100,005-150,000] while 25% have less than 50,000 Cfa.

Figure. 4.8. Food in security, fuel prices and gender

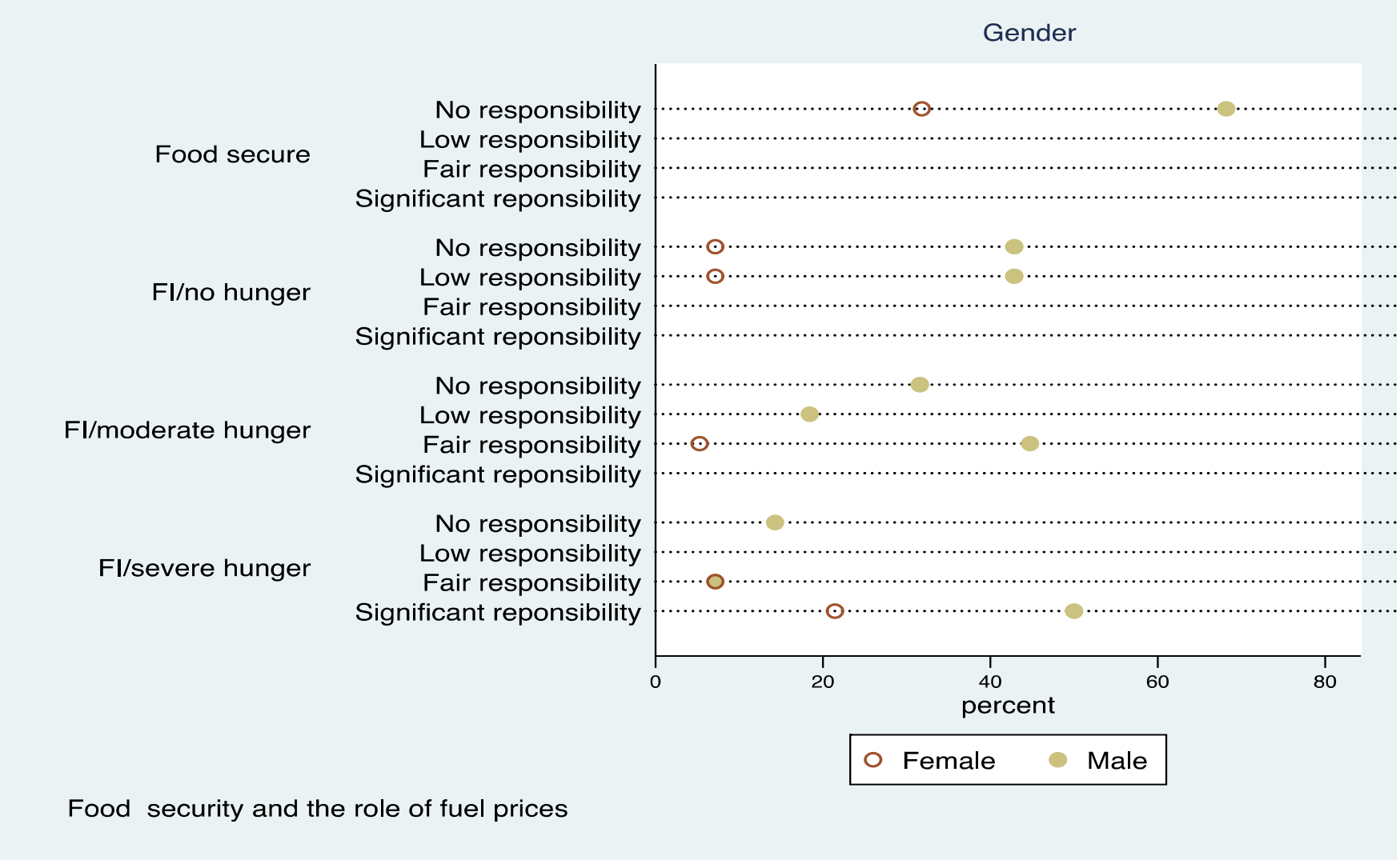


Figure 4.9. Food security, fuel prices and education

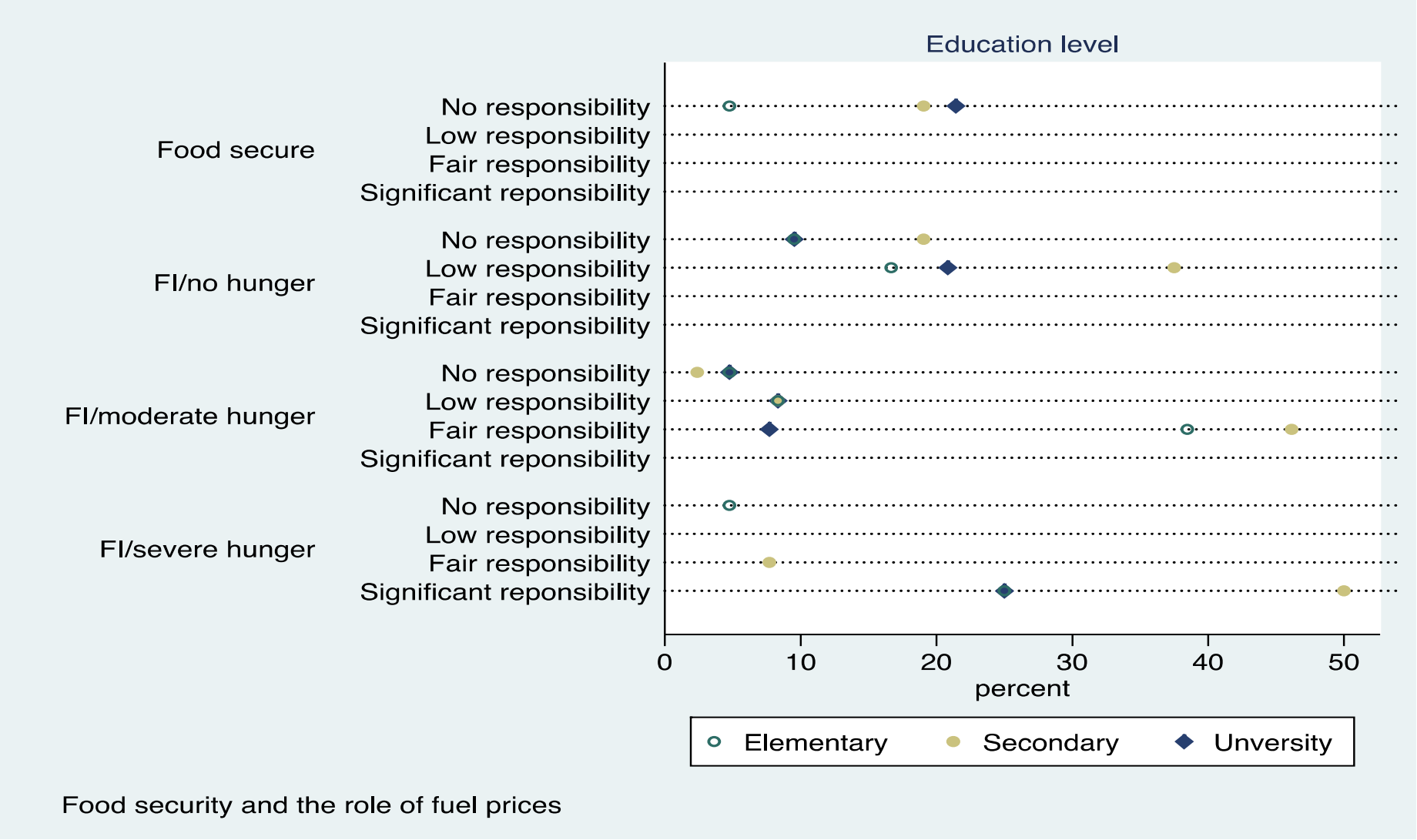


Table. 4.10. Food security, fuel prices and marital status

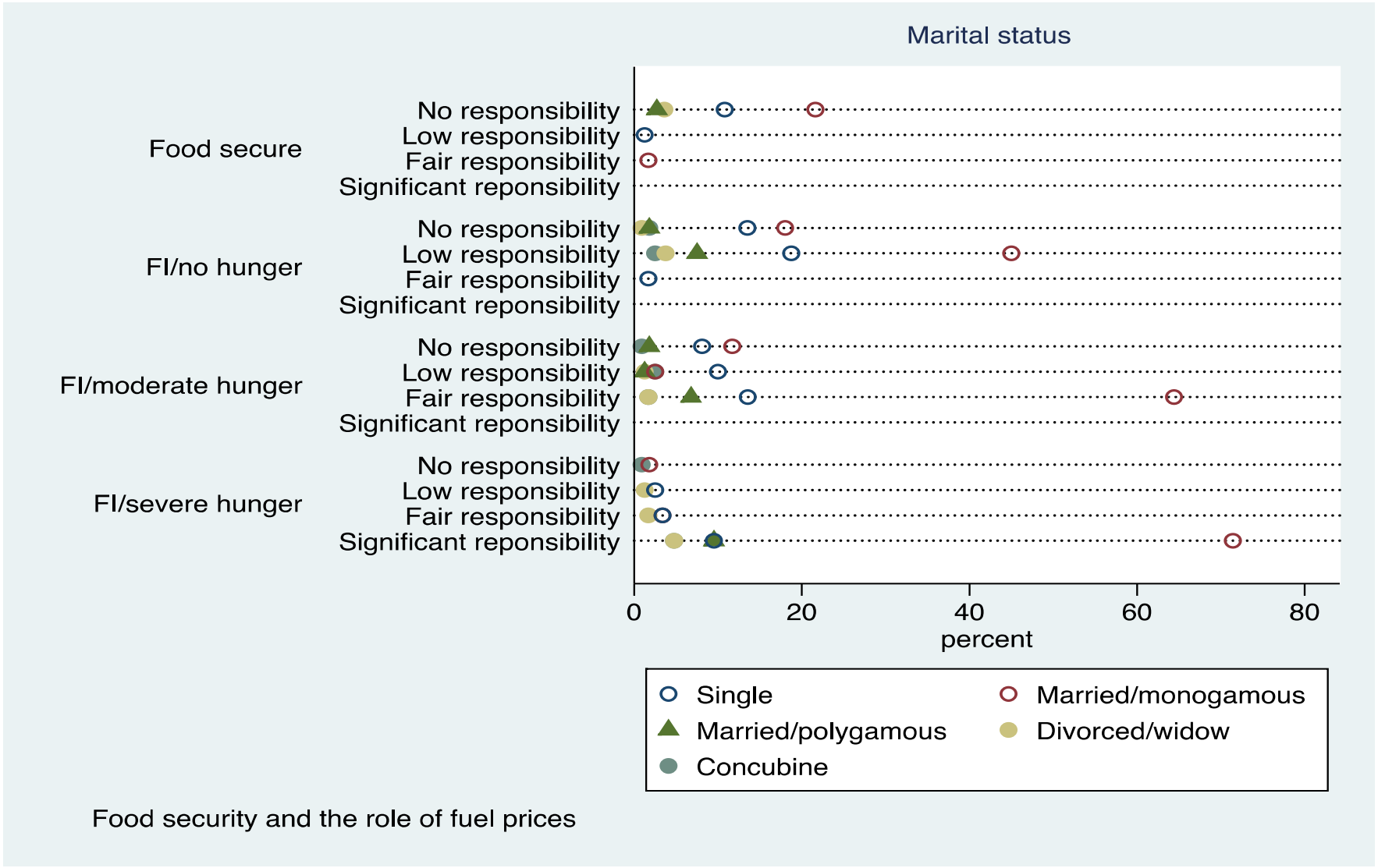


Figure 4.11. Food security, fuel prices and household size

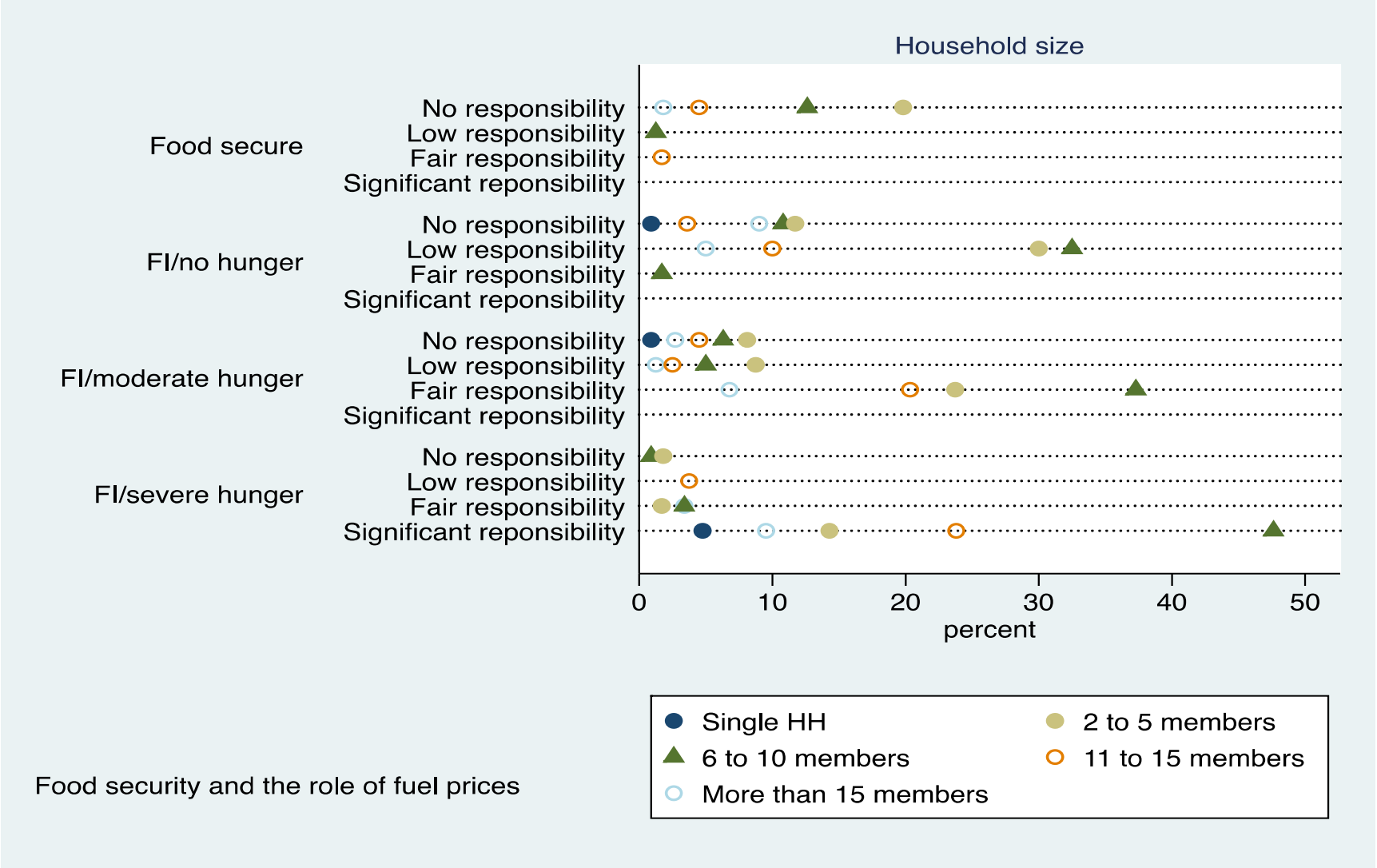


Figure 4.12. Food security, fuel prices an economic activity

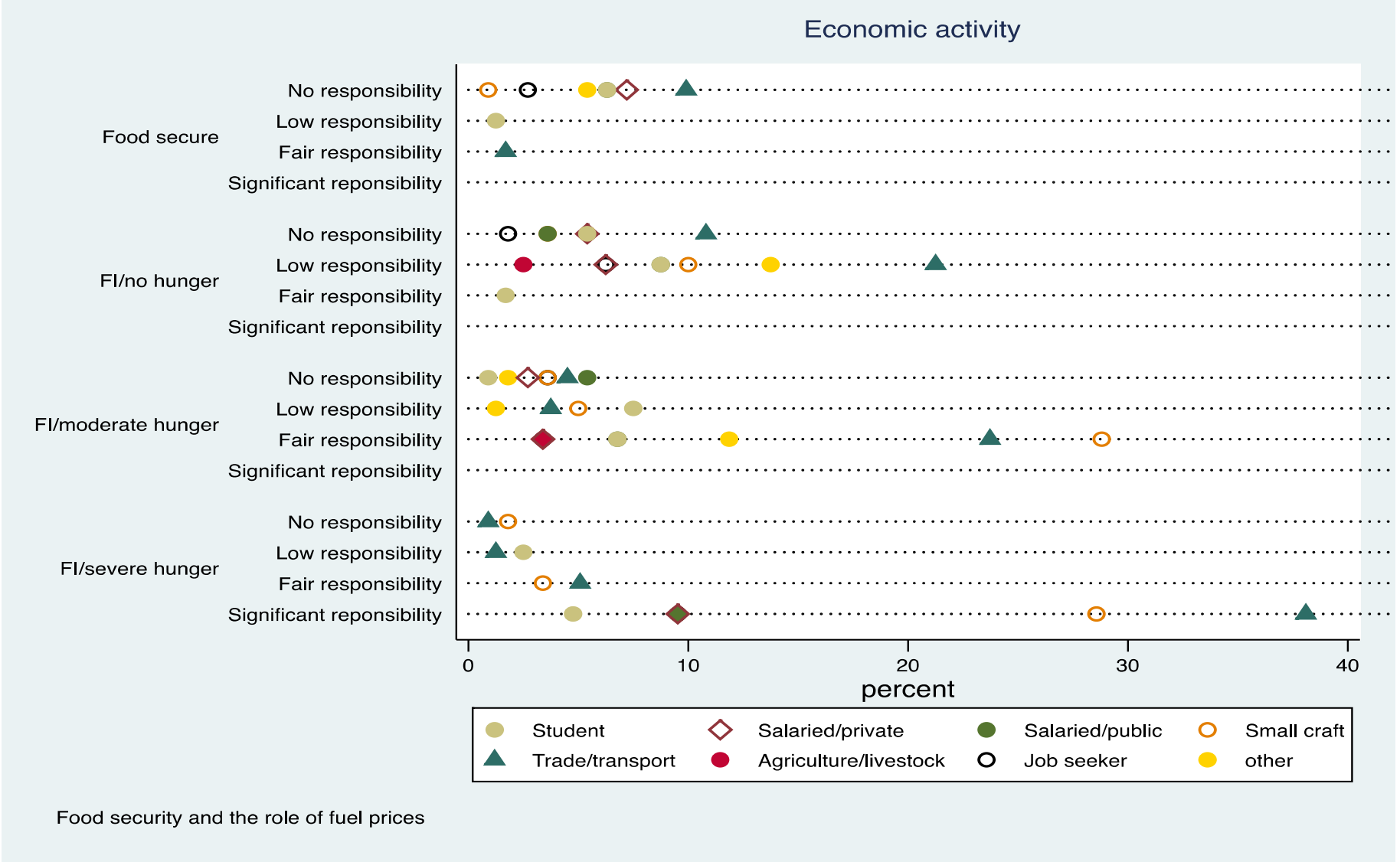


Figure 4.13. Food security, fuel prices and income level

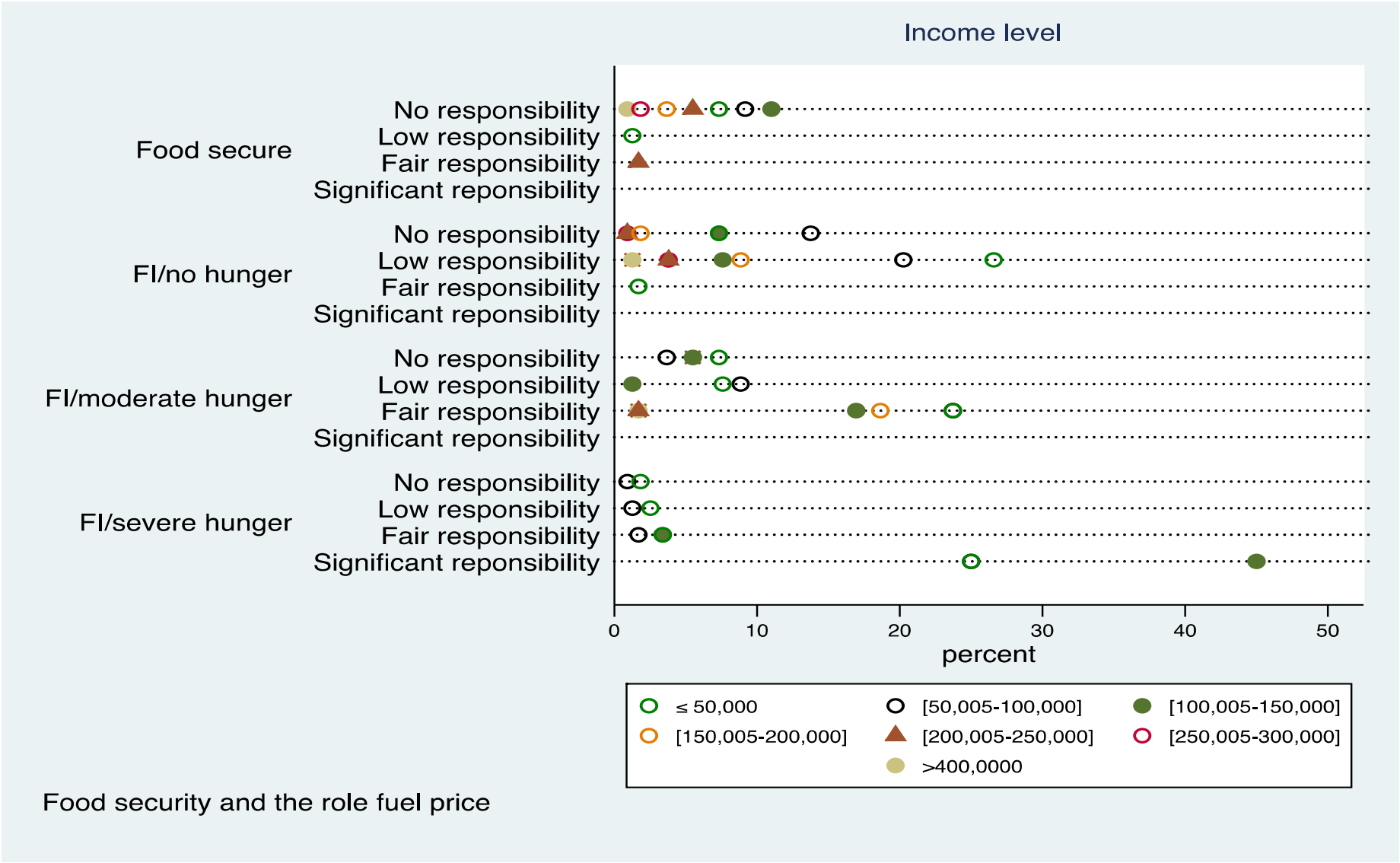
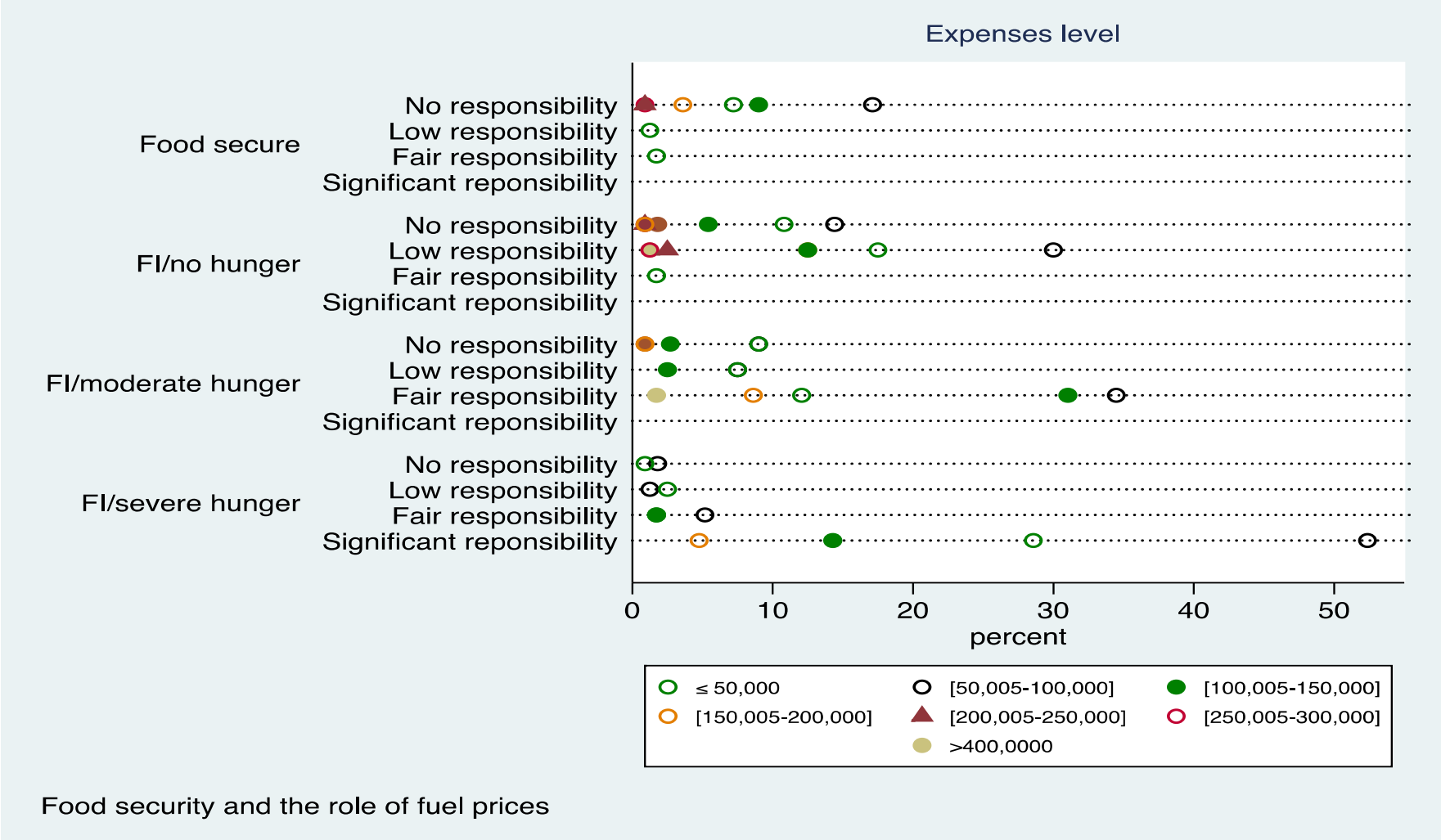


Figure 4.14. Food security, fuel prices and expenses level



To sum up this section, most respondents (71%) find that fuel prices contribute to some extent to the deterioration of their food condition. Respondents who experience severe food insecurity tend to put high responsibility on fuel prices. The vast majority of them use public transportation less often and possess personal locomotion (essentially motorbikes). Men are less exposed to severe food insecurity as opposed to women, but they are the ones who put the highest responsibility on fuel prices regarding their food insecurity level. Low educated are not only the most exposed to severe food insecurity and low dietary diversity, but also they are the ones who give more responsibility to fuel prices regarding their condition. Polygamic couples, widowed and divorces, although they are the most prone to severe food insecurity as opposed to other marital categories, they are likely to put less responsibility on fuel prices. Singles, on the contrary, give the highest share of responsibility to fuel prices. A family size of 2-5 members appears to be optimal. Above this range, high exposure to severe food insecurity, partially amplified by the significant contribution of fuel prices to total monthly expenses is predominant. Finally, having an income below the average range increases the vulnerability to food insecurity and triggers a high contribution of fuel prices to total expenses.

Given that fuel prices affect most households' food security level, and a large share of them tend to blame fuel prices, this brings others concerns: how do/would households react in different scenarios of fuel prices changes? Is their reaction the same when fuel prices fluctuate smoothly or considerably? Is that reaction symmetric whether it is an increase or a decrease in fuel prices? What type of expenses they change or what actions they take/would take in responses to fuel price changes? Exploring these concerns is essential to capture not only behavioral responses but also the type of policy responses that can be appropriate.

4.6. Behavioral responses to different scenarios of fuel prices changes

This part is a complementary section to the previous ones. Households are found to experience different levels of food insecurity. For some of them, fuel prices significantly contribute to their food conditions. For others, the contribution of fuel prices is medium or low. And for a last group, fuel prices do not determine their food conditions. To have a better understanding of the way fuel prices contributes to improving or deteriorating households' conditions, a behavioral assessment is added to the last section of the questionnaire. Each question is open, and all answers provided transcribed. During the survey, questions were explained in detail and often repeated, to ensure the clarity and consistency of answers. Each respondent was asked the way she/he would behave in response to four scenarios of fuel price changes.

- The first scenario assumes a smooth and positive change in fuel prices: *What would you or do you do if fuel prices go smoothly up by 50 or 100 Cfa (about 10% to 20%)?*
- The second scenario is similar to the first, but this time is related to a decrease: *What would you or do you do if this time the prices go smoothly down by 50 or 100 Cfa (about 10% to 20%)?*
- The third scenario assumes a sudden and sharp increase in fuel prices, similar to some of the shocks the country experienced: *What would you do if fuel prices suddenly go up by 1000 or 2000 Cfa (about 70 % to 300%)*
- Finally, the last scenario assumes (although it rarely happens) a negative shock. *What if this time fuel prices go down by 300 or 400 Cfa (about 50% to 70%)?* Similar large amount as the previous scenario cannot be applied given the minimum price of 550 Cfa (most of the time)

Responses to questions in scenarios 2 and 4 could appear straightforward or meaningless in the first place (as they come right after 1 and 3, respectively), but they were included in the conversation in such a way that respondents do not necessarily see any straight response, and freely express what goes through their mind, and more importantly what they usually do. The analyses of their responses provided strong indications on the relevance of the questions. Besides, including scenarios 2 and 4 offers the advantage of exploring possible symmetry/asymmetry of responses.

Each transcript was carefully analyzed, and common responses were coded and classified into themes. The following themes were derived:

- In the event of rise in fuel prices, whether smoothly or sharply, respondents take either of the following actions: cut meals, cut other consumption (unnecessary calls, snacks, lottery etc.),

cut rides (use motorbikes only when urgently needed), change their locomotion (walk, use either bus or bicycle), no action at all or do something else (such as ask help from others, purchase cheap fuels in the black market etc.).

- If prices drop, the list of responses includes increase food consumption, increase rides, increase other consumptions, save, no action, or do something else (such as helping others with the surplus).

The questions ask the first action to take following the aforementioned scenarios. When a respondent mentions more than one response, the question asks on the action that she/he would prioritize.

The next lines explore the responses in the full sample, and across two main categories: the level of food security and the scale of responsibility attributed to fuel prices. In the last section, the scenarios are tabulated across each component of the social and economic characteristics of households to evaluate the responses from different angles.

4.6.1. Food security, the role of fuel prices and responses to different scenarios of fuel prices changes

Figure 4.15 provides an overview of responses to each of the four scenarios detailed above. Smooth changes in fuel prices would leave around 30% to 34% of respondents unaffected. There is an asymmetry in responses to changes in fuel prices. Respondents' response to a decrease in fuel prices (whether smooth or sharp) is not of the same magnitude when prices go down. For 17.9% of respondents, the household's meal will be reduced to afford to locomote, if fuel prices to go up smoothly. If prices go smoothly down, an additional 10% will increase their food consumption. A smooth increase in fuel prices would push 26.9% of them to cut their rides. A similar reduction would induce a 12.8% increase in rides (the 14.1% difference would choose to either save or increase their food consumption). Fuel prices shocks have a more pronounced impact. Half of the respondents choose to change their locomotion and go for either walks, bicycles, shared rides, or buses if fuel prices go up significantly. 20.3% would cut their rides, and very few (5.5%) would jeopardize their meals. On the contrary, if prices go sharply down, similar opposite effects are not necessarily induced. Respondents would keep their locomotion unchanged, but 43.3% will instead prioritize saving. An increased number would ameliorate their diet (25.6%) while 17.7% would increase their rides.

From this preliminary analysis, it can be noted that many households have precautionary behaviors and place an important role in savings to circumvents future adverse events. A smooth increase in fuel prices leads to a cut in meals and rides for about a quarter of them. If the rise is sharp enough, nearly half will change their locomotion, and around 20% would cut their rides. In the event of price shortfall, smooth drops would induce, in order of importance, an increase in food consumption, saving, and rides. Negative shocks would instigate higher saving, followed a by a rise in food consumption and increase in rides.

Now turn to the distribution across food security status and the responsibility scales attributed to fuel prices regarding their food conditions (figure 4.16). The 30% to 34% respondents that are not affected by smooth changes in fuel prices (found in the full sample above) is mostly dominated by food-secure respondents and those experiencing food insecurity with no hunger. The percentage of food secure and food insecure with no hunger respondents who are not affected by smooth changes in fuel prices is higher than that of moderate and severely food-insecure households by about 10 points. 28% of severely food insecure would cut the household meals if fuel prices smoothly go up. 24% would cut their ride. If the rise is sharp enough, 61.3% would give up on a motorbike and go for alternatives. In the worst case, 9.7% would cut their food consumption. In the opposite case (decrease in prices), more respondents among severely food-insecure households (34.5%) would improve their meals if prices go down by up to 20%. In the event of sharp shortfalls, an increase in other consumptions is more predominant. Across all food security scales, severely food-insecure respondents have the lowest share of saving, in response to sharp shortfalls in fuel prices. Food secure and food insecure with no hunger respondents, however, have the highest share of saving. The features of moderately food-insecure households do not deviate a lot from those of severely food-insecure except that they appear to in a better position in terms of precautionary saving when prices go down.

Regarding the scale of responsibility attributed to fuel prices (figure 4.17), 42.1% of respondents who put significant responsibility on fuel prices on their food conditions would increase their food consumption if fuel prices go down. If the decrease is sharp enough, about 30% (instead of 42.1%) will improve their food consumption. The difference would be allocated to rides and other consumptions. Like as in food security analysis, about 1/3 of respondents who give low or no responsibility to fuel prices do not find any significant effect of smooth changes in fuel prices. It can also be noted that the behavior of respondents who give

no (or low) responsibility to fuel prices regarding their conditions do not deviates much from those who are food secure. Also, the same pattern can be established between respondents who give a fair responsibility to fuel prices and moderately food-insecure households on the one hand, and between respondents who put high responsibility on fuel prices and severely food-insecure households on the other hand.

Figure 4. 15. Responses to changes in fuel prices

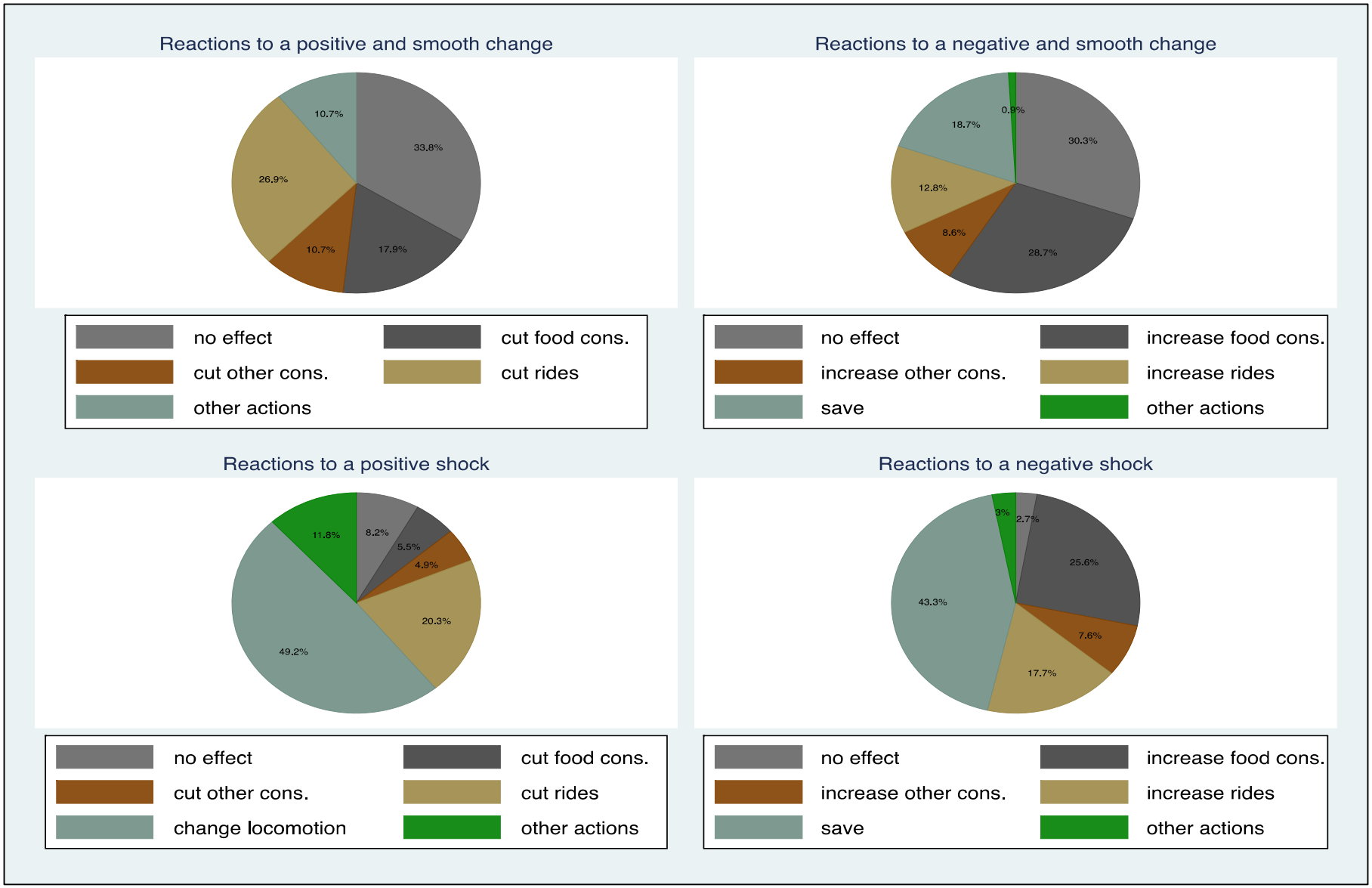


Figure 4.16. Food security and responses to changes in fuel prices

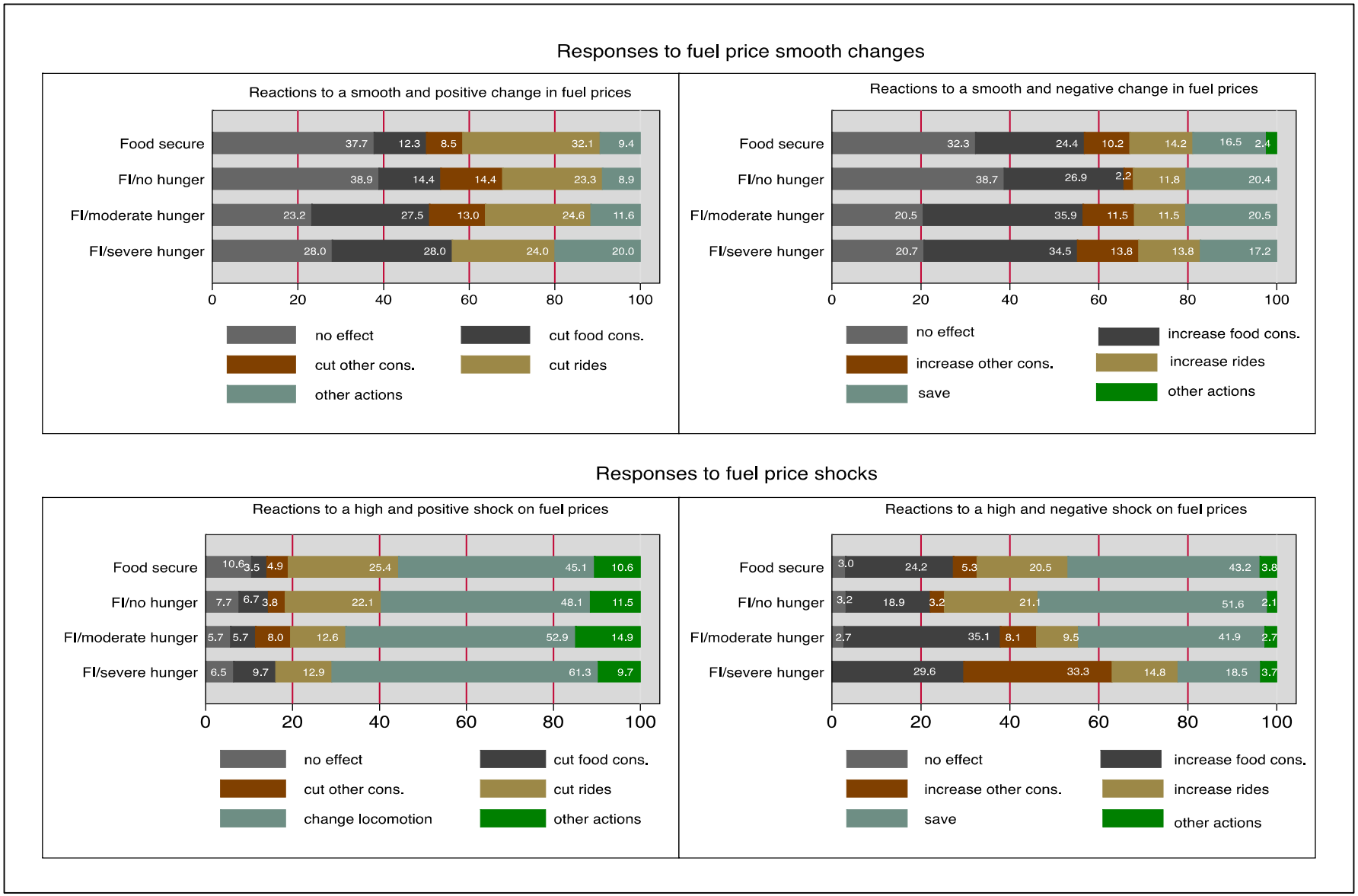
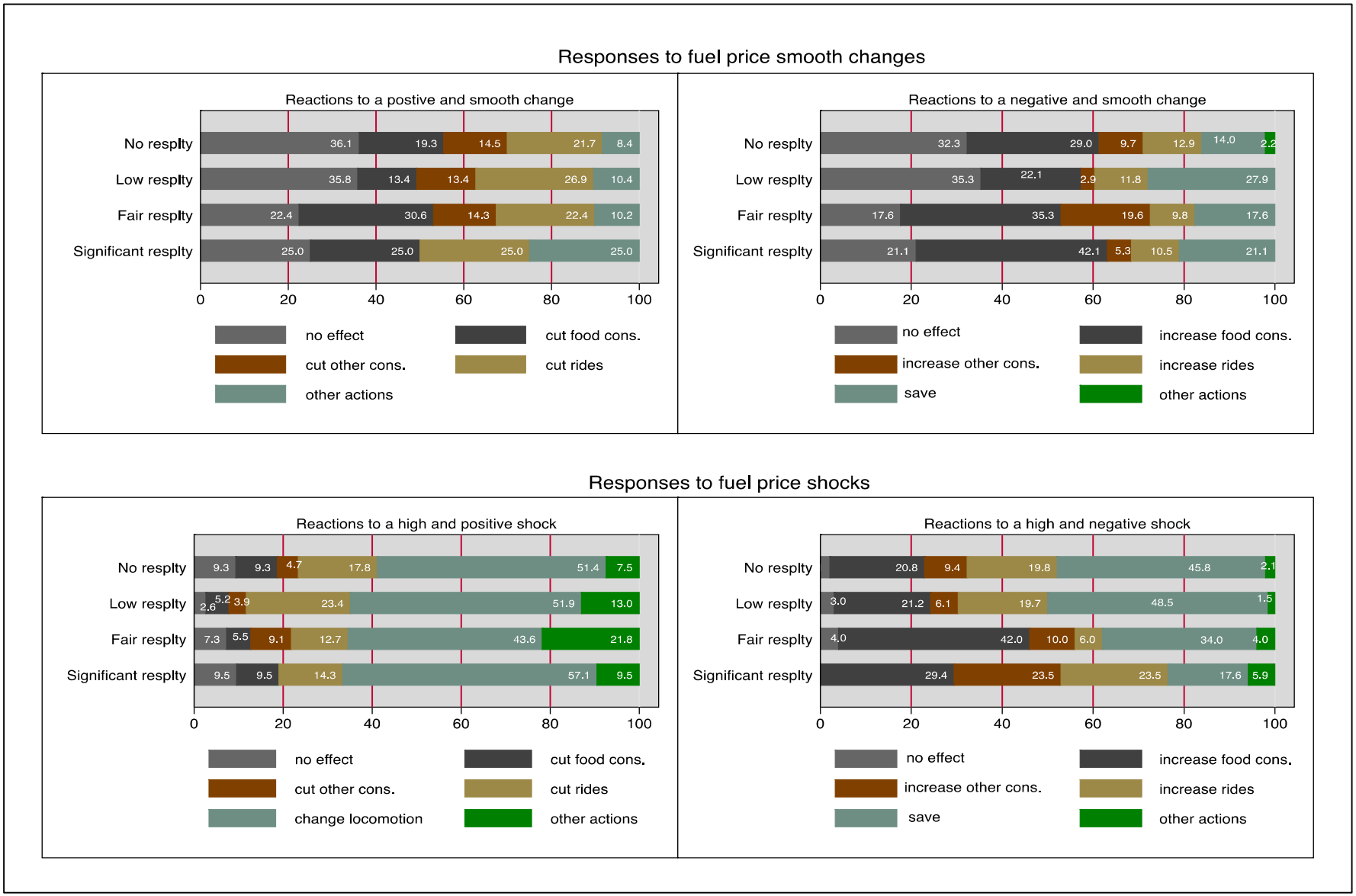


Figure 4.17. Role of fuel prices and responses to fuel price changes



4.6.2. Responses to different scenarios of fuel prices changes across social and economic characteristics

This section looks at respondents social and economic characteristics and their responses to each of the scenarios of fuel price changes. Results are reported in tables 4.16 to 4.19. The analysis does not go through to each of the components of social and economic characteristics as depicted in the tables, but mostly focuses on the ones identified in previous sections as containing the most exposed to severe food security and low dietary diversity: gender, marital status, households' size, education, and economic activity.

The tables reveal that both males and female give more importance to saving and food consumption when fuel prices shrink sharply. However, males tend to save more than females, and females tend to spend more on household meals than males. Similar interpretations apply for fuel price shocks except that in the event of high and positive shock more females (52.1%) would give up their locomotion. Across marital status, polygamous couples, widowed, and divorcees are the most sensitive to fuel prices changes. On average, 33% of them cut their food, and 19% reduce their rides following a smooth increase in fuel prices. 61% would abandon motorbikes and use different locomotion if the rise is quite sharp (15% of them would, however, cut their ride). If prices go smoothly down, 27.5% improve their meals, and 18.5% would save. These two rates will improve to an average of 46% and 34% respectively in the event of a sharp decrease in fuel prices. None of the divorcees reported increasing their rides if prices go down shapely while 17.1% of polygamous couples would do.

In general, respondents from a household size of 2 to 5 appear to be comparatively less vulnerable and less sensitive to fuel price changes as opposed to a larger size. A smooth increase if fuel prices push 17.6% of them to cut their meals. These cuts in meals occur, however, in an average of 19.5% higher size household. If the rise is sharp, nearly 22% of respondents from higher size households are likely to cut more rides to maintain the household meals, against 12.5% of 2-5 size respondents (more respondents would instead change their locomotion). Besides, if fuel prices decrease significantly, most households who chose to prioritize saving have 2 to 5 members. When fuel prices go up, unlike less educated respondents, those with higher education tend to cut other spending and rides to maintain their food consumption. Relatively fewer share of them (35.2%, against 53% for low educated respondents) will change their locomotion if prices rise significantly.

In terms of economic activities, two categories are significantly impacted by a smooth rise in fuel prices: trade/transport and agriculture/livestock, with the highest impact found on the latter. A smooth change in fuel prices would induce cut in meals for 27.8% and 50.5% of these households, respectively. If the rise in fuel prices is significantly high, for 61.6% of respondents in the agricultural/livestock sector, cutting ride to keep meals would be prioritized while 51.3% of respondents in trade/transport would change their locomotion.

In the opposite scenario, a smooth change would induce 34.6% increase in food consumption for traders/transporters while for those in the agriculture and livestock sector, the reaction is shared between other consumptions and rides. When the decrease is significant enough, most respondents in trade and transport will prioritize saving (47.3%) over meals improvement (22.7%). Those in agriculture and livestock would favor rides (42.3%) over the improvement of food consumption (16.2%). The behavior of respondents from the private sector portrays their comparatively less favorable condition as opposed to those in the public sector. A rise in fuel price induces a cut in rides for 25.9% of them (for public sector heads the cut occurs for 21% of them). If the rise is significant, more than half will change their locomotion, while a quarter of salaried from the public sector will have a similar reaction. In a period of decrease in fuel prices, a higher proportion of salaried from the private sector would choose to save for precaution. Their proportion is higher than that of salaried workers in the public sector and increases with the magnitude of fuel prices shrinks. Public sector salaried would rather tend to ameliorate their household meals.

Besides, job seekers are highly sensitive to fuel prices changes and have more or less the same behavior. More than 50% will cut their ride if fuel prices go up. If the rise if strong enough, a similar 50% would change their locomotion. If prices decrease, 17.4% will increase their food consumption. In the event of negative shocks, the rate goes up to 37%. Another 28.7% would favor saving.

During the survey, most households expressed their disappointment regarding fuel prices constant rises. Beyond the categorized responses above, many respondents expressed different ways to respond to fuel prices rises. Some of the responses are related to resources management. For example, one respondent stated: "*if fuel prices rise that high, I have no option, I need to keep riding my motorbike to bring something to my family. What I could do in this situation is to reduce my consumption of electricity and avoid wasting water".* This show that some

respondents are highly relying on fuels, mostly due to the type of economic activity they are involved in, the distance to their workplace and their motorbike usage habits. Most respondents in the trade sector or who are business owners prefer replicating the rise in fuel prices to their customers. One respondent stated: "*I will simply have to replicate this rise to my products."* Another one said: "*my employees would be the losers because I am going to cut their pay a little bit."* From the reactions of business owners and traders/sellers, it is clear that the poorest could be profoundly and severely affected in two ways. As the poor are also motorbikes users, a rise in fuel prices can harm their purchasing power and cause a contraction of their household food consumption, as explained above. Furthermore, food prices can be negatively impacted due to business owners, and traders/sellers' replication of their costs on their customers. As noted in chapter 1 of the thesis, these replications of costs on consumers can be higher than the percentage increase in fuel prices, due to size-asymmetries. Thus, the combination of both fuel prices rises, and food prices increases represent a high jeopardizer of food security to the poor.

What is the take from this analysis? Smooth increases in fuel prices have more impact on food security than sharp increases. When prices smoothly go up, a high proportion of households chose to cut their food consumption to maintain their rides. Those who chose to maintain their food consumption prefer to reduce their rides. When prices go down, symmetric behavior does not occur. Although a high promotion would increase their food consumption, their responses are also distributed across other actions such as an more rides and more importantly saving. The share of respondents who favor saving goes significantly high if fuel price reduces considerably. Respondents that favor high saving are usually better advantaged. Those that are highly vulnerable would also improve their meals. A high proportion of food cut consumption is prevalent among Married/polygamous and Divorced/widow, trade/transport, agriculture/livestock. These categories represent some of the most exposed to food insecurity. This finding implies that they are highly exposed to food insecurity due to fuel prices. Furthermore, households with a size ranging from 2 to 5 members appear to be relatively good in terms of coping capacity of fuel prices changes. Besides, special attention and polices should take into consideration the most vulnerable groups identified in the study, such as unplanned family size, widowed/divorces. Actions are also needed in the agricultural, livestock, trade, and transport sector to ensure their better condition. Finally, improving education an ensuring better job for graduate should remain some of the priorities of the government.

Table 4.16. Responses to fuel prices smooth changes across social characteristics

	Reactions to a **positive and smooth** change						Reactions to a **negative and smooth** change						
Characteristics	*no effect*	*cut food cons.*	*cut other cons.*	*cut rides*	*other actions*	*Total*	*no effect*	*increase food cons.*	*increase other cons.*	*increase rides*	*save*	*other actions*	*Total*
Gender													
Female	33.2%	22.0%	11.6%	27.3%	5.9%	100%	30.7%	30.1%	8.7%	13.1%	15.4%	2.0%	100%
Male	33.9%	13.9%	10.7%	27.4%	14.1%	100%	30.1%	26.2%	9.0%	12.7%	22.0%	0.0%	100%
	Pearson chi2(4) = 8.0382 Pr = 0.090								Pearson chi2(5) = 5.8547 Pr = 0.321				
Age													
<20	22.4%	0.0%	18.1%	59.4%	0.0%	100%	55.5%	28.4%	16.1%	0.0%	0.0%	0.0%	100%
[20-30[	37.6%	13.7%	15.7%	22.3%	10.7%	100%	30.4%	19.7%	12.5%	17.5%	18.9%	1.0%	100%
[30-40[	34.5%	19.8%	7.0%	27.3%	11.4%	100%	26.5%	32.3%	4.5%	11.0%	25.6%	0.0%	100%
[40-50[	32.9%	26.5%	4.7%	21.1%	14.8%	100%	28.3%	33.9%	10.6%	8.6%	16.4%	2.2%	100%
[50-60[	19.8%	17.8%	19.7%	40.9%	1.8%	100%	26.4%	38.6%	10.2%	10.5%	11.8%	2.6%	100%
60+	43.0%	13.2%	5.0%	30.2%	8.7%	100%	48.0%	15.7%	4.0%	18.4%	13.9%	0.0%	100%
	Pearson chi2(20) = 26.6606 Pr = 0.145								Pearson chi2(25) = 28.4061 Pr = 0.289				
Marital status													
Single	36.3%	13.2%	13.5%	24.8%	12.2%	100%	35.0%	17.2%	10.5%	16.9%	19.5%	1.1%	100%
Married/monogamous	31.7%	17.3%	12.3%	30.4%	8.4%	100%	29.2%	33.1%	7.5%	10.1%	18.9%	1.3%	100%
Married/polygamous	35.6%	27.4%	0.0%	18.7%	18.4%	100%	23.9%	22.5%	19.7%	17.4%	16.6%	0.0%	100%
Divorced/widow	36.0%	38.9%	0.0%	19.2%	5.9%	100%	34.5%	31.8%	0.0%	13.3%	20.4%	0.0%	100%
Concubine	31.8%	19.6%	9.4%	30.4%	8.8%	100%	20.2%	43.4%	8.7%	16.9%	10.8%	0.0%	100%
	Pearson chi2(16) = 15.2734 Pr = 0.505								Pearson chi2(20) = 17.5093 Pr = 0.620				
Household size													
Single (1 member)	48.9%	0.0%	22.8%	28.2%	0.0%	100%	33.2%	14.7%	0.0%	18.2%	33.9%	0.0%	100%
2-5 members	31.3%	17.6%	12.7%	29.3%	9.1%	100%	27.4%	29.3%	11.2%	12.3%	17.1%	2.8%	100%
6-10 members	38.5%	16.7%	11.2%	22.6%	11.0%	100%	29.0%	25.3%	5.6%	15.8%	24.4%	0.0%	100%
11-15 members	27.8%	22.8%	2.4%	36.8%	10.2%	100%	35.8%	30.7%	11.3%	11.4%	10.8%	0.0%	100%
> 15 members	30.9%	19.2%	16.8%	21.8%	11.2%	100%	39.3%	35.0%	12.2%	3.5%	10.0%	0.0%	100%
	Pearson chi2(16) = 10.9668 Pr = 0.812								Pearson chi2(20) = 19.9390 Pr = 0.462				
Literacy													
No	33.4%	17.3%	4.1%	30.7%	14.5%	100%	30.5%	35.3%	13.8%	10.1%	10.4%	0.0%	100%
Yes	33.6%	18.1%	12.7%	26.6%	9.0%	100%	30.4%	26.3%	7.6%	13.6%	20.9%	1.3%	100%
	Pearson chi2(4) = 4.4723 Pr = 0.346								Pearson chi2(5) = 7.9984 Pr = 0.156				

Education level													
Elementary	35.2%	19.9%	4.4%	25.8%	14.7%	100%	31.4%	26.8%	4.1%	10.5%	27.2%	0.0%	100%
Secondary	32.1%	23.7%	14.3%	23.9%	6.0%	100%	29.5%	30.1%	7.8%	13.7%	17.0%	1.9%	100%
University	34.7%	8.8%	15.9%	31.0%	9.6%	100%	30.9%	19.7%	9.9%	15.8%	22.4%	1.3%	100%
	Pearson chi2(8) = 13.1501 Pr = 0.107						Pearson chi2(10) = 8.0751 Pr = 0.622						

Table 4.17. Responses to fuel prices shocks across social characteristics

	Reactions to a **high and positive** shock							Reactions to a **high and negative** shock						
Characteristics	*no effect*	*cut food cons.*	*cut other cons.*	*cut rides*	*change locomotion*	*other actions*	*Total*	*no effect*	*increase food cons.*	*increase other cons.*	*increase rides*	*save*	*other actions*	*Total*
Gender														
Female	11.5%	4.4%	4.7%	17.9%	52.1%	9.4%	100%	3.6%	31.8%	7.3%	16.9%	36.7%	3.8%	100%
Male	5.3%	6.6%	5.8%	22.6%	46.6%	13.2%	100%	2.5%	19.9%	7.9%	18.8%	48.3%	2.6%	100%
	Pearson chi2(5) = 7.6706 Pr = 0.175							Pearson chi2(5) = 8.5398 Pr = 0.129						
Age														
<20	0.0%	0.0%	15.5%	32.8%	51.7%	0.0%	100%	0.0%	17.7%	33.4%	16.5%	13.9%	18.5%	100%
[20-30[	5.9%	6.5%	7.1%	25.5%	40.9%	14.2%	100%	4.1%	13.6%	8.5%	22.1%	50.6%	1.1%	100%
[30-40[	10.4%	5.6%	4.3%	17.2%	51.3%	11.2%	100%	2.3%	28.5%	6.3%	11.8%	47.7%	3.4%	100%
[40-50[	10.8%	5.4%	5.2%	15.2%	51.8%	11.7%	100%	4.1%	36.8%	7.0%	22.3%	28.0%	1.8%	100%
[50-60[	9.2%	4.8%	2.5%	17.0%	54.0%	12.4%	100%	0.0%	33.3%	5.2%	13.5%	40.5%	7.6%	100%
60+	6.2%	3.7%	3.8%	24.4%	62.0%	0.0%	100%	4.6%	35.8%	7.5%	18.9%	28.7%	4.5%	100%
	Pearson chi2(25) = 19.2800 Pr = 0.784							Pearson chi2(25) = 39.6280 Pr = 0.032						
Marital status														
Single	7.8%	6.0%	7.3%	26.8%	38.8%	13.4%	100%	3.1%	9.2%	11.5%	23.2%	50.8%	2.3%	100%
Married/monogamous	8.2%	5.8%	4.2%	19.0%	51.1%	11.7%	100%	3.3%	31.0%	6.9%	16.7%	39.3%	2.8%	100%
Married/polygamous	13.0%	0.0%	5.0%	11.4%	61.7%	9.0%	100%	4.9%	33.6%	5.4%	17.1%	34.6%	4.4%	100%
Divorced/widow	6.2%	6.3%	7.1%	19.7%	60.7%	0.0%	100%	0.0%	57.9%	0.0%	0.0%	35.0%	7.1%	100%
Concubine	9.4%	7.9%	0.0%	0.0%	74.7%	7.9%	100%	0.0%	28.8%	0.0%	15.0%	47.0%	9.1%	100%

	Pearson chi2(20) = 17.5698 Pr = 0.616							Pearson chi2(20) = 32.7411 Pr = 0.036					
Household size													
Single (1 member)	0.0%	15.7%	14.7%	35.6%	18.2%	15.7%	100%	0.0%	15.7%	14.7%	33.9%	18.2%	17.5%	100%
2-5 members	10.1%	5.4%	5.3%	12.5%	54.9%	11.9%	100%	3.8%	24.5%	4.7%	19.8%	44.5%	2.6%	100%
6-10 members	6.4%	6.0%	4.0%	29.7%	43.0%	11.0%	100%	1.9%	26.1%	8.2%	18.2%	42.9%	2.6%	100%
11-15 members	7.0%	6.8%	6.2%	14.2%	55.6%	10.3%	100%	4.3%	29.0%	11.3%	13.4%	39.6%	2.4%	100%
> 15 members	13.4%	0.0%	6.6%	20.8%	47.3%	11.9%	100%	3.2%	27.3%	8.9%	12.3%	41.9%	6.5%	100%
	Pearson chi2(20) = 23.7416 Pr = 0.254							Pearson chi2(20) = 12.7214 Pr = 0.889					
Literacy													
No	13.7%	1.2%	3.3%	19.3%	54.2%	8.3%	100%	3.6%	28.1%	6.1%	18.4%	35.6%	8.3%	100%
Yes	7.0%	6.6%	5.7%	20.6%	48.0%	12.1%	100%	2.9%	25.3%	7.9%	17.7%	44.1%	2.0%	100%
	Pearson chi2(5) = 8.6687 Pr = 0.123							Pearson chi2(5) = 7.3983 Pr = 0.193					
Education level													
Elementary	5.7%	7.8%	3.7%	10.3%	53.3%	19.2%	100%	0.0%	26.8%	15.8%	7.5%	49.9%	0.0%	100%
Secondary	10.1%	6.6%	4.5%	16.7%	53.9%	8.1%	100%	4.4%	29.8%	6.0%	18.2%	39.2%	2.4%	100%
University	3.2%	5.8%	8.9%	33.9%	35.2%	12.9%	100%	2.7%	16.5%	5.2%	24.5%	48.2%	2.9%	100%
	Pearson chi2(10) = 25.7166 Pr = 0.004							Pearson chi2(10) = 20.3653 Pr = 0.026					

Table 4.18. Responses to fuel prices smooth changes across economic characteristics

	Reactions to a **positive and smooth** change						Reactions to a **negative and smooth** change						
Characteristics	*no effect*	*cut food cons.*	*cut other cons.*	*cut rides*	*other actions*	*Total*	*no effect*	*increase food cons.*	*increase other cons.*	*increase rides*	*save*	*other actions*	*Total*
Hh head monthly revenue													
<50,000	8.4%	13.6%	33.5%	27.5%	16.9%	100%	27.7%	50.1%	11.9%	5.0%	5.4%	0.0%	100%
[50,005-100,000]	20.5%	16.8%	10.9%	39.0%	12.8%	100%	20.8%	27.0%	9.7%	13.3%	26.8%	2.5%	100%
[100,005-150,000]	30.0%	17.3%	11.6%	33.0%	8.2%	100%	22.4%	27.0%	19.8%	15.6%	15.3%	0.0%	100%
[150,005-200,000]	11.9%	24.8%	19.1%	26.5%	17.8%	100%	15.0%	50.7%	7.1%	13.8%	13.3%	0.0%	100%
[200,005-250,000]	65.0%	0.0%	0.0%	35.0%	0.0%	100%	15.8%	61.0%	0.0%	23.2%	0.0%	0.0%	100%
250,0000+	55.4%	8.2%	5.4%	26.7%	4.3%	100%	34.6%	20.0%	4.1%	20.6%	20.8%	0.0%	100%
	Pearson chi2(20) = 20.2815 Pr = 0.440						Pearson chi2(25) = 20.1859 Pr = 0.737						

Hh head monthly expenses													
<50,000	6.2%	10.6%	31.4%	46.1%	5.8%	100%	14.3%	39.8%	10.7%	10.0%	25.3%	0.0%	100%
[50,005-100,000]	32.7%	17.1%	10.2%	26.0%	14.0%	100%	30.6%	32.9%	14.0%	6.4%	14.6%	1.5%	100%
[100,005-150,000]	20.8%	16.7%	8.3%	37.5%	16.7%	100%	23.7%	32.6%	8.8%	25.9%	9.1%	0.0%	100%
[150,005-200,000]	35.1%	13.8%	14.7%	36.5%	0.0%	100%	27.7%	28.1%	7.1%	7.9%	29.3%	0.0%	100%
[200,005-250,000]	100.0%	0.0%	0.0%	0.0%	0.0%	100%	28.0%	0.0%	0.0%	50.0%	22.0%	0.0%	100%
[250,005-300,000]	100.0%	0.0%	0.0%	0.0%	0.0%	100%	0.0%	30.3%	0.0%	36.1%	33.6%	0.0%	100%
250,0000+	44.7%	0.0%	20.1%	18.7%	16.5%	100%	36.3%	28.9%	0.0%	22.4%	12.5%	0.0%	100%
	Pearson chi2(20) = 18.9474 Pr = 0.525						Pearson chi2(25) = 18.0965 Pr = 0.838						
Function													
Student	32.1%	12.1%	21.5%	26.9%	7.4%	100%	25.2%	23.0%	15.0%	22.5%	14.3%	0.0%	100%
Salaried/private sector	36.5%	23.9%	8.3%	25.9%	5.4%	100%	32.3%	25.1%	5.2%	12.2%	25.1%	0.0%	100%
Salaried/public sector	30.2%	22.2%	16.5%	21.0%	10.2%	100%	29.6%	33.2%	8.0%	10.8%	15.5%	2.9%	100%
Small craft	25.9%	9.5%	19.5%	26.9%	18.2%	100%	22.4%	33.2%	2.3%	8.2%	32.0%	2.0%	100%
Trade/transport	39.2%	27.8%	5.6%	19.4%	8.0%	100%	29.5%	36.4%	9.6%	8.5%	14.6%	1.5%	100%
Agriculture/livestock	26.5%	50.5%	0.0%	23.0%	0.0%	100%	60.7%	0.0%	20.1%	19.3%	0.0%	0.0%	100%
Job seeker	22.4%	10.4%	4.4%	52.8%	10.0%	100%	55.4%	17.4%	20.1%	0.0%	7.2%	0.0%	100%
Others	39.2%	7.2%	4.9%	36.4%	12.4%	100%	31.6%	19.4%	7.1%	22.0%	20.0%	0.0%	100%
	Pearson chi2(28) = 41.8786 Pr = 0.045						Pearson chi2(35) = 45.0317 Pr = 0.119						
Habitation													
Poor construction	31.4%	35.4%	14.7%	7.3%	11.2%	100%	31.2%	48.7%	0.0%	8.9%	11.2%	0.0%	100%
Hard wall	30.6%	20.0%	13.9%	23.2%	12.4%	100%	25.1%	31.4%	13.0%	10.2%	19.3%	1.1%	100%
Mini-villa	28.9%	10.2%	9.2%	44.1%	7.7%	100%	28.9%	23.5%	5.0%	23.7%	18.9%	0.0%	100%
Villa	49.7%	9.6%	1.8%	35.2%	3.7%	100%	51.3%	7.3%	2.4%	15.8%	21.1%	2.1%	100%
	Pearson chi2(12) = 29.2941 Pr = 0.004						Pearson chi2(15) = 39.3436 Pr = 0.001						
Locomotion													
No personal locomotion	32.4%	18.5%	11.7%	27.1%	10.3%	100%	29.0%	29.4%	9.7%	12.4%	18.8%	0.7%	100%
Motorbike	43.8%	0.0%	0.0%	56.2%	0.0%	100%	45.2%	11.2%	0.0%	15.9%	27.7%	0.0%	100%
Motorbike and car	47.1%	16.7%	6.5%	19.8%	9.9%	100%	46.1%	15.0%	0.0%	19.2%	14.2%	5.5%	100%
	Pearson chi2(8) = 7.4748 Pr = 0.486						Pearson chi2(10) = 11.7526 Pr = 0.302						

For the very few respondents with no personal locomotion questions ask in the event they have one, how would they react to these scenarios.

Table 4.19. Responses to fuel prices shocks across economic characteristics

	Reactions to a **high and positive** shock							Reactions to a **high and negative** shock						
Characteristics	*no effect*	*cut food cons.*	*cut other cons.*	*cut rides*	*change locomotion*	*other actions*	*Total*	*no effect*	*increase food cons.*	*increase other cons.*	*increase rides*	*save*	*other actions*	*Total*
Hh head monthly revenue														
<50,000	4.7%	4.7%	11.1%	13.1%	51.3%	15.2%	100%	0.0%	10.2%	16.6%	26.6%	46.6%	0.0%	100%
[50,005-100,000]	6.6%	10.8%	0.0%	23.0%	50.3%	9.3%	100%	2.7%	23.8%	11.5%	18.4%	43.6%	0.0%	100%
[100,005-150,000]	8.7%	14.1%	3.0%	10.8%	57.7%	5.7%	100%	0.0%	37.0%	0.0%	15.0%	44.4%	3.6%	100%
[150,005-200,000]	0.0%	0.0%	5.5%	23.7%	57.9%	13.0%	100%	0.0%	16.6%	0.0%	7.7%	59.3%	16.4%	100%
[200,005-250,000]	11.7%	0.0%	0.0%	34.2%	54.0%	0.0%	100%	0.0%	67.1%	0.0%	19.6%	13.3%	0.0%	100%
[250,005-300,000]	0.0%	13.3%	24.7%	11.5%	29.7%	20.8%	100%	0.0%	34.7%	9.0%	11.5%	44.8%	0.0%	100%
250,0000+	3.8%	4.4%	11.9%	40.7%	24.3%	14.9%	100%	4.6%	16.4%	7.4%	8.1%	58.8%	4.7%	100%
	Pearson chi2(25) = 22.4495 Pr = 0.610							Pearson chi2(25) = 26.2012 Pr = 0.397						
Hh head monthly expenses														
<50,000	4.5%	14.5%	4.5%	8.7%	48.8%	19.2%	100%	0.0%	9.2%	20.3%	13.4%	51.2%	6.0%	100%
[50,005-100,000]	7.3%	10.5%	1.7%	19.7%	55.0%	5.8%	100%	2.0%	31.1%	4.5%	21.4%	41.0%	0.0%	100%
[100,005-150,000]	2.5%	3.6%	3.6%	22.7%	56.5%	11.1%	100%	4.3%	34.0%	2.9%	11.2%	39.7%	7.9%	100%
[150,005-200,000]	13.3%	0.0%	20.0%	19.1%	34.8%	12.9%	100%	0.0%	28.6%	8.0%	16.6%	46.9%	0.0%	100%
[200,005-250,000]	0.0%	0.0%	0.0%	38.8%	38.8%	22.5%	100%	0.0%	0.0%	0.0%	65.9%	34.1%	0.0%	100%
[250,005-300,000]	0.0%	0.0%	27.9%	26.0%	46.1%	0.0%	100%	0.0%	69.7%	0.0%	0.0%	30.3%	0.0%	100%
250,0000+	6.5%	0.0%	6.5%	39.5%	41.1%	6.5%	100%	0.0%	20.7%	7.6%	9.5%	62.2%	0.0%	100%
	Pearson chi2(25) = 26.8058 Pr = 0.366							Pearson chi2(25) = 38.6639 Pr = 0.039						
Function														
Student	2.1%	4.0%	9.3%	26.7%	47.1%	10.8%	100%	2.3%	15.2%	8.1%	22.0%	50.2%	2.3%	100%
Salaried/private sector	5.4%	8.0%	8.4%	15.6%	56.1%	6.6%	100%	0.0%	21.0%	5.4%	17.5%	50.2%	6.0%	100%
Salaried/public sector	21.2%	4.5%	12.7%	22.7%	27.9%	10.9%	100%	2.9%	36.4%	6.4%	15.0%	39.3%	0.0%	100%
Small craft	5.0%	12.4%	0.0%	12.4%	48.7%	21.6%	100%	0.0%	29.4%	9.9%	15.4%	40.8%	4.4%	100%
Agriculture/livestock	0.0%	0.0%	0.0%	61.6%	22.2%	16.2%	100%	0.0%	16.2%	22.2%	42.3%	19.3%	0.0%	100%
Job seeker	9.3%	0.0%	0.0%	14.1%	53.1%	23.6%	100%	6.8%	37.0%	6.8%	20.7%	28.7%	0.0%	100%
Others	8.5%	4.3%	2.4%	19.4%	61.5%	3.9%	100%	4.8%	32.1%	3.9%	23.3%	31.7%	4.3%	100%
	Pearson chi2(35) = 58.1051 Pr = 0.008							Pearson chi2(35) = 27.3669 Pr = 0.818						

Habitation														
Poor construction	8.5%	7.0%	0.0%	8.7%	64.9%	10.9%	100%	0.0%	50.9%	9.3%	11.9%	27.9%	0.0%	100%
Hard wall	7.6%	7.2%	5.9%	17.3%	49.8%	12.3%	100%	1.7%	25.2%	9.0%	16.8%	44.3%	3.1%	100%
Mini-villa	8.7%	1.8%	5.3%	16.8%	53.0%	14.5%	100%	6.7%	28.9%	5.6%	17.0%	39.7%	2.1%	100%
Villa	10.7%	2.1%	6.9%	46.4%	29.8%	4.1%	100%	7.1%	9.0%	2.6%	26.9%	47.2%	7.3%	100%
		Pearson chi2(15) = 36.4013 Pr = 0.002								Pearson chi2(15) = 29.7536 Pr = 0.013				
Locomotion														
No personal locomotion	8.0%	6.0%	5.4%	18.9%	49.8%	11.9%	100%	2.9%	27.0%	7.5%	18.6%	40.9%	3.2%	100%
Motorbike	0.0%	0.0%	14.6%	59.5%	26.0%	0.0%	100%	0.0%	11.2%	0.0%	0.0%	88.8%	0.0%	100%
Motorbike and car	16.3%	0.0%	0.0%	31.9%	46.8%	5.0%	100%	7.3%	11.4%	12.4%	11.4%	51.8%	5.8%	100%
		Pearson chi2(10) = 13.7735 Pr = 0.184								Pearson chi2(10) = 9.2578 Pr = 0.508				
Trade/transport	9.7%	3.9%	4.8%	22.1%	51.3%	8.2%	100%	5.1%	22.7%	8.5%	13.0%	47.3%	3.5%	100%

For respondents with no personal locomotion questions ask in the event they have one, how would they react to these scenarios.

As a brief summary, food insecurity and poor dietary diversity are well present in the city of Ouagadougou, where nearly 90% of the surveyed households possess a motorbike, and only 15% use a public transport at least once a month. Severely food-insecure households tend to put high responsibility on fuel prices regarding their condition. The assessment of behavioral responses to scenarios of fuel price changes reveals that smooth changes in fuel prices have more impacts on food insecurity than shocks. Following fuel prices shocks, most respondents will give up on motorbikes and go for alternatives to preserve their food consumption. In the event of a decrease in fuel prices, many households go for saving or the improvement of their food consumption, depending on their food security status. Some, however, will choose to increase their rides. The most exposed to low dietary diversity and high food insecurity is found among females, widowed and divorcees, low educated, households' heads in the agricultural/livestock and trade/transport sectors, polygamic couples and households with a size beyond five members. The next two figures present a mapping of the study for the two scenarios: the scenario of fuel price increase, and the scenario of fuel price decrease.

The next and last part of the chapter investigates this linkage between food security and fuel consumption more in-depth using a quantitative method and compares the results with the key findings from this qualitative analysis.

Figure 4.18. Mapping of the study: scenario of fuel price increase

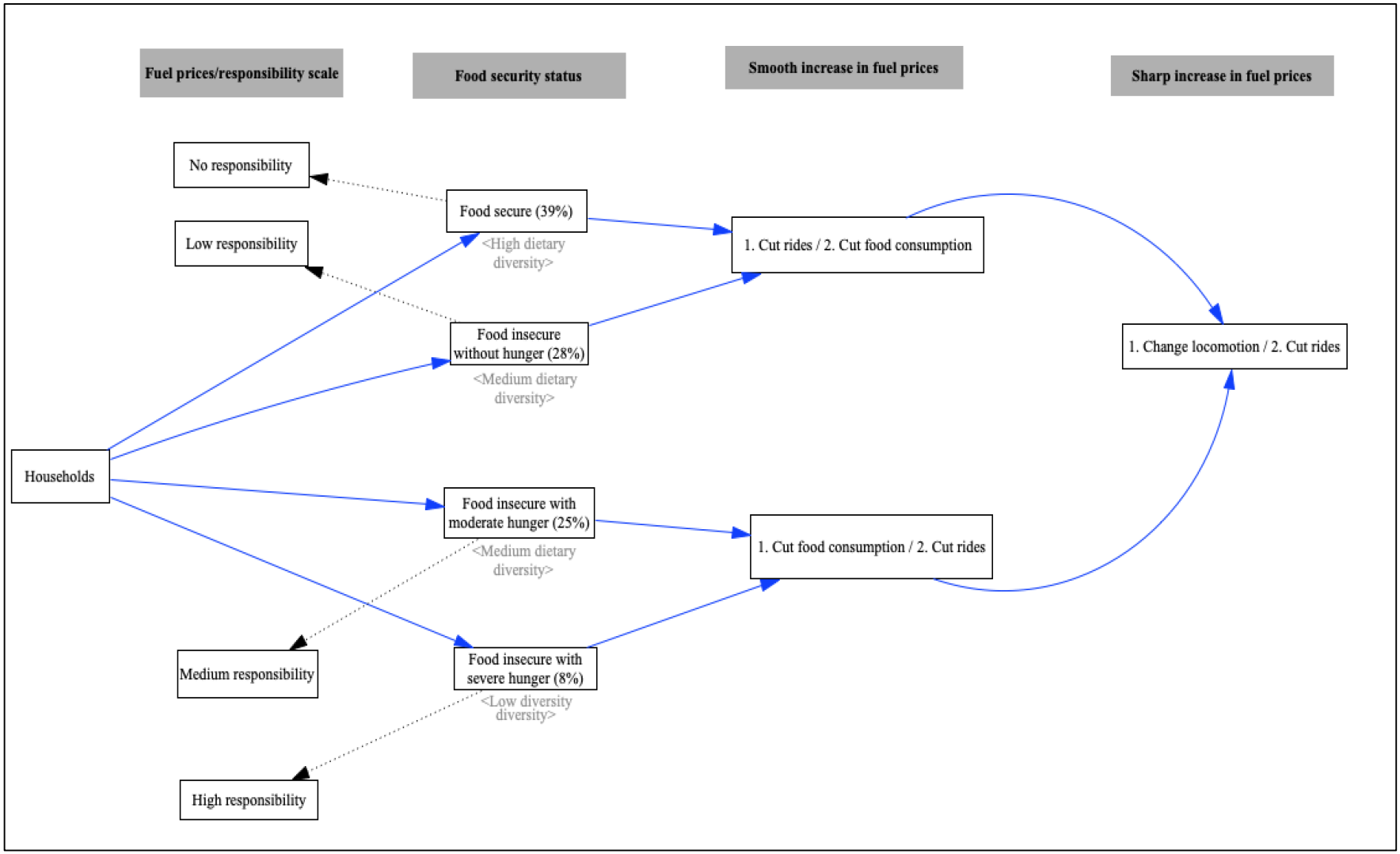
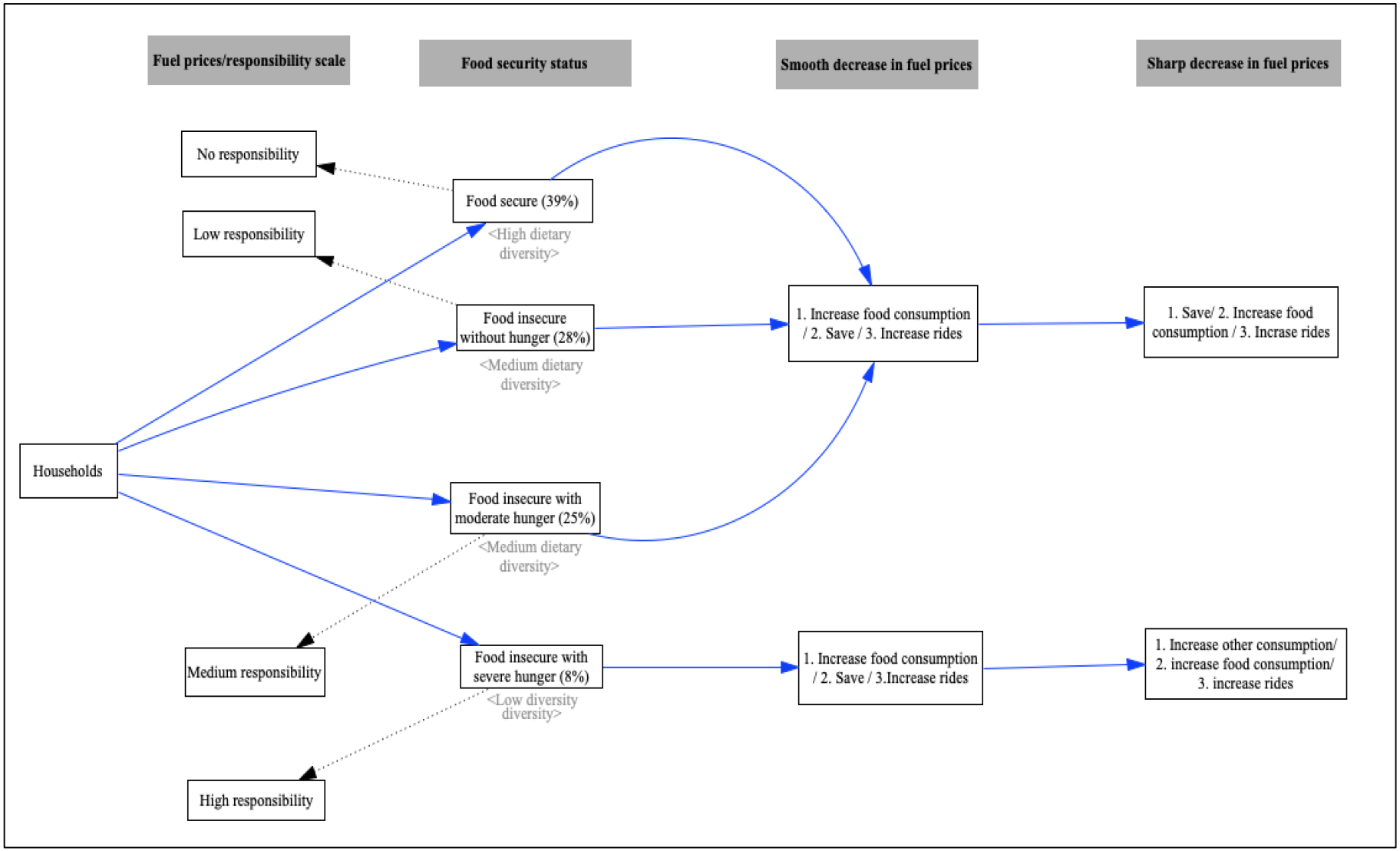


Figure 4.19. Mapping of the study: scenario of fuel price decrease



Part B: Econometric analysis

This section represents the quantitative part of the chapter. It is a complement and extension of part A related to the qualitative analysis.

4.7. Estimations and results from the quantitative approach

The section covers the two approaches detailed in the methodology part. The approaches are: 1) the investigation of factors affecting the likelihood to switch across food security scales. This approach uses an ordered logit and ordered probit models; 2) the analysis of the drivers of fuel and food consumption. It uses a robust OLS and a quantile regression.

The majority of the variables included in the two studies is derived from the previous qualitative study. Some additional, and non-categorical variables have been added to improve the variability of the type of regressors as many of the indicators are not numerical. The selected variables are the ones that are the most likely to interact in the nexus food security-fuel consumption. To assist with the interpretations of the results, the list of variables is presented in table 4.21.

Before detailing the description of the selected variables, the next table (4.20) presents the Pearson pairwise correlation among some of the variables drawn from the dataset. Some of them have been used in previous sections. The cross-correlation table gives a preview of possible associations between the variables, which will be examined more rigorously. Given the topic of the study, the interpretation of the table is restricted to food security.

The table shows that variables such as gender, age, literacy, education, monthly revenue, weekly food purchase, location, and the type of habitation are positively correlated with the level of food security. On the opposite, marital status, household size, fuel purchase, and usage of public transportation move in the opposite direction of food security level. Note that correlation does not necessarily imply causality. It simply indicates possible co-movements between variables.

Table 4.20. Pearson pairwise correlation

Variables (probability)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Food security	1												
(2) Gender	0.062	1											
	(0.211)												
(3) Age	0.048	-0.002	1										
	(0.335)	(0.97)											
(4) Marital status	-0.071	**-0.214**	**0.376**	1									
	(0.156)	(0.000)	(0.000)										
(5) Household size	**-0.188**	-0.042	0.073	**0.130**	1								
	(0.000)	(0.398)	(0.146)	(0.009)									
(6) Literacy	**0.224**	**0.139**	**-0.217**	**-0.175**	**-0.116**	1							
	(0.000)	(0.005)	(0.000)	(0.000)	(0.02)								
(7) Education level	**0.307**	**0.093**	**-0.196**	**-0.274**	**-0.218**	**0.324**	1						
	(0.000)	(0.099)	(0.000)	(0.000)	(0.000)	(0.000)							
(8) Monthly revenue	**0.281**	**0.127**	**0.290**	**0.119**	-0.02	0.034	0.071	1					
	(0.000)	(0.014)	(0.000)	(0.021)	(0.702)	(0.513)	(0.225)						
(9) Weekly food expenses	**0.168**	**-0.092**	**0.189**	**0.193**	**0.124**	-0.070	-0.017	**0.433**	1				
	(0.001)	(0.067)	(0.000)	(0.000)	(0.013)	(0.162)	(0.766)	(0.000)					
(10) Weekly fuel expenses	-0.066	**0.167**	0.073	0.005	0.032	0.036	-0.003	**0.400**	**0.314**	1			
	(0.197)	(0.001)	(0.151)	(0.93)	(0.53)	(0.481)	(0.959)	(0.000)	(0.000)				
(11) Usage of public transport at least once a week	**-0.159**	**-0.164**	-0.057	0.084	0.102	-0.087	-0.097	-0.006	**0.120**	0.018	1		
	(0.019)	(0.016)	(0.408)	(0.217)	(0.136)	(0.204)	(0.213)	(0.928)	(0.079)	(0.794)			
(12) Division	0.042	0.050	-0.035	**-0.095**	-0.005	0.037	0.042	0.078	**0.100**	-0.058	**-0.115**		
	(0.401)	(0.32)	(0.479)	(0.057)	(0.924)	(0.454)	(0.455)	(0.133)	(0.045)	(0.256)	(0.091)		
(13) Type of habitation	**0.335**	-0.029	0.037	-0.044	-0.071	**0.257**	**0.296**	**0.151**	0.075	**0.197**	0.060	0.021	1
	(0.000)	(0.561)	(0.457)	(0.383)	(0.157)	(0.000)	(0.000)	(0.003)	(0.136)	(0.000)	(0.377)	(0.674)	

10% (and below) significant correlations are bolded. Pvalues in parenthesis.

Table 4.21. Selected variables

Dependent Variables	Description or sample mean/std dev
Food security	Ordered dummy (food secure to food insecure)
Dietary diversity	Ordered dummy (low diversity to high diversity)
Independent variables	
Gender	Dummy
Age	Mean: 37 years Std dev: 13.43
Household size	Mean: 7 members Std dev: 4.98
Marital status	Dummy
Literacy	Ordered dummy (no literate to literate)
Education level	Ordered dummy (low education to higher education)
Monthly revenue	Ordered dummy (low income class to high)
Weekly fuel expenses	Mean: 5478 CFA (local currency) Std dev: 15490
Weekly food expenses	Mean: 12168 CFA (local currency) Std dev: 9451
Type of habitation (lower to better)	Ordered dummy (low quality to high quality)
Usage of public transport at least once a week	Dummy
Location dummy	Dummy

Note: Weekly fuel expenses and weekly food expenses are used as dependent variables. The component of each dummy variable has been detailed in earlier sections. The dummy *type of economic activity* has been excluded to improve the quality of the estimates. However, the variable *monthly income* (non-categorical) is highly correlated with the type of economic activity to that including it provides a good alternative to circumvent the issue of excluding a relevant variable.

4.7.1. Factors explaining the likelihood to switch between food security scales

Recall that coefficients in ordered probit and logit models are not directly interpretable. Only the signs can be interpreted (direct interpretation is possible for marginal effects). The interpretation is based on the order of the dependent variable *food security*. In this research, a negative coefficient on a regressor implies a decrease in the probability that food security deteriorates. In other words, a negative coefficient implies a chance to be food secure. In contrast, a positive coefficient means a risk of deterioration of food security conditions. Thus, a negative coefficient is always desirable. Results of the estimate are presented in tables 4.22, 4.24 and 4.26.

The estimation confirms the findings drawn from the qualitative analysis for the vast majority of the selected variables. Factors that significantly increase the chances to fall into better food conditions include gender (being a male, i.e. gender dummy=1), literacy (being able to read, literacy dummy=1)

higher education level, higher income and higher food expenses per week. Living in a better-quality habitation is an indication of better food security status. Besides, the result confirms the finding that higher fuel consumption increases the risk to fall into food insecurity. Higher age is associated with better food security condition, although this result is not significant, as many factors can explain opposite effects such as income, fuel consumption, etc. Surprisingly, the usage of public transportation has no significant impact on the chance to become food secure. In fact, a few respondents use public transport and those who use do it very less often. Besides, the public transport system in Ouagadougou is not developed so that its impact on people locomotion is less perceived. This could be the reason why the coefficient in the regression is not significant. Results from both ordered probit and ordered logit are do not significantly differ from each other.

To measure the impact of each regressor, the marginal effect is computed and presented in table 4.23. Note that the interpretation of marginal effects is more appropriate for non-categorial variables. For categorical variables, the exception is made for the ones that are ordered, such as education level, literacy, or type of habitation. For categorical variables like gender, it would make more sense to limit the interpretations to the ordered probit and logit estimations.

Results show significant effects of literacy, education, income, and food expenses to the capacity to become (or remain) food secure or less food insecure (whether food insecure with no hunger, moderate hunger or severe hunger). The highest contribution is coming from literacy. A 1% increase in literacy increases the capacity to be food secure by 0.2%. A 1% increase in each of the variables identified above increments the capacity to become food secure by a rate ranging from 0.09 to 0.2 % and significantly reduces the probability to becomes food insecure. In contrast, increasing household size or fuel expenses reduces the capacity to become or remain food secure and increases that of switching to any of the categories of food insecurity. Fuel consumption is the variable with the highest marginal impact. A 1% increase in fuel consumption reduces the capacity to be food secure by 0.08% and increase that of becoming more food insecure by 0.02%.

Table 4.22. Estimation results

VARIABLES	**Ordered Logit** *Food security*	**Ordered Probit** *Food security*
Gender	-0.457**	-0.715**
	(0.208)	(0.356)
Age	-0.006	-0.012
	(0.012)	(0.020)
Household size	0.048**	0.084**
	(0.021)	(0.036)
Marital status	-0.099	-0.218
	(0.279)	(0.487)
Literacy	-0.684**	-1.131**
	(0.314)	(0.518)
Education level	-0.290*	-0.496*
	(0.162)	(0.292)
Monthly revenue	-0.128**	-0.196**
	(0.059)	(0.096)
Weekly fuel expenses (log)	0.245*	0.414*
	(0.134)	(0.219)
Weekly food expenses	-0.349**	-0.580**
	(0.159)	(0.273)
Type of habitation (lower to better)	-0.354**	-0.624***
	(0.139)	(0.234)
Usage of public transport at least once a week	0.438	0.739
	(0.281)	(0.477)
Location dummy	0.028	0.010
	(0.119)	(0.200)
Constant 1	-3.886**	-6.601**
	(1.583)	(2.682)
Constant 2	-2.904*	-4.950*
	(1.577)	(2.663)
Constant 3	-1.643	-2.706
	(1.571)	(2.663)
Observations	157	157
Number of parameters	15	15
Model degrees of freedom	12	12
Pseudo-R-squared	0.156	0.153
Log likelihood	-160.7	-161.3
Chi-squared	59.46	58.16
Significance of model test (p)	0.000	0.000
Number of iterations	4	4
Convergence dummy	1	1

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4.23. Marginal effects

	Marginal effect: Ordered Logit				Marginal effect: Ordered Probit			
	Food secure	FI/ no hunger	FI /moderate hunger	FI/severe hunger	Food secure	FI/ no hunger	FI/moderate hunger	FI/severe hunger
VARIABLES	*Food security scales*				*Food security scales*			
Gender	0.133**	-0.025*	-0.075**	-0.033*	0.142**	-0.023*	-0.079**	-0.040*
	(0.064)	(0.014)	(0.037)	(0.019)	(0.062)	(0.013)	(0.036)	(0.020)
Age	0.002	-0.000	-0.001	-0.001	0.002	-0.000	-0.001	-0.001
	(0.004)	(0.001)	(0.002)	(0.001)	(0.004)	(0.001)	(0.002)	(0.001)
Household size	-0.016**	0.003*	0.009**	0.004**	-0.015**	0.002*	0.008**	0.004**
	(0.007)	(0.002)	(0.004)	(0.002)	(0.006)	(0.001)	(0.004)	(0.002)
Marital status	0.040	-0.008	-0.023	-0.010	0.031	-0.005	-0.017	-0.009
	(0.090)	(0.017)	(0.051)	(0.023)	(0.087)	(0.015)	(0.048)	(0.024)
Literacy	0.210**	-0.039	-0.119**	-0.052*	0.213**	-0.035	-0.118**	-0.060*
	(0.095)	(0.024)	(0.053)	(0.027)	(0.096)	(0.021)	(0.053)	(0.031)
Education level	0.092*	-0.017	-0.052*	-0.023	0.090*	-0.015	-0.050*	-0.025*
	(0.053)	(0.011)	(0.031)	(0.015)	(0.049)	(0.009)	(0.028)	(0.015)
Monthly revenue	0.036**	-0.007*	-0.021**	-0.009*	0.040**	-0.007*	-0.022**	-0.011*
	(0.017)	(0.004)	(0.010)	(0.005)	(0.018)	(0.004)	(0.010)	(0.006)
Weekly fuel expenses (log)	-0.077*	0.014	0.043*	0.019*	-0.076*	0.013	0.042*	0.021*
	(0.040)	(0.009)	(0.023)	(0.011)	(0.041)	(0.008)	(0.023)	(0.013)
Weekly food expenses (log)	0.108**	-0.020*	-0.061**	-0.027*	0.109**	-0.018*	-0.060**	-0.030*
	(0.048)	(0.011)	(0.028)	(0.015)	(0.048)	(0.010)	(0.027)	(0.016)
Type of habitation (lower to better)	0.116***	-0.022**	-0.065***	-0.029**	0.110***	-0.018*	-0.061**	-0.031**
	(0.042)	(0.011)	(0.025)	(0.013)	(0.042)	(0.009)	(0.024)	(0.014)
Usage of public transport at least once a week	-0.137	0.026	0.077	0.034	-0.136	0.022	0.076	0.038
	(0.088)	(0.019)	(0.050)	(0.023)	(0.086)	(0.017)	(0.049)	(0.025)
Location dummy	-0.002	0.000	0.001	0.000	-0.009	0.001	0.005	0.002
	(0.037)	(0.007)	(0.021)	(0.009)	(0.037)	(0.006)	(0.020)	(0.010)
Constant 1	0.133**	-0.025*	-0.075**	-0.033*	0.142**	-0.023*	-0.079**	-0.040*
	(0.064)	(0.014)	(0.037)	(0.019)	(0.062)	(0.013)	(0.036)	(0.020)
Constant 2	0.002	-0.000	-0.001	-0.001	0.002	-0.000	-0.001	-0.001
	(0.004)	(0.001)	(0.002)	(0.001)	(0.004)	(0.001)	(0.002)	(0.001)
Constant 3	-0.016**	0.003*	0.009**	0.004**	-0.015**	0.002*	0.008**	0.004**
	(0.007)	(0.002)	(0.004)	(0.002)	(0.006)	(0.001)	(0.004)	(0.002)
Observations	157	157	157	157	157	157	157	157

FI: food insecurity. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

To have a closer glimpse to the factors that explain the probability to switch to different food security scales, and to assess one of the key findings from the qualitative analysis (i.e low dietary diversity is not strictly related to high food insecurity or poor living conditions, given people's consumption habits and cultures) the estimation is replicated across dietary diversity scales. The first attempt to analyze in each of the three categories of dietary diversity (low, medium, and high diversity) faced several issues of spurious results due to very small sample size. To resolve this issue, dietary diversity has been recategorized into two: low and high. Results of the ordered probit and logit models as well the marginal effects are reported in tables 4.24 to 4.27.

The analysis from the dietary diversity perspective shows interesting insights. In the full sample, increasing age had no significant implication on the probability to be more or less food secure. After splitting the data, age is found to have a more negative and significant impact on the probability to be food secure among households experiencing low dietary diversity; and more positive impact among those with better dietary diversity. Among households with low dietary diversity, being a male increases the probability to fall into food insecurity. The result is the opposite among respondents with higher diversity. Better literacy, higher food expenses, or income have more significant implications for food security among respondents with poor dietary. On the opposite, increasing fuel expenses significantly increases the chance to be more food insecure among households experiencing low dietary diversity as opposed to those with improved dietary.

The combination of these results provides a strong suggestion: lower dietary diversity is associated with poorer food security or living standard, contrasting the finding that low dietary is not strictly associated with poor food security (or implicitly living standard). In fact, from the finding above, those with better dietary can strongly be assumed to have a better livelihood and be more food secure. That is why, increasing income, fuel expenses, or reducing food purchases does not necessarily imply a higher risk to become food insecure.
Besides, in both dietary categories, household size plays a crucial role in explaining the probability to be food insecure.

The estimation of the marginal effects shows a strong effect of literacy on the capacity to become more food secure or less food insecure. A 1% increase in literacy increases the capacity to become

food secure by 0.4% and reduces that of leaving the state of severe food insecurity by 0.1%. Among households with lower dietary diversity, a 1% rise in fuel purchases or a 1% cut in food purchases reduces the capacity to be more food secure by about 0.19% and increases that of falling into the category of severely food insecure by around 0.5 %.

As a summary, this section provides evidence that gender, literacy, education, income, and increased food expenses play vital roles in determining the risk to fall into any of the food insecurity categories (food insecure with no hunger, food insecure with moderate hunger, food insecure with severe hunger). Higher fuel consumption or household size jeopardizes the likelihood to be more food secure. However, as opposed to the suggestion that dietary diversity is more linked to culture and habit than wealth, the probability of becoming more or less food secure seems to depend on dietary diversity partially. The analysis suggests that higher dietary diversity can imply better living standard, higher food security, and a negligible risk to become food insecure.

Table 4.24. Estimation results: low dietary diversity

VARIABLES	**Ordered Logit** *Food security*	**Ordered Probit** *Food security*
Gender	0.729*	1.280*
	(-0.387)	(-0.663)
Age	0.052**	0.089**
	(-0.022)	(-0.039)
Household size	0.153**	0.292**
	(-0.073)	(-0.13)
Marital status	-0.644	-1.084
	(-0.551)	(-0.998)
Literacy	-1.552***	-2.688***
	(-0.579)	(-1.022)
Education level	-0.469	-0.797
	(-0.311)	(-0.534)
Monthly revenue	-0.406***	-0.698**
	(-0.153)	(-0.285)
Weekly fuel expenses (log)	0.709**	1.315**
	(-0.337)	(-0.602)
Weekly food expenses (log)	-0.754**	-1.369**
	(-0.304)	(-0.565)
Type of habitation (lower to better)	-0.177	-0.277
	(-0.336)	(-0.578)
Usage of public transport at least once a week	0.48	0.75

	(-0.531)	(-0.937)
Location dummy	-0.267	-0.572
	(-0.244)	(-0.444)
Constant 1	-3.527	-6.137
	(-3.221)	(-5.72)
Constant 2	-2.272	-3.962
	(-3.203)	(-5.667)
Constant 3	-0.436	-0.725
	(-3.217)	(-5.685)
Observations	152	152
Number of parameters	15	15
Model degrees of freedom	12	12
Pseudo-R-squared	0.316	0.313
Log likelihood	-43.16	-43.34
Chi-squared	39.8	39.44
Significance of model test (p)	0.000	0.000
Number of iterations	5	5
Convergence dummy	1	1

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4.25. Marginal effects: low dietary diversity

	Marginal effect: Ordered Logit				Marginal effect: Ordered Probit			
	Food secure	FI/ no hunger	FI /moderate hunger	FI/severe hunger	Food secure	FI/ no hunger	FI /moderate hunger	FI/severe hunger
VARIABLES	*Food security scales*				*Food security scales*			
Gender	-0.181**	0.044	0.093*	0.044*	-0.181**	0.041	0.097*	0.042*
	(0.087)	(0.028)	(0.051)	(0.026)	(0.091)	(0.028)	(0.053)	(0.026)
Age	-0.013**	0.003	0.006**	0.003**	-0.013**	0.003*	0.007**	0.003*
	(0.005)	(0.002)	(0.003)	(0.002)	(0.005)	(0.002)	(0.003)	(0.002)
Household size	-0.041**	0.010	0.021**	0.010*	-0.038**	0.009	0.020**	0.009*
	(0.017)	(0.007)	(0.009)	(0.005)	(0.018)	(0.006)	(0.010)	(0.005)
Marital status	0.153	-0.037	-0.079	-0.037	0.160	-0.037	-0.086	-0.037
	(0.141)	(0.042)	(0.073)	(0.035)	(0.136)	(0.037)	(0.074)	(0.033)
Literacy	0.380***	-0.092	-0.196***	-0.093**	0.385***	-0.088	-0.206***	-0.090**
	(0.134)	(0.061)	(0.074)	(0.043)	(0.136)	(0.055)	(0.078)	(0.043)
Education level	0.113	-0.027	-0.058	-0.027	0.116	-0.027	-0.062	-0.027
	(0.071)	(0.020)	(0.040)	(0.020)	(0.073)	(0.019)	(0.041)	(0.021)
Monthly revenue	0.099***	-0.024	-0.051**	-0.024**	0.101***	-0.023*	-0.054***	-0.024**
	(0.037)	(0.016)	(0.021)	(0.012)	(0.035)	(0.014)	(0.020)	(0.012)
Weekly fuel expenses (log)	-0.186**	0.045	0.096**	0.045*	-0.176**	0.040	0.094**	0.041*
	(0.081)	(0.033)	(0.041)	(0.025)	(0.080)	(0.028)	(0.043)	(0.024)
Weekly food expenses	0.194***	-0.047*	-0.100**	-0.047*	0.187***	-0.043**	-0.100**	-0.044*
	(0.067)	(0.024)	(0.045)	(0.024)	(0.066)	(0.020)	(0.044)	(0.023)
Type of habitation (lower to better)	0.039	-0.009	-0.020	-0.010	0.044	-0.010	-0.024	-0.010
	(0.081)	(0.020)	(0.043)	(0.020)	(0.083)	(0.019)	(0.045)	(0.020)
Usage of public transport at least once a week	-0.106	0.026	0.055	0.026	-0.119	0.027	0.064	0.028
	(0.131)	(0.033)	(0.070)	(0.032)	(0.129)	(0.031)	(0.072)	(0.031)
Location dummy	0.081	-0.020	-0.042	-0.020	0.066	-0.015	-0.035	-0.015
	(0.062)	(0.020)	(0.030)	(0.017)	(0.060)	(0.017)	(0.031)	(0.015)
Constant 1	-0.181**	0.044	0.093*	0.044*	-0.181**	0.041	0.097*	0.042*
	(0.087)	(0.028)	(0.051)	(0.026)	(0.091)	(0.028)	(0.053)	(0.026)
Constant 2	-0.013**	0.003	0.006**	0.003**	-0.013**	0.003*	0.007**	0.003*
	(0.005)	(0.002)	(0.003)	(0.002)	(0.005)	(0.002)	(0.003)	(0.002)
Constant 3	-0.041**	0.010	0.021**	0.010*	-0.038**	0.009	0.020**	0.009*
	(0.017)	(0.007)	(0.009)	(0.005)	(0.018)	(0.006)	(0.010)	(0.005)
Observations	152	152	152	152	152	152	152	152

FI: food insecurity. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4.26. Estimation results: high dietary diversity

VARIABLES	**Ordered Logit** *Food security*	**Ordered Probit** *Food security*
Gender	-0.884***	-1.457***
	(0.287)	(0.507)
Age	-0.029*	-0.050*
	(0.016)	(0.029)
Household size	0.048**	0.081**
	(0.023)	(0.041)
Marital status	-0.054	-0.184
	(0.352)	(0.617)
Literacy	-0.602	-0.998
	(0.437)	(0.714)
Education level	-0.195	-0.426
	(0.221)	(0.409)
Monthly revenue	-0.057	-0.090
	(0.071)	(0.115)
Weekly fuel expenses (log)	0.187	0.314
	(0.166)	(0.273)
Weekly food expenses (log)	-0.242	-0.409
	(0.218)	(0.391)
Type of habitation (lower to better)	-0.405**	-0.661**
	(0.183)	(0.312)
Usage of public transport at least once a week	0.331	0.441
	(0.391)	(0.692)
Location dummy	0.043	0.038
	(0.151)	(0.253)
Constant 1	-4.030*	-7.169**
	(2.076)	(3.638)
Constant 2	-2.986	-5.392
	(2.066)	(3.602)
Constant 3	-1.672	-3.067
	(2.058)	(3.598)
Observations	105	105
Number of parameters	1	1
Model degrees of freedom	12	12
Pseudo-R-squared	0.187	0.186
Log likelihood	-103.5	-103.7
Chi-squared	47.68	47.31
Significance of model test (p)	0.000	0.000
Number of iterations	4	4
Convergence dummy	1	1

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 4.27. Marginal effects: high dietary diversity

	Marginal effect: Ordered Logit				Marginal effect: Ordered Probit			
	Food secure	FI/ no hunger	FI /moderate hunger	FI/severe hunger	Food secure	FI/ no hunger	FI /moderate hunger	FI/severe hunger
VARIABLES	*Food security scales*				*Food security scales*			
Gender	0.248***	-0.036	-0.146***	-0.066**	0.256***	-0.037*	-0.145***	-0.074**
	(0.078)	(0.022)	(0.050)	(0.031)	(0.075)	(0.021)	(0.047)	(0.032)
Age	0.009*	-0.001	-0.005*	-0.002	0.008*	-0.001	-0.005*	-0.002
	(0.005)	(0.001)	(0.003)	(0.002)	(0.005)	(0.001)	(0.003)	(0.002)
Household size	-0.014**	0.002	0.008**	0.004*	-0.014**	0.002	0.008**	0.004*
	(0.007)	(0.002)	(0.004)	(0.002)	(0.006)	(0.001)	(0.004)	(0.002)
Marital status	0.031	-0.005	-0.018	-0.008	0.016	-0.002	-0.009	-0.005
	(0.105)	(0.016)	(0.062)	(0.028)	(0.102)	(0.015)	(0.058)	(0.030)
Literacy	0.170	-0.025	-0.100	-0.045	0.175	-0.025	-0.099	-0.051
	(0.120)	(0.023)	(0.072)	(0.035)	(0.125)	(0.023)	(0.071)	(0.039)
Education level	0.073	-0.011	-0.043	-0.019	0.056	-0.008	-0.032	-0.016
	(0.069)	(0.012)	(0.040)	(0.020)	(0.064)	(0.011)	(0.036)	(0.019)
Monthly revenue	0.015	-0.002	-0.009	-0.004	0.017	-0.002	-0.009	-0.005
	(0.019)	(0.003)	(0.011)	(0.005)	(0.021)	(0.003)	(0.012)	(0.006)
Weekly fuel expenses (log)	-0.053	0.008	0.031	0.014	-0.054	0.008	0.031	0.016
	(0.046)	(0.008)	(0.027)	(0.013)	(0.048)	(0.008)	(0.028)	(0.015)
Weekly food expenses (log)	0.070	-0.010	-0.041	-0.019	0.070	-0.010	-0.040	-0.020
	(0.065)	(0.011)	(0.038)	(0.019)	(0.062)	(0.010)	(0.036)	(0.019)
Type of habitation (lower to better)	0.112**	-0.016	-0.066**	-0.030*	0.118**	-0.017	-0.066**	-0.034*
	(0.051)	(0.012)	(0.032)	(0.016)	(0.051)	(0.011)	(0.031)	(0.018)
Usage of public transport at least once a week	-0.075	0.011	0.044	0.020	-0.096	0.014	0.054	0.028
	(0.118)	(0.019)	(0.070)	(0.031)	(0.113)	(0.018)	(0.065)	(0.033)
Location dummy	-0.007	0.001	0.004	0.002	-0.012	0.002	0.007	0.004
	(0.043)	(0.006)	(0.025)	(0.011)	(0.044)	(0.006)	(0.025)	(0.013)
Constant 1	0.248***	-0.036	-0.146***	-0.066**	0.256***	-0.037*	-0.145***	-0.074**
	(0.078)	(0.022)	(0.050)	(0.031)	(0.075)	(0.021)	(0.047)	(0.032)
Constant 2	0.009*	-0.001	-0.005*	-0.002	0.008*	-0.001	-0.005*	-0.002
	(0.005)	(0.001)	(0.003)	(0.002)	(0.005)	(0.001)	(0.003)	(0.002)
Constant 3	-0.014**	0.002	0.008**	0.004*	-0.014**	0.002	0.008**	0.004*
	(0.007)	(0.002)	(0.004)	(0.002)	(0.006)	(0.001)	(0.004)	(0.002)
Observations	105	105	105	105	105	105	105	105

FI: food insecurity. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.7.2. The drivers of food and fuel consumption

This section provides a comparative analysis between the determinants of food and fuel consumption in the full sample and among different percentiles of the sample. It helps to analyze the tradeoff between food and fuel consumption and factors that drive the two consumptions. Tables 28 and 29 report the drivers of food and fuel consumption, respectively.

Among the set of variables included in the regression, four are fundamental drivers of food purchases, and 3 are significant drivers of fuel purchases. Being a male gives more responsibility for fuel purchases. This carries sense as men usually locomote more than women for their activity or leisure. Being in a relationship or having higher income puts pressure on food purchases. High fuel purchases reduce the capacity to afford food and can jeopardize food security. A 1% increase in fuel purchase reduces the amount of food purchase by around 0.2% to 0.3%.

For the dependent variable *weekly fuel expenses*, the most significant and positive drivers are gender and income. Food purchase, on the opposite, is the most significant and negative explanatory variable.

There are neither contrasting nor significant differences between OLS and quantile regressions. However, coefficients appear more significant below and above the median (50% quantile). The impact of gender, marital status, and fuel purchases are more pronounced among the 25% lowest food consumers (who are usually poor) than among the 50% or the 75% percentiles.

Combining the two tables, the most critical driver of food and fuel purchases is income. Higher income leads to more consumption as confirmed by several theories and works on consumption (consumption and disposable income, Keynes, 1936; relative consumption expenditure, Duesenberry,1949; principles of economics, Mankiw 1998). Besides, fuel and food purchases are significantly and negatively intertwined. Higher food consumption can jeopardize fuel consumption and vice versa.

Table 4.28. Drivers of food expenses

VARIABLES	OLS (Robust) *Weekly food expenses(log)*	Quantile (25%) *Weekly food expenses(log)*	Quantile (50%) *Weekly food expenses(log)*	Quantile (75%) *Weekly food expenses(log)*
Gender	-0.202*	-0.268*	-0.209	-0.057
	(0.105)	(0.153)	(0.139)	(0.138)
Age	0.010	0.010	0.005	0.001
	(0.006)	(0.008)	(0.008)	(0.008)
Household size	0.012	-0.010	0.001	0.034**
	(0.012)	(0.016)	(0.014)	(0.014)
Marital status	0.330**	0.678***	0.312	0.169
	(0.152)	(0.209)	(0.191)	(0.188)
Literacy	0.171	0.176	0.198	0.010
	(0.149)	(0.248)	(0.226)	(0.224)
Education level	-0.005	0.003	-0.154	0.000
	(0.091)	(0.121)	(0.110)	(0.109)
Monthly revenue	0.100***	0.046	0.134***	0.113***
	(0.032)	(0.041)	(0.037)	(0.037)
Type of habitation (lower to better)	0.021	0.010	-0.006	0.069
	(0.074)	(0.101)	(0.092)	(0.091)
Weekly fuel expenses (log)	-0.243***	-0.312***	-0.241***	- 0.295***
	(0.058)	(0.095)	(0.086)	(0.085)
Usage of public transport at least once a week	0.022	-0.149	0.041	0.086
	(0.145)	(0.211)	(0.192)	(0.190)
Location dummy	-0.054	-0.151*	-0.089	0.011
	(0.062)	(0.090)	(0.082)	(0.081)
Constant	6.395***	5.941***	7.040***	6.219***
	(0.530)	(0.860)	(0.785)	(0.776)
Observations	403	403	403	403
R-squared/ Pseudo R-squared	0.427	0.313	0.268	0.263
Log likelihood	-141.2	.	.	.
Model degrees of freedom	11	11	11	11
Sum of absolute deviations	.	28.33	35.57	27.05

Table 4.29. Drivers of fuel expenses

VARIABLES	OLS (Robust) *Weekly fuel expenses(log)*	Quantile (25%) *Weekly fuel expenses(log)*	Quantile (50%) *Weekly fuel expenses(log)*	Quantile (75%) *Weekly fuel expenses(log)*
Gender	0.373***	0.103	0.280**	0.373*
	(0.127)	(0.150)	(0.139)	(0.194)
Age	-0.015*	-0.003	-0.012	-0.028**
	(0.008)	(0.008)	(0.008)	(0.011)
Household size	-0.005	-0.001	-0.002	0.005
	(0.011)	(0.016)	(0.015)	(0.020)
Marital status	0.104	-0.114	-0.101	0.169
	(0.173)	(0.212)	(0.197)	(0.274)
Literacy	-0.185	-0.011	-0.164	-0.118
	(0.311)	(0.249)	(0.230)	(0.321)
Education level	-0.011	0.006	-0.030	-0.120
	(0.092)	(0.121)	(0.112)	(0.156)
Monthly revenue	0.109***	0.056	0.085**	0.225***
	(0.038)	(0.041)	(0.038)	(0.053)
Type of habitation (lower to better)	0.221*	0.067	0.172*	0.219*
	(0.119)	(0.099)	(0.092)	(0.127)
Weekly food expenses	-0.338***	-0.159	-0.292***	-0.244*
	(0.093)	(0.112)	(0.104)	(0.144)
Usage of public transport at least once a week	0.010	-0.175	0.083	0.160
	(0.200)	(0.211)	(0.195)	(0.272)
Location dummy	0.031	0.012	0.001	-0.129
	(0.073)	(0.090)	(0.083)	(0.116)
Constant	4.490***	5.957***	5.171***	6.551***
	(0.896)	(1.050)	(0.973)	(1.354)
Observations	403	403	403	403
R-squared/ Pseudo R-squared	0.321	0.038	0.132	0.223
Log likelihood	-167.1	.	.	.
Model degrees of freedom	11	11	11	11
Sum of absolute deviations	.	29.68	39.52	34.52

What can be derived from this quantitative part of the chapter? First, gender, literacy, education, income, and high food expenses play critical roles in determining the risk to fall into any of the food insecurity categories. Second, increasing fuel purchase or household size can reduce the probability to be or remain food secure. These results confirm the findings from the qualitative analysis. Third, higher dietary diversity can imply better living standard and food conditions. This finding contradicts that of the qualitative approach and suggests further investigations, especially in areas of sociology or anthropology.

Besides, there is a tradeoff between fuel and food consumption, especially among the poor; and income is a key parameter in this tradeoff.

CHAPTER 5: Conclusion

West African economies are still pathing their way to reach a 100% food self-sufficiency ratio. Food insecurity remains one of the key priorities of governments in the region. Among the pillars of food security, food access is the most predominant. Numerous factors can undermine food access and lead to food insecurity, such as peace, infrastructure, environment, among others. Most development initiatives in the region aim at reducing physical access to food. Yet, income can play an essential role in food access, especially in non-farming areas. To bring substantial contributions to what have so far been done on food security analysis, this research focuses on financial access to food and uses one of the most important commodities in which many West African countries rely, and which has a major impact on the economies, namely fuel cost. The main research question is addressed through 3 sub-questions. These questions guide the flow of the analyses and represent the objectives of the research. The first objective is to get a glimpse of the impact of fuel prices uncertainty on domestic prices of goods and services in general. The methodology used to address this concern is a combination of a VAR-GARCH-M estimation and various bias tests. Data include crude oil prices (Brent, Nigeria bonny light, OPEC basket) and domestic prices of each of the analyzed economies, namely Burkina Faso, Ghana, Cote d'Ivoire, Niger, and Nigeria.

The second concern or objective is to capture at the disaggregated level, the transmission channel of international crude oil prices to food prices and the link between the results and food security in the region. This question is addressed following two consecutive steps: i) the transmission of crude oil price changes to domestic fuel prices; ii) and the transmission of fuel price changes to local food prices. To do this, issues such as cointegration, error correction and pass-through elasticity are included in the approach. Data incorporate crude oil prices, domestic fuel prices, exchange rate, and prices of the most consumed staple foods such as millet, sorghum, maize, and rice. The analysis is centered on three countries sharing a common border: Burkina Faso, Mali, and Niger.

After addressing this second concern, the last section measures households' food security and dietary diversity level before looking at their consumption behavior with respect to fuel price

changes. The approach is based on a survey implemented in Burkina Faso, a country highly exposed to food insecurity and that highly relies on fuels. The sample is selected in Ouagadougou, the capital of the country. The analysis is investigated from both qualitative and quantitative sides. The qualitative analysis explores data visualization and statistical tables. As for the econometric part, it uses an ordered logit and probit models, a robust OLS and quantile regressions.

From the literature perspective, the research brings novelty and contributes to filling the gap in several respects. First, the analysis of the impact of fuel prices on food security at the household level is incorporated in a qualitative study and is composed of more open questions and discussions than a questionnaire with pre-established answers. The open discussions help to get a more complete sense of households' perceptions of fuel prices, as well as their behavior when fuel prices fluctuate. Also, combining qualitative and quantitative approaches gives more robust results and interpretations. Second, the integration of fuel price roles in the standard food security measurement scales gives the advantage of measuring the contribution of fuel costs to households' food conditions directly. The standard approach looks at food security measurement scales and compares with information on fuel prices. Third, considering domestic fuel pricing mechanism in each country allows getting a more in-depth understanding of the difference between countries in terms of crude oil prices pass-through to local food prices. Fourth, the disaggregation of the pass-through of international food and fuel prices at regional market level helps to account for regional disparities and hypothesize on possible smuggling of fuel or food in the region. Last, the distinction made between low or high dietary diversity contributes to establishing a possible link between households' livelihood, cultures/habits, and food security, which can help to rethink our approach of livelihood.

What can we derive from the study? At the macroeconomic level, not only high crude oil prices impact domestic prices level, but also, uncertainty about future prices positively affects domestic prices of goods and services. This risk about future prices of goods and services can be a reason justifying government regulation of the fuel market. The choice of fuel pricing mechanism and food policy are critical factors explaining countries' capacity to curb international crude oil and food price shocks. In general, at the disaggregated level, the pass-through of domestic fuel prices to food prices is higher than that of crude oil prices to domestic fuel prices. High pass-through of

domestic fuel prices to food prices versus low pass-through of crude oil prices to domestic fuel prices implies that the actual fuel pricing policies benefit high fuel buyers more than high food buyer (who are usually poor, due to the large share of income dedicated to food purchases. See Ceballos et al., 2017). Besides, porous borders can hamper markets forces, as well as government efforts.

At the microeconomic or household level, taking the case of Ouagadougou in Burkina Faso, results show that a significant proportion of households have low dietary diversity. Only 8% have a high diversity. The low diversity is not strictly and always associated with households' conditions. In fact, open questions reveal that habits and cultures matter as well for some households. Except for a few cases, households with high diversity are usually better off and have better food security level. The analysis also shows that food insecurity is well present in the selected sample. 38.7% of households are food secure, 28.3% food insecure with no hunger, 28.4% food insecure with moderate hunger, and 8.2% severely food insecure. There is a correlation between food security level and the scale of responsibility attributed to fuel prices. 71% of respondents who experienced food distress (i.e all food insecurity levels) state that fuel prices play a role. Severely food-insecure households tend to give high responsibility to fuel prices about their conditions. The vast majority of them mostly use motorbikes and less public transport (like all respondents), which contribute to worsening their conditions. Households facing moderate food insecurity state that fuel prices have a moderate contribution to their food conditions. Those facing food insecurity with no hunger give a low role to fuel prices. Finally, for food-secure households, any occurrence of food insecurity triggering factors has nothing to do with fuel prices. Across households, the most exposed to low dietary diversity and high food insecurity are found among females, widowed and divorcees, low educated, households' heads in agriculture/livestock or trade/transport, polygamic couples and households composed of more than five members.

The quantitative analysis shows and confirms the negative trade-off between food and fuel consumption, especially among the poor, and income plays a key role in this dilemma. Gender, literacy, education, income, and food expenses play vital roles in determining the risk to fall into food insecurity. Having a low income or a high household size increases the vulnerability to food insecurity. These households are more likely to fall into low, moderate, or severe food insecurity

unless their income raises high. Being from the above categories also reduces the chance to get out of severe food insecurity once trapped in. Finally, higher dietary diversity can imply a better living standard and food condition. The introduction of dietary diversity in the analysis shows that households with improved dietary are less prone to food insecurity and are the ones with better living conditions. The qualitative analysis reveals from the discussion with some respondents that low dietary diversity is not necessarily linked to poor living conditions or food insecurity but often to their consumption cultures or habits. Contrasting this finding with that of the quantitative analysis above, the study concludes that, as there are 60 tribes and cultures in Burkina Faso, researches aiming at linking food quality to food security and livelihood should be undertaken cautiously, on a case by case basis by considering each of these tribes' habits. For example, in some tribes, pregnant women and children are not allowed to eat eggs (risk of becoming a thief or having a thief child). These types of research need expertise from sociologists or anthropologists.

The analysis of behavioral responses to fuel price changes shows that smooth increases in fuel prices have more negative impacts on food security than sharp increments. A large proportion of households tend to cut their food consumption to respond to increase in fuel prices. The most impacted households are the most prone to food insecurity identified above. About 28% of severely food-insecure households will cut their food consumption if fuel prices go smoothly up. For some households, however, cut in non-necessary rides is an alternative. This alternative is present in 24% of severely food insecure households. When prices go significantly high, most households choose to change their locomotion and opt for walks, bicycles, or buses. Besides, there is an asymmetry in households' responses to fuel prices changes. A shortfall in fuel prices does not necessarily lead to a reaction similar to increases. In these events of shortfall in fuel prices, the most vulnerable households generally prioritize meals improvements while the less vulnerable choose to save. If prices go significantly down, irrespective of the living condition, precautionary saving appears to be the most noticeable behavior. Finally, some households increase their rides during cuts in fuel prices.

What is the answer to the central question: to what extent fuel costs contribute to food insecurity in West Africa?

In a straightforward answer, food insecurity is partially triggered and strengthened by two joint factors: 1) high pass-through of domestic fuel prices to food prices that increases poor households' vulnerability to fuel price shocks and food insecurity; and 2) high dependency on fuel purchases and motorcycle as primary locomotion that jeopardizes food budgets and food security.

The aforementioned findings have several implications and can contribute to governments' ex-ante and ex-post coping strategies. Affordable food prices policy through lowering input costs should not originate in fuel pricing, but instead, from direct actions on staple food prices as they are highly consumed by the poor. Reducing fuel prices to retrench transportation costs and food prices is not highly effective to reach food security for two reasons. The first reason is the asymmetrical price transmission which seems to be the rule rather than the exception (Meyer and Cramon-Taubadel, 2004 and Peltzman, 2000), as market agents always tend to maintain prices at a higher level for more profits. Therefore, fuel prices can be low (at the expense of government subsidies and the benefit of fuel buyers), while poor people will wait long before seeing a real impact in their livelihood. The second reason is supported by Baig et al. (2007) and Coady et al. (2010) who state that petroleum products subsidies are usually poorly targeted, and often harm social spending. In this regard, Cooke et al. (2014) estimated that around 78% of Ghana's fuel subsidies in 2013 profited the wealthiest quintile of the population, while less than 3% benefited the most impoverished. An additional reason is that in remote regions, many farmers rely on remote means of transportation to local markets such as carts and wheelbarrows, and are not affected by fuel price changes.

The impacts of high domestic food prices on the poor can be reinforced if the country's exchange rate depreciates. A depreciation of the currency leads to higher domestic food prices and more harms to the poor through direct and indirect channels. In the indirect channel, the depreciation of the currency increases crude oil prices transmission rate to domestic fuel prices, due to high import costs (for the case of Burkina Faso and Cote d'Ivoire, the two countries' common currency is pegged to the Euro and depends on the strength of the Euro). High real import costs of crude oil lead to high domestic fuel prices and thereby, high domestic food prices. The direct channel occurs through increments in import costs of food that directly impact the domestic market. As a full suspension of fuel price subsidy can affect input costs and also food prices, a maintaining of

government current effort or at least a smooth reduction of fuel price subsidies to channel them to staple food is necessary.
Besides, there is a need for governments to coordinate their actions for more safety guard on borders to avoid harmful practices that could lead to distortions in the food/fuel markets and obstructions of food access.

High and persistent increases in fuel prices pose to be severe problems for households living standard. The impact can be more severe among households facing severe food insecurity. On the other hands, households, especially those in non-favorable conditions or those facing harsh food distress, have a certain level of responsibility. High reliance and usage of motorbikes despite their critical conditions represent a significant threat that needs to be addressed. Furthermore, the conversation with respondents on the scenarios of fuel prices changes reveals that many have unnecessary rides and do not solely ride for work. Curtailing unnecessary rides and bounding to the most important ones could lessen the high reliance on fuels and improve food budget. This reduction in reliance on fuels will be possible if the government develops and invest in public transportation and road infrastructures, and more importantly, incentivize the population to use more public transportation. Affordable biofuel policy is an indispensable initiative government should stress on too, to increase households' long-term financial leeway.

This research, however, has the following caveats. First, only regional markets for which data are available and over a long period have been analyzed. There possibly exist small markets in each country where prices are not captured by policymakers or where data are not enough to undertake comprehensive studies. Second, the study does not incorporate local transport fares, marketing, and distribution costs as proxies for input costs. Third, it does not capture the possible effects of markets proximities as well as the roles of transport infrastructures. Fourth, counterfactual approach is missing. The study uses a set of countries with some characteristics and features to analyze the transmission of crude oil prices to food prices and derives the implication for food security. It does not take into account cases where countries have opposite features to make a comparison and derive a more comprehensive interpretation. For example, do the results differ between countries adopting a flexible and fixed exchange regime? Net oil-importing countries and net oil-exporting countries? Urban and rural areas? Net food buyers and net food sellers? Private

locomotion users and public transportation users? etc. In many cases, when such samples are selected, a good level of caution in the interpretations is necessary given the difference of contexts and backgrounds. All four caveats suggest that the results and interpretations should be considered as a representation of a portion of the phenomenon as many uncaptured factors intervene in fuel-food security nexus.

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Appendix

CHAPTER 2: Crude oil prices uncertainty and domestic prices of goods and services

A.2.1. Brief extended explanation of the VAR-GARCH-M

The general specification of GARCH-M models is specified as follows:

Mean equation:

$$y_t = \Phi + \sum_{i=1}^{p} \Gamma_i \, y_{t-i} + \Psi\sqrt{h_t} + \varepsilon_t \quad (1)$$

Variance equation: the zero-restriction version of the conditional structural is given by:

$$vec(H_t) = W + X_1 vec(\varepsilon_{t-1}\varepsilon'_{t-1}) + X_2 vec(\varepsilon_{t-2}\varepsilon'_{t-2}) + \cdots + X_j vec\left(\varepsilon_{t-j}\varepsilon'_{t-j}\right) +$$

$$Y_1 vec(H_{t-1}) + Y_2 vec(H_{t-2}) + \cdots Y_i vec(H_{t-i}) \quad (2)$$

where

$\varepsilon_t|\Omega_{t-1} \sim iid\ N(0, H_t)$

Ω_{t-1} is the information set in period $t-1$; ψ is a matrix polynomial included in the lag operator; 0 the null vector; H_t is a matrix of conditional variance-covariance; Φ is a vector of constants; Γ_i a matrix of coefficients on the lagged variables y_{t-i} where *i* is the number of lags (p is the maximum number of lags). W is a parameter vector and *dim(W) =N×1,* X and Y are squared matrices and *dim(X)=dim(Y)=N×N*, *vec(.)* is the vector operator that stacks the columns of the matrix. The specification of the conditional variance equation follows Engle and Kroner (1995), who extended Engle's (1982) ARCH and Bollerslev's (1986) GARCH models to multivariate settings.

Assuming *i=j=1*, the number of parameters to estimate is $(N^2+N+1)(N^2+N)/2$. The identification of such a system requires numerous restrictions in the parameterization. One frequently employed is the diagonal representation. This method was used by Engle, Granger, and Kraft (1984) in their ARCH model, and by Bollerslev et al., (1988) in their capital asset pricing model applied in a GARCH framework. Recently, Elder (2004) used a similar procedure in the VAR GARCH-M model. In the diagonal representation, conditional variances are set as functions of their own past squared residuals and covariance functions of residuals cross-products (Engle and Kroner, 1995). If equation (2) is expressed in terms of structural disturbances (for example $\varepsilon_t = H_t^{1/2} z_t$ implies

that $H_t = (\varepsilon_t z_t^{-1})^2$ and replace in equation (2)), and common identifying assumptions are imposed on the system, the equation becomes a diagonal one, as contemporaneous structural shocks are assumed not correlated. It ends up with the following specification to be estimated:

$$diag(H_t) = W + X_1 diag(\varepsilon_{t-1}\varepsilon'_{t-1}) + X_2 diag(\varepsilon_{t-2}\varepsilon'_{t-2}) + \cdots + X_j diag\left(\varepsilon_{t-j}\varepsilon'_{t-j}\right) + Y_1 diag(H_{t-1}) + Y_2 diag(H_{t-2}) + \cdots Y_i diag(H_{t-i}) \quad (3)$$

Besides, the approach follows Elder and Serletis' (2010) procedure for the case of bivariate VAR GARCH-M. Thus, i=j=1, the model is estimated by maximizing, with respect to the structural parameters B, Φ , Γ_i(i=$\overline{1,p}$), Ψ , W, X and, the log-likelihood function of the full information maximum likelihood (FIML) given by:

$$l_t = -\frac{1}{2}N\ln(2\pi) + ln\,|B| - \frac{1}{2}ln|H_t| - \frac{1}{2}(\varepsilon'_t H_t^{-1}\varepsilon_t) \quad (4)$$

The pre-sample values of the conditional matrix H_0 are set to their unconditional expectations and conditions on the pre-sample values $y_t(t = \overline{0, t-p+1})$. A non-negativity constraint is imposed on the matrices W, X and Y in the conditional variance equation (3) as follows: W=0 if W<0; X=0 if X<0; and Y=0 if Y<0. This restriction aims to ensure that H_t is positive definite (Engle and Kroner, 1995; Elder, 2004; Elder and Serletis, 2010).

A.2.2. Unit root tests

Country	Variables	ADF	P. Perron	DF-GLS	KPSS
	$\Delta ln\ oil$	-12.968***	-12.556***	-5.490***	0.108
Burkina Faso	$\Delta ln\ cpi$	-16.780***	-16.921***	-16.382***	0.115
Cote d'Ivoire	$\Delta ln\ cpi$	-11.102***	-11.215***	-9.719***	0.289
Ghana	$\Delta ln\ cpi$	-8.067***	-7.891***	-0.279	0.067
Niger	$\Delta ln\ cpi$	-11.637***	-11.389***	-7.917***	0.081
Nigeria	$\Delta ln\ cpi$	-7.151***	-10.342***	-7.012***	0.145*

ADF, P. Perron and DF-GLS null hypothesis: the variable has a unit root KPSS null hypothesis: the variable is stationary * significance at 10% ** significance at 5% ***significance at 1%

A.2.3. Johansen cointegration test crude oil, cpi

Country	Eigenvalue	Trace Statistic	Prob(5%)	Result
Burkina Faso	0.035	10.595	0.270	Not cointegrated
Cote d'Ivoire	0.033	10.357	0.126	Not cointegrated
Ghana	0.030	12.494	0.157	Not cointegrated
Niger	0.029	9.010	0.293	Not cointegrated
Nigeria	0.032	14.025	0.215	Not cointegrated

A.2.4. Alternative specifications of table 2.3

Table A.2.4.a) Alternative 1: Pre-2008 major oil crisis

Variables	Burkina Faso	Cote d'Ivoire	Ghana	Niger	Nigeria
	Cpi	Cpi	Cpi	Cpi	Cpi
Coef. on $h(t)^{1/2}$: impact of oil price uncertainty on Cpi (Ψ_1 in Mean Equation or $H_{2,2}$)	0.173***	0.389***	0.854***	-0.070	0.573***
	(0.070)	(0.075)	(0.073)	(0.064)	(0.082)
Cpi (-1)	0.452***	0.34*	0.334**	0.891**	0.55**
	(0.01)	(0.021)	(0.031)	(0.102)	(0.103)
Constant	0.005***	0.003*	0.101	0.002**	0.06*
	(0.002)	(0.001)	(0.011)	(0.003)	(0.043)
R-squared	0.560	0.123	0.343	0.56	0.34
Log likelihood	323.132	348.44	432.233	561.23	644.904
SIC	-6.225	-3.344	-5.78	-4.159	-7.67

* significance at 10% ** significance at 5% ***significance at 1%. Sample size for OPEC reference basket: 2003m01-2013m12.
A post-2008 crisis could not be estimated as the sample period was short.

Table A.2.4.b) Alternative 2: Brent (nominal)

Variables	Burkina Faso	Cote d'Ivoire	Ghana	Niger	Nigeria
	Cpi	Cpi	Cpi	Cpi	Cpi
Coef. on $h(t)^{1/2}$: impact of oil price uncertainty on Cpi (Ψ_1 in Mean Equation or $H_{2,2}$)	0.153***	0.290***	0.802**	-0.025	0.671***
	(0.060)	(0.063)	(0.065)	(0.055)	(0.065)
Cpi (-1)	0.89**	0.83**	0.83***	0.81***	0.55**
	(0.063)	(0.001)	(0.021)	(0.012)	(0.34)
Constant	0.051*	0.005*	0.011***	0.342	0.06**
	(0.017)	(0.031)	(0.003)	(0.035)	(0.104)
R-squared	0.239	0.341	0.642	0.821	0.561
Log likelihood	394.12	588.394	445.231	583.15	464.124
SIC	-2.345	-5.34	-6.516	-7.19	-4.55

* significance at 10% ** significance at 5% ***significance at 1%. Sample size for OPEC reference basket: 2003m01-2013m12.
A post-2008 crisis could not be estimated as the sample period was short.

Table A.2.4.c). Alternative 3: OPEC reference basket prices

Variables	Burkina Faso	Cote d'Ivoire	Ghana	Niger	Nigeria
	Cpi	Cpi	Cpi	Cpi	Cpi
Coef. on $h(t)^{1/2}$: impact of oil price uncertainty on Cpi (Ψ_1 in Mean Equation or $H_{2,2}$)	0.145	0.208***	0.827***	0.233**	0.834***
	(0.099)	(0.080)	(0.106)	(0.101)	(0.011)
Cpi (-1)	0.33**	0.912***	0.45**	0.661*	0.95****
	(0.006)	(0.001)	(0.011)	(0.12)	(0.066)
Constant	0.07*	0.45**	0.211***	0.202*	0.016**
	(0.111)	(0.231)	(0.023)	(0.145)	(0.004)
R-squared	0.89	0.66	0.75	0.67	0.76
Log likelihood	673.111	566.33	457.133	544.222	455.134
SIC	-6.133	-5.34	-3.516	-4.209	-4.589

* significance at 10% ** significance at 5% ***significance at 1%. Sample size for OPEC reference basket: 2003m01-2013m12.
A post-2008 crisis could not be estimated as the sample period was short.

CHAPTER 3: International crude oil pass-through to domestic food prices, the implications for food security

Table A.3.1 Unit root tests

Country	Variables	ADF	P. Perron	DF-GLS	KPSS
Burkina Faso	$\Delta ln\ fuel$	-7.504***	-7.457***	-6.064***	0.035
	$\Delta ln\ food$	-11.373***	-11.3***	-7.179***	0.035
	$\Delta ln\ maize$	-8.422***	-8.218***	-8.227***	0 .046
	$\Delta ln\ sorghum$	-9.663***	-9.66***	-7.223***	0.048
Cote d'Ivoire	$\Delta ln\ fuel$	-13.093***	-11.028***	-8.29***	0.051
	$\Delta ln\ food$	-9.793***	-9.655***	-8.017***	0.031
	$\Delta ln\ maize$	-14.891***	-14.997***	-8.23***	0.041
	$\Delta ln\ rice$	-13.578***	-14.119***	-7.463***	0.019
Ghana	$\Delta ln\ fuel$	-7.415***	-7.272***	-6.364***	0.056
	$\Delta ln\ food$	-11.301***	-11.301***	-7.609***	0.095
	$\Delta ln\ maize$	-9.842***	-9.727***	-7.284***	0.046
	$\Delta ln\ sorghum$	-8.079***	-7.711***	-7.803***	0.016
	$\Delta ln\ rice$	-19.63***	-20.479***	-10.082***	0.020

Table A.3.2. Johansen cointegration test: crude oil prices, exchange rate, and domestic fuel prices

Country	Eigenvalue	Trace statistic	Prob (5%)	Result
Cote d'Ivoire	0.399	36.868	0.007	1 cointegrated equation
Ghana	0.245	29.797	0.002	1 cointegrated equation
Burkina Faso	0.127	34.875	0.012	1 cointegrated equation

Table A.3.3. Johansen cointegration test: crude oil prices, world food prices, exchange rate, domestic fuel

Country	Eigenvalue	Trace statistic	Prob (5%)	Result
Cote d'Ivoire	0.413863	54.3737	0.0108	1 cointegrated equation
Ghana	0.171548	17.45926	0.025	3 cointegrated equation
Burkina Faso	0.207136	41.09267	0.1857	No cointegration

Table A.3.4. Johansen cointegration test: domestic fuel and food prices

	Eigen value	Trace Statistic	Prob (5%)	Result
Cote d'Ivoire				
Maize	0.307	24.270	0.189	No cointegration
Local rice	0.39	32.128	0.026	1 cointegrated equation
Bandama				
Maize	0.287	25.201	0.154	No cointegration
local rice	0.525	45.219	0.000	1 cointegrated equation
Montagnes				
Maize	0.525	45.219	0.000	1 cointegrated equation
local rice	0.551	47.009	0.000	1 cointegrated equation
Ghana				
Maize	0.121	15.196	0.767	No cointegration
Rice	0.282	30.872	0.037	1 cointegrated equation
Sorghum	0.256	31.951	0.027	1 cointegrated equation
Greater Accra				
Maize	0.059	10.561	0.970	No cointegration
Rice	0.181	20.042	0.42	No cointegration
Sorghum	0.194	23.465	0.224	No cointegration
Upper East				
Maize	0.142	16.064	0.707	No cointegration
Rice	0.123	15.349	0.757	No cointegration
Sorghum	0.126	17.003	0.639	No cointegration

Northern				
Maize	0.145	16.238	0.695	No cointegration
Rice	0.146	16.526	0.674	No cointegration
Sorghum	0.248	30.016	0.047	1 cointegrated equation
Ashanti				
Maize	0.171	18.628	0.519	No cointegration
Sorghum	0.061	9.827	0.982	No cointegration
Burkina Faso				
Maize	0.124	13.892	0.846	No cointegration
Sorghum	0.091	18.514	0.528	No cointegration
Mouhoun				
Maize	0.110	21.049	0.354	No cointegration
Sorghum	0.116	16.960	0.643	No cointegration
Sahel				
Maize	0.079	15.401	0.753	No cointegration
Sorghum	0.104	17.233	0.622	No cointegration
Centre				
Maize	0.152	26.517	0.114	No cointegration
Sorghum	0.114	17.335	0.615	No cointegration