DEMAND FOR COFFEE BY CLASS:

THE CASE OF UGANDA (1994-2024)

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DECLARATION

I declare that this dissertation is of my own authorship and that it results from my own research. This is the first time I submit it to obtain an academic degree at any educational institution.

Maputo, 16th /12/ 2025

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DEDICATION

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LIST OF ABBREVIATIONS

AC	Arabica Coffee
AIDS	Almost Ideal Demand System
CED	Cross Price Elasticity of Demand
FIML	Full Information Maximum Likelihood
GOU	Government of Uganda
IAIDS	Inverse Almost Ideal Demand System
ICO	International Coffee Organization
IDS	Incomplete Demand Systems
ILDS	Inverse Lewbel Demand System
INLES	Inverse Non-separable Linear Expenditure System
ITLDS	Inverse Translog Demand System
LAIDS	Linear Approximation to the Almost Ideal Demand System
LHS	Left-hand-side
LR	Likelihood ratio
MAAIF	Ministry of Agriculture, Animal Industries and Fisheries
OPED	Own-Price Elasticity of Demand
P	Price aggregator
P_1	Price of Arabica coffee
P_2	Price of Robusta coffee
P_r	Price of the related good (tea)
RC	Robusta Coffee
UBOS	Uganda Bureau of Statistics
UCDA	Uganda Coffee Development Authority
UEPB	Uganda Export Promotion Board
UGX	Uganda Shillings
UNHS	Uganda National Household Survey
USA	United States of America
WB	World Bank
X	Quantities demanded of Uganda's coffee exports
X_1	Quantities demanded of Uganda's Arabica coffee exports
X_2	Quantities demanded of Uganda's Robusta coffee exports
YED	Income Elasticity of Demand

ABSTRACT

Uganda's coffee falls into two main classes, namely Arabic coffee (AC) and Robusta coffee (RC). Given its significant role as a major coffee producer, the local coffee market remains small; even a large increase in coffee consumption domestically will not have a significant influence on global coffee demand and consumption. This study examines the interactions between demand for coffee exports by class on one hand, coffee prices, and expenditures on the other hand, which is important for stakeholders in the coffee trade. The fact that there is a growing demand for Uganda's coffee by consumers abroad, estimating this demand for coffee, is insightful for importers, exporters, and policymakers. To achieve the central objective of this study, an econometric method based on regression analysis is used. More precisely, it estimates the Rotterdam and Linear Approximation to the Almost Ideal Demand System (LAIDS) models, which are commonly used by most agricultural economists to analyse such interactions. The estimation of both models uses time series data from Uganda's economy, covering the period 1994-2024. The major findings and their implications indicate that Uganda's AC is a heterogeneous good, implying that the demand pattern for AC varies by quality, and RC is a homogeneous good, which generates less income from exports. Moreover, the demand for both coffee classes is inelastic, indicates that foreign consumers purchase similar quantities of coffee regardless of price changes, and implying that Uganda's coffee exporters have greater control over their prices because consumers are less likely to reduce their purchases in response to a price increase. Furthermore, AC and tea are substitute goods, which implies that increased demand for AC exports appeals to niche markets. Finally, AC is an inferior good, which implies that foreign exports demand for it increases during economic depression, while RC is both a normal good and a necessity, thus benefiting from higher RC exports revenue. In this context, this study recommends that exporters should enhance coffee demand by exporting both AC and RC that are of improved quality to increase export value and that future research should be applied in both domestic, and import coffee trade dynamics.

Keywords: Coffee classes, Coffee exports, Demand for coffee, Homogeneity/Heterogeneity, Demand elasticities, and Consumers' income

SUMÁRIO

No Uganda, há duas classes principais de café de Uganda, nomeadamente café arabico (AC) e café robusto (RC). Apesar do seu papel significativo como um dos principais produtores de café, o mercado interno é ainda reduzido; mesmo um grande aumento do consumo interno não teria influência significativa na procura e no consumo global. Este estudo examina as interacções entre a procura de exportações de café por classe, por um lado, os preços do café e as despesas, por outro, o que é importante para os intervenientes no comércio de café. O facto de existir uma procura crescente de café do Uganda por parte dos consumidores estrangeiros, e a estimativa dessa procura, são informações valiosas para os importadores, exportadores e decisores políticos. Para atingir o objetivo central deste estudo, é utilizado um método econométrico baseado na análise de regressão. Mais precisamente, estimam-se os modelos de Roterdão e de Aproximação Linear ao Sistema de Procura Quase Ideal (LAIDS), comummente utilizados pela maioria dos economistas agrícolas para analisar tais interações. A estimação de ambos os modelos utiliza dados de séries temporais da economia do Uganda, abrangendo o período de 1994 a 2024. As principais conclusões e as suas implicações indicam que o café do Uganda (AC) é um bem heterogéneo, o que implica que o padrão de procura de AC varia de acordo com a qualidade, e o café comum (RC) é um bem homogéneo, que gera menos receitas com as exportações. Além disso, a procura por ambas as classes de café é inelástica, indicando que os consumidores estrangeiros compram quantidades semelhantes de café, independentemente das alterações de preço, e implicando que os exportadores de café do Uganda têm um maior controlo sobre os seus preços, porque os consumidores são menos propensos a reduzir as suas compras em resposta a um aumento de preço. Além disso, o AC e o chá são bens substitutos, o que implica que o aumento da procura de exportações de AC atrai mercados de nicho. Finalmente, o AC é um bem inferior, o que implica que a procura estrangeira de exportações aumenta durante a recessão económica, enquanto o RC é tanto um bem normal como uma necessidade, beneficiando, por isso, de uma maior receita proveniente das exportações de RC. Neste contexto, este estudo recomenda que os exportadores aumentem a procura de café exportando AC e RC de qualidade melhorada para aumentar o valor das exportações e que a investigação futura seja aplicada tanto na dinâmica do comércio interno como na da importação de café.

Palavras-chave: Classes de café, Exportações de café, Procura de café, Homogeneidade/Heterogeneidade, Elasticidades da procura e Rendimento do consumidor.

CHAPTER I
INTRODUCTION

The sections that follow provide background information on the study, describe the study's motivation, present problem statement, define objectives, and present structure of the dissertation.

1.1 Background of the Study

Agriculture is a dominant sector in developing strategic efforts to reduce hunger, poverty, and increase foreign earnings (Mwesigwa *et al.,* 2023). About 50% of the population of Uganda is predominantly involved in this sector for their livelihoods and income sources (Turyasingura & Agaba, 2022). Agriculture production and exports contribute to economic growth with a 23% contribution to the GDP (UNHS, 2020). Over the years, many studies have described the characteristics of Uganda's agriculture sector. For instance, Aribo (2024) indicate that this sector is characterized by low production, mainly due to the use of traditional farm inputs and low investments. Along with Sette & Bukumunhe (2022) and Aribo (2024), they also indicate that coffee continues to be a commodity that significantly contributes to Uganda's economic growth, in terms of increased agricultural production and exports revenues.

Furthermore, the International Coffee Organisation (ICO) also reveals that coffee is a key cash crop, generating foreign exchange for developing countries like Uganda, which is important for safeguarding global market access for imports of goods and services (ICO, 2023). The World Bank report indicates that coffee acts as a livelihood source for about 12 million people nationwide in Uganda. There are two main coffee classes, such as Robusta coffee (accounting for 83% of exports) and Arabica coffee (accounting for 17% of exports), in the year 2023 (WB, 2023). According to UCDA (2019a), out of the 44 districts (51%), 32% grow only Arabica, 3% grow only Robusta, while 17% grow both Arabica and Robusta. The coffee value chain contributes approximately 3% to Uganda's GDP (Sette & Bukumunhe, 2022).

Still, coffee is the most commonly consumed beverage in the USA, with a higher demand that yields numerous benefits in moderate daily consumption (Ahsan & Bashir, 2019). However, intake of excess also leads to health complications. Coffee beans are decorated and roasted for their flavour and aroma, with an attractive caffeine component (Ahsan & Bashir, 2019).

According to Amrouk *et al.* (2023), Vietnam and Brazil are major coffee producers globally, together accounting for about 50% of the coffee produced globally and the same authors indicate that the estimated coffee production value globally amounted to US$23 billion, whereas global coffee trade exceeded US$26 billion in 2023 (Amrouk *et al.,* 2023).

Additionally, the world's coffee production is estimated at 9,232,140kgs in the financial year 2016/17, and further, the authors show that in Africa, Uganda was being the top leading coffee producers with 3.8 million 60kg bags after Ethiopia (Torga & Spers, 2020). This is presented in the table below.

Table 1.1: Major coffee-producing countries by class, (10^3 60-kg bags) 2010-2017

Country	Class	Years						
		2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Brazil	AC/RC	53.428	50.59	55.420	54.698	52.299	50.388	55.000
Colombia	AC	8.523	7.652	9.927	12.163	13.339	14.009	14.500
Indonesia	AC/RC	9.129	10.64	11.519	11.265	11.418	12.317	11.491
Vietnam	AC/RC	20.000	26.50	23.402	27.610	26.500	28.737	25.500
India	AC/RC	5.033	5.233	5.303	5.075	5.450	5.800	5.333
Uganda	AC/RC	3.267	3.115	3.914	3.633	3.744	3.650	3.800
Honduras	AC	4.331	5.887	4.686	4.578	5.258	5.766	5.934
Ethiopia	AC	7.500	6.798	6.233	6.527	6.625	6.714	6.600
Peru	AC	4.069	5.373	4.453	4.338	2.883	3.304	4.222
Guatemala	AC/RC	3.950	3.85	3.763	3.189	3.310	3.420	3.500
Top 10 producers		119.23	125.6	128.62	133.08	130.83	134.10	135.88
World		139.60	147.9	149.62	152.23	148.74	151.57	153.87

Source: Torga & Spers (2020)
Notes: Class RC is Robusta and AC is Arabica coffee.

Table 1.1 above clearly indicates that Vietnam and Brazil are the leading producers globally. In contrast, Uganda and Ethiopia are the top producers in Africa, particularly for the two classes of coffee. The only significant difference in figures is that Peru, Uganda, and Honduras increased their global market share, whereas Guatemala's market share remains slightly low, as the main players still compose the top four (Brazil, Vietnam, Colombia, and Indonesia).

Notwithstanding frequent fluctuations in global pricing and corresponding reductions in coffee production among several African countries, Uganda has consistently maintained coffee as a primary engine of its national economic growth, exporting an average of four million 60-kilogram (kg) bags each year (Ategeka, 2022). Additionally, the exports growth is mainly dependent on increased crop exports earnings, led by coffee, cocoa, and tobacco. Coffee exports earnings more than doubled to $167.68 million in February 2025 from $82.56 million in the same month of 2024 (MoFPED, 2023). This followed a general increase in coffee prices on the international market, coupled with a rise in the volume of Ugandan coffee exported, which increased from 434,582 60-kg bags in February 2024 to 555,756 bags in February 2025 (Ategeka, 2022). Thus, this reveals that coffee remains a significant crop in Uganda, as presented in the table below.

Table 1.2: Major Ugandan crops and their exports value, (10^6 US$) 2010-2017

Major tradeable crops	2010	2011	2012	2013	2014	2015	2016	2017
Coffee	284.64	466.66	372.50	425.41	407.40	402.63	371.65	555.44
Non-Coffee Formal Exports	1351.00	1696.63	1984.25	1982.05	1902.79	1865.43	2130.36	2245.44
Cotton	21.19	27.34	76.00	31.42	21.83	20.57	31.43	50.70
Tea	68.26	71.81	73.90	85.62	84.70	69.94	71.58	79.72
Tobacco	69.35	54.52	61.59	114.94	65.27	73.13	61.73	46.22
Simsim	12.87	17.28	11.56	28.61	55.11	52.20	14.52	17.27
Maize	35.42	27.34	59.16	42.09	47.26	90.97	70.17	95.91
Beans	7.96	18.86	12.68	16.02	25.12	53.88	38.26	84.21

Sources: Sette & Bukumunhe (2022), UBOS (2021), and MoFPED (2023)

Figures in the table above provide numerical evidence that coffee is an important crop with the highest exports value of $555.44 million in 2017, as compared to other crops in Uganda.

According to Kwame (2021), it is worth noting that coffee have always played a significant role in traditional norms and customs, as it was traditionally used to express friendship and welcome in Uganda. Also, the government's implementation of liberalisation and privatisation policies in the early 1990s helped the coffee sector by providing substantial support to coffee growers while also enhancing the business environment (Kwame, 2021).

Uganda is second largest exporter of coffee in Africa that offer two coffee classes such as Arabica and Robusta (Davis *et al.,* 2022). A study describes Robusta coffee as an indigenous crop and planted on a higher altitude (of between one thousand, and one thousand and three hundred meters). This class of coffee is notorious for its good taste and that is mostly dry-processed as well as useful for blending purposes (Parizat *et al.,* 2011). On the other hand, Arabica coffee originated from Malawi and Ethiopia. In Uganda, this class of coffee is grown mostly on the Mountain Rwenzori and the Elgon Mountains slopes. It is mostly pulped and washed. For many last-mile rural areas, coffee sub-sector improves livelihoods for 1.7 million homes (UCDA, 2019a).

Despite of the economic importance of coffee, the world coffee consumption statistics for the year 2023/24 show that consumption is anticipated to rise by 2.2% which strongly influences its demand. Consequently, the coffee market globally, exhibit a 1.0 million bags of surplus (ICO, 2023). According to Ategeka (2022), Uganda faces problem in its benefits; whereas volume of coffee produced appears high, there is relatively low consumption locally. Ugandans usually consume, on average, 3% to 4% of the coffee produced, whereas the remaining percentage is exported (Davis *et al.,* 2022; Sette & Bukumunhe, 2022).

Uganda is recognized for better quality coffee, yet its consumption domestically remains low in relation to the volume exported, and even if local consumption demand is enhanced could not absorb Uganda's coffee production, thus this is very vital to analyse the demand for Uganda's coffee exports. Table below supports the above numerical evidence; the same table presents Uganda's trends of coffee in the period 2004-2010.

Table 1.3: Coffee production, exports, and domestic consumption, (Tons) 2004-2010

Year	Production (Tons)	Exports (Tons)	Domestic consumption (Tons)	Exports as % of production
2004	170,081	159,983	10,098	94%
2005	158,100	142,513	15,587	90%
2006	133,310	126,887	6,423	95%
2007	175,346	164,540	10,806	94%
2008	218,781	200,640	18,141	92%
2009	196,055	181,324	14,731	92%
2010	166,925	159,433	7,492	96%

Sources: Ahmed (2012) and Ategeka (2022)

Figures in the above table show that in 2009, marketed production as coffee quantities demanded (that is, used as a proxy for production) totaled 196,055 tons.

According to Ahmed (2012), this is equivalent to 3.3 million 60-kg bags of coffee. Comprising 153,822 tone of RC and 42,050 tons of AC. Following the same author and FAO statistics, overall, there was a reduction of 14.3% in the quantity of coffee obtained in 2010 compared to 2009, due to a 20.5% decline in the Robusta coffee production, which is mostly grown than Arabica coffee (Ahmed, 2012).

Furthermore, Table 1.3 compares coffee domestic consumption to production and exports, which is relatively low, between 4-10% of production. As such, coffee is a major crop that is exported annually. When the objective of increasing consumption domestically (currently estimated at 7,500 tons) is to enhance consumers incomes, that is unlikely to be accomplished.

According to Amrouk *et al.* (2023), the European Union (EU), together with USA are the top consuming coffee markets internationally. Moreover, in many low-income countries, coffee exports acts as revenue source. For example, in 2023, the coffee exports generated earnings of 33.8% and 15.4% for Ethiopia and Uganda, respectively (Ahmed, 2012). Still, actual production is subject to demand for coffee exports, which in turn enhance consumption demand for importing countries. The countries that purchase the most coffee exports as regarded as the biggest consumers of the global market, are not limited to the United States and Germany (Torga & Spers, 2020). This is presented in the table below.

Table 1.4: Domestic consumption of major importing countries, (10^3 60-kg bags)

Country	2010	2011	2012	2013	2014	2015	2016
United States	21.783	22.044	22.232	23.417	23.767	24.438	25.243
Germany	9.292	9.460	8.830	9.378			
Japan	7.192	7.015	7.131	7.435	7.494	7.695	7.872
France	5.713	5.962	5.790	5.707			
Italy	5.781	5.689	5.710	5.634			
Russian Federation	3.700	3.754	3.696	3.648	4.021	3.846	4.438
Spain	3.232	3.149	3.435	3.501			
United Kingdom	3.134	2.925	2.926	2.828			
Poland	2.156	2.034	1.936	1.669			
Netherlands	1.347	909	1.382	1.625			
European Union	41.196	40.756	40.979	41.852	42.234	41.578	43.307
Top 10 countries	63.330	62.941	63.068	64.842	35.281	35.979	37.553
Total number of importing countries	67.548	73.683	76.540	76.438	76.910	79.457	80.661
World	94.784	107.137	118.892	120.390	122.225	125.565	127.905

Notes: European Union (EU) countries are excluded due to specific data availability limitations, which only extend to 2013. The world's consumption is the sum of the total consumption of importing and exporting countries.
Sources: ICO (2021) and Torga & Spers (2020)

Figures in the table above show that the EU represents more than 50% of coffee consumption total consumption by importers. The majority of coffee consumers from outside EU are the USA, which holds the largest global coffee consumption, the Russian Federation, and Japan. Moreover, these four countries' coffee consumption accounted for the global consumption of 96% in 2016 by importing countries.

According to UCDA (2019a) and Mwesigwa *et al.* (2023), Ugandan coffee owes its originality to the highlands of Malawi and Ethiopia. As introduced in 1900, purposely for revenue generation by colonials. Henceforth, nearly all Uganda's nationals subordinate it to mandatory labor, leading to *Kiboko* name, which refers to a whip in *Kiswahili* (Agaba *et al.,* 2023).

Furthermore, Sette & Bukumunhe (2022) also indicate that Uganda produces superior processed Arabica coffee and accounts for 20% of Uganda's coffee quantities. As also indicated by the same authors, it grows on the gentle slopes Mt. Rwenzori, Muhabura, and Okoro highlands at an altitude between 1,200-2,500m above sea level.

Also, the coffee crop is mostly grown in the central and southern Ugandan districts of Kasese, Mpigi, Wakiso, Mbale, and Rakai, with about 23%, 57%, and 10% in eastern, central, and western regions, respectively, while the rest of the areas are non-traditional and represent about 10%. The marketed coffee in Uganda is the washed, or dry, berries.

Moreover, UBOS (2021) statistics point out that Uganda's mean yearly coffee production is about 5 million 60 kg bags, of which a higher percent belongs to the Robusta class of almost 80% and the remaining percent is for Arabica. Most of the Uganda's coffee exporters in the foreign markets are Europe, North America, and Asia, which increases foreign exchange. The table below presents coffee exports by destination in the period 2009-2010 / 2016-2017.

Table 1.5: Coffee exports by destination, (60-kilo bags) 2009/2017

Destinations	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
EU	1,939,235	2,365,159	1,828,300	2,468,890	2,373,392	2,386,995	2,254,512	2,844,350
Sudan	499,755	460,032	427,573	454,007	577,348	508,506	455,970	663,816
Switzerland	98,626	119,797	42,130	33,903	58,952	55,767	22,108	71,282
USA	79,485	95,168	106,489	195,561	77,105	106,939	117,985	152,821
India	-	-	72,868	90,080	99,604	94,720	131,532	233,072
Russia	5,186	26,280	34,101	22,148	20,891	32,192	32,710	28,975

Source: Sette & Bukumunhe (2022)

Figures in the above table show that during the period 2009-17, the largest Ugandan coffee destination was the EU, followed by Sudan, the USA, India, Switzerland and least was Russia.

Nevertheless, the ICO supports increased production levels, and the Uganda's domestic coffee consumption remains low, associated with exports quantities (ICO, 2023).

Moreover, Bamwesigye (2015) highlights some of the major Uganda's coffee sector challenges that including price instability, shifting global market demands, and limited processing as well as storage infrastructures. These hinder the farmers' income stability and further decrease the expansion of domestic consumption and demand for exports. In Uganda, there are efforts to solve these problems, including improving export demand for coffee and consumption through sensitisation of farmers and exporters about advantages of coffee value addition.

According to Sette & Bukumunhe (2022) points out that quality standards enhancement leads to increased coffee sector productivity in Uganda through better agricultural practices. This sector's production is fostered by its economic importance, climatic conditions, and global market demand (Turyasingura & Agaba, 2022). Coffee cultivation is one of the major income source for last-mile areas and significantly boosts agricultural sector development (Nahanga *et al.,* 2015). The health benefits are many for coffee and its products; For instance, research studies indicated that coffee consumption prevent against diabetes and colorectal cancer. However excessive coffee intake rise blood level of low-density lipoproteins in human beings. Also have been seen in pregnant ladies in the form of still birth, miscarriages and mentally retard fetus as cited in Ahsan & Bashir (2019).

This study was focused on Uganda, which is an agricultural-based economy, contributing to GDP by 24%, and employs population about 70% (UBOS, 2021b). Coffee is a leading cash crop that is exported and around 5 million Ugandans are involved in production then added coffee value chains associated firms (UCDA, 2019a). Despite the many traded commodities like tea, maize, and cocoa, coffee is the main Ugandan exports commodity, as depicted in 2017/2018.

Coffee was valued at US$492 million, accounting for for16% of overall exports. About the production volumes, Uganda is ranked first among Commonwealth coffee producers and second in Africa, as well as eighth in the world. As such, it is the fourth-largest producer of Robusta globally (UCDA, 2019b).

Furthermore, this study considered coffee by class and its price trend data, as well as the price of tea as a substitute good. This is because they are Uganda's four major traditional exports, which is evident (UBOS, 2024). The table below supports the choice of such goods and shows the most current monthly exports value in million US dollars for four key traditional exports of Uganda.

Table 1.6: Uganda's major traditional exports, (10^6 US$) 2023/2024

Commodity	2023							2024					
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Coffee	90.6	105	111	94.4	79	70.7	66.1	86	83	65.6	84.9	127	162
Cotton	3.0	0.8	2.1	1.8	0.4	0.0	1.3	2.0	5.9	3.5	2.3	1.4	0.3
Tea	8.6	7.6	6.3	5.9	8.1	6.0	5.2	6.5	4.9	4.4	5.8	5.8	4.9
Tobacco	4.7	6.0	5.4	4.0	7.7	5.5	6.9	4.3	4.0	15	8.1	7.3	5.4
Total	107	120	125	106	95	82.3	80	99	97	88	101	142	173

Source: UBOS (2024)

Figures in the table show coffee exports increased significantly, reaching a peak in June 2024 of US$162.4 million from US$65.6 million in May the same year. Exports of tea were relatively stable, with a high of US$8.1 million in August 2023 and ending at US$5.8 million in June 2024.

Another study by Ategeka (2022) points out that coffee market is guaranteed, maintainable, and demand for quality coffee is significantly increasing. At this moment, international coffee demand is approximately 150 million bags compared to exports capacity of 148 million bags, which indicates a significant deficit of 2 million bags. Following the same author, in 2020, the coffee demand increased to 175.8 million bags. Given intact potential coffee production, Uganda has an occasional advantage of increasing both its coffee volumes and quality to have an adequate supply to close the increasing demand (Ategeka, 2022). Coffee is a vital crop traded in Uganda that provide potential investment, as farmers earn incomes of over UGX10 million each hectare of land yearly at the household level (Sette & Bukumunhe, 2022).

Thus far, farmers adopt good agricultural practices like growing pest and disease-resistant, and high-yielding varieties of coffee. To achieve these, coffee actors need timely technical, market demand information to direct their operations in this sector. The above practices are expected to increase coffee production, exports volumes, and value to the rest of the world's coffee consumers. Although the demand for coffee in Uganda remains low in domestic market due to several factors, such as limited information and a preference for other substitutes, such as tea, in rural communities, as well as high prices of sugar (NPHC, 2017). Additionally, inadequate economic infrastructure for value addition and marketing also contribute to such low domestic demand and subsequent consumption. This not only hinders Uganda's coffee sector sustainability but also worsens socio-economic inequalities in coffee-producing communities (Davis *et al.,* 2022).

Demand for Ugandan coffee exports is said to have inelastic demand in international market, which indicates a significant gap in Uganda's coffee consumption to the rest of the world, as compared to domestic consumption levels (Aribo, 2024). Despite attempts to increase Uganda's coffee exports, it becomes imperative to strengthen economic flexibility, reduce global market dependency, and maximize socio-economic benefits derived from coffee. The elementary concepts predominant at domestic, global, and economic level is consumer demand, and budget share or expenditure share of the household and/or the country's consumption (exports consumption in this case of the study) is meant to satisfy their needs and wants (Razzaq & Aima, 2015).

According to Ahsan & Bashir (2019) all commodities durable and non-durable are included in household or country's demand to satisfy needs which details financial budget and planning that considers demand preferences and spending since such an expenditure comprises huge income percentage of the country's GDP; thus, stakeholders should also put into consideration how demand changes with income and price changes. Furthermore, some studies did not explain deeply why individuals, demand and consume less coffee (Mussatto *et al.,* 2011). Therefore, addressing the question related to how demand for Uganda's coffee abroad be boosted through this study. This links to the section that follows.

1.2 Motivation for the Study

Many food and cash crops are different by classes. Thus, coffee has a significant role in the county's economy, and it is necessary to investigate about behavior of its demand function. This study investigate interaction between the quantities demanded of two important coffee classes, their respective prices, and expenditure in contrast. The exclusion of the other classes from this study is accounted for by the fact that quantity demanded data on other coffees are very limited and this study assumes that subclasses of coffee are not subject of the matter.

The motive of this study is based on the grounds of academic, professional growth in agricultural economics for business growth, making policy decisions, and economic development through understanding how access to coffee prices and incomes influences demand for Uganda's coffee by foreign consumers. This research lies in its potential to provide valuable insights into how interactions between prices and income changes influence demand.

The motives for this study are as follows; academic, business growth and strategy, policy making and decisions, and economic development as explained below. Academic contribution:- This study contributes to academia by adding to empirical literature on connection between demand for coffee and sector performance in Uganda. It delivers empirical findings that can enrich theoretical frameworks and serve as a ground for further studies in this area. Despite several research studies done in general on demand for food commodities and in particular on coffee. This research is distinctive and significant from an academic perspective to investigate the following reasons: first of all, it addresses the scarcity of studies focusing on the demand for coffee by class, a case of Uganda. The critical importance of this study is for advancing knowledge on the demand for coffee by class internationally, quantities demanded for coffee, which is a vital engine of sustainable economic growth and employment generation for the working-age population, that has not been widely explored in Uganda.

Furthermore, there is an existing gap in understanding specific interactions of quantities demanded, prices, and expenditures, as well as demand elasticities that influence demand for coffee by class, especially in the case of Uganda. Thus, this research differs from preceding empirical studies, further strengthened in sections (2.2) and (2.3), since it investigates a wider range of issues. As indicated in sections (1.3) and justified in section (2.2), not enclosed in the studies. This difference makes this study significantly contribute to the field of economics, mostly agricultural economics, as also justified in sections (2.2) and (2.3). Some of the empirical findings reported thus far reinforced the suggestion that coffee is a heterogeneous good and hence that, ideally, demand for coffee modelling had better not be aggregated across classes, as indicated in section (3.1).

Given the context, this research is also vital as it is conducted under the assumption that coffee is a heterogeneous good. For itself, it is anticipated to deliver empirical evidence on the controversy over whether or not coffee is a heterogeneous good. Thus, this study is relevant; subsequently, it serves as an upcoming research work on demand systems benchmark.

Business growth and strategy: For businesses to thrive, especially coffee in Uganda, this study's findings can offer valuable insights into the importance of analyzing coffee prices and quantities in enhancing demand and coffee marketing. This understanding can guide strategic decision-making regarding profit capital investment, human capital, and operational processes to optimize business performance.

Policy making and decisions: The ultimate aim of this new knowledge is to inform policymakers, development practitioners, and stakeholders about the critical demand for coffee interactions. Thus, the findings can inform policymakers about the effectiveness of coffee exports policies and regulations in facilitating access to global markets to increase demand. This knowledge can guide the development of targeted policies aiming at improving coffee market inclusivity and promoting economic growth.

Lastly, but not least, economic development and alignment with national development strategies: This study can provide a robust foundation for designing effective interventions that increase demand for coffee by class, a case of Uganda, and foster socio-economic growth. The findings will also support national development strategies, including National Development Plans (NDPII and III) and the Vision 2040, which underscore the crucial role of the coffee subsector in developing the agricultural sector.

1.3 Statement of the Research Problem

Most existing studies on the demand for goods have emphasized the changes in price and income effects, investigating how these changes affect demand for goods. This research is directed under the basic assumption that in Uganda, coffee is a heterogeneous good (that is, different classes of coffee should be considered as separate goods).

According to Sette & Bukumunhe (2022), the annual domestic consumption of coffee in Uganda, categorized by coffee class, has shown a steady increase from the 2009/10 to 2017/18 period. Specifically, Robusta coffee consumption grew from 147,900 bags in 2009/10 to 183,600 bags in 2017/18, reflecting consistent growth over the years. Arabica coffee consumption also increased, from 40,800 bags in 2009/10 to 61,200 bags in 2017/18, indicating a rising preference for Arabica coffee because a more percentage rise in preference for AC (0.5%) as compared to RC (0.24%). This trend highlights gradual but sustained rise in domestic coffee consumption across both classes over the years. Moreover, Sette & Bukumunhe (2022) further indicate that the coffee domestic consumption is still low with about 3-5 % of Uganda’s yearly of coffee produced.

Given Uganda’s relatively small coffee market, even large increases in coffee consumption domestically will not exhibit a significant effect on demand for coffee globally and consumption. Thus, no effect on world price (Musumba & Gupta, 2013). This is the reason why the study is restricted to the demand for Ugandan coffee by the rest of the world. Thus, in this study, problem being investigated is that despite Uganda's great role as a major producer of coffee as shown in

Table (1.1), with robust production levels primarily of Robusta class as shown in Table (1.3), the country faces major challenge of low consumption domestically as also shown in Table 1.3), inspite of having the European Union as the leading Ugandan coffee exports destination in the rest of the world as shown in Table (1.5).

According to the UCDA (2023) report, the high total coffee exports of 553,529 60-kg bags are evident in June 2023 of the season. Furthermore, USDA (2024) observes that 300,000 bags of coffee in total are locally consumed as compared to 4 million bags of annual exports. This disparity between significant production levels for exports and narrow domestic consumption forms economic vulnerabilities as the country becomes more reliant on the unstable foreign coffee market. Currently, what is exported is not good enough on the international market. Nevertheless, low coffee consumption by Ugandans locally weakens economic potential profits from increased domestic consumption, namely an increase in farmers' income, economic growth, and preservation of culture.

Based on the description above, an attempt is made to answer the fundamental question in this research below.

- What are the interactions between demand for coffee by class on one hand and prices of coffee, and expenditures, on the other hand?

This study covers a 30-year timespan from 1994 to 2024. The choice of this study period is justifiable for the structural policy shifts in Uganda's coffee sector, such as Uganda's liberalisation policies (post-early 1990s) (Bamwesigye, 2016), global market policy reforms (end of International Coffee Organization quota system in 1989, with effects felt into the 1990s) (Musumba & Gupta, 2013), and major policy interventions affecting demand for coffee and trade (for instance, the restructuring of UCDA back into the mother ministry (MAAIF) to fulfill the coffee act, with effects felt into 2024) have typically influenced demand for its exports (Government of Uganda, 2021). This period starts from a date that is depicted by the available data. Thus, this study uses time series data on Arabica and Robusta classes of coffee, their prices, and expenditures on Uganda's coffee exports, and in this context, at least considers one selected substitute good price (Price of tea (P_r)) since it is one of the major traditional exports commodities as indicated in Table (1.6), indicating that tea exports were relatively stable, with a highest exports value of US$8.1 million (UBOS, 2024). This study attempts to analyze such a relationship as mentioned, taking Uganda's coffee by classes as a case study.

1.4 Objectives of the Study

This general objective is to analyse the demand for coffee by class, taking Uganda as a case study. In this context, the specific objectives are:

- To assess whether Uganda's coffee exhibits heterogeneous demand patterns; and
- To estimate Uganda's coffee demand elasticities in the international coffee market.

1.5 Structure of the Dissertation

This research study is structured into chapters, namely Introduction, Literature review, Methodology, Analysis of Results, and Conclusions.

Chapter II presents the relevant literature (that is, directly related to the research topic), taking into consideration both a theoretical framework, empirical studies, and a critical evaluation of literature. Chapter III presents methodology for this study. Chapter IV presents, interprets, and analyses the results. The last chapter concludes the dissertation, gives policy recommendations, and presents the study limitations.

CHAPTER II
LITERATURE REVIEW

The sections that follow describe the theoretical framework of analysis, present some selected previous empirical studies related to the research topic, and undertake a critical evaluation of the reviewed literature.

2.1 Theoretical Framework

The subsections that follow define the key concepts used in this study, describe the theories of demand for goods, and present the modeling of demand for goods relationships.

2.1.1 Definition of Key Concepts

Paragraphs that follow define the key concepts used in this study, namely; Coffee classes, Coffee exports, Demand for coffee, Homogeneity/Heterogeneity, Demand elasticities and Consumers' income.

Among the existing definitions, those developed by Hrishika (2014) and UCDA (2019b) stand out. In this context, Hrishika (2014) defines coffee as a brewed beverage derived from roasted or baked seeds of various species belonging to an evergreen shrub of the genus coffee. In turn, UCDA (2019b) defines coffee as the most ancient and vital commercial agricultural commodity, serving as a principal source of foreign exchange, and accounting for 15% of annual exports earnings over the past decade. Similar to Hrishika, UCDA also classifies coffee as the Arabica and Robusta classes, which are considered to be the two most important coffee beans sources, and they are highly sought after for trade worldwide.

According to Nahanga *et al.* (2015), coffee exports refer to the quantity of coffee exported by individuals or groups over a specified period. This can be measured in terms of total volume (60-kg bags) per year (Parizat *et al.,* 2011). Moreover, Torga & Spers (2020) defined demand for coffee as coffee quantities demanded by persons or countries over time. It is considered both domestically and internationally in terms of demand.

Many authors over the years have attempted to define the concept of demand as quantities of a good that buyers are ready to pay at a given price within a specified time (Zin, 2022; Wu, 2023). Moreover, the consumer expectations and willingness to pay are often reflected in demand for a commodity given the price (Wu, 2023). Thus, following the same author, from necessities to luxury goods indeed range in price (Wu, 2023).

Following Topik (2004) homogeneous situation for goods occurs when a country mainly produces and or exports similar goods elsewhere in another country. Whereas a heterogeneity situation for goods is defined as when a country mainly produces and or exports differentiated goods in quality, flavour, and taste. The same authors indicate that fact that, coffee is a semitropical luxury good produced primarily for exports rather than domestic use. Thus, heterogeneity, more important in the coffee's early 1990s than homogeneity. A policy to establish coffee grades, standards, and the prevention of contamination was mostly handled by the private sector. In the 20th century, such policy intervention was implemented by many exporting countries. Thus, the concept of heterogeneity for coffee (Topik, 2004).

Many authors have also attempted to define demand elasticities by types, namely, own-price, cross-price, and income elasticity of demand, for instance (Kumar *et al.,* 2011). Own-price elasticity of demand (OPED) quantifies how amount of a commodity bought changes based on its price, while cross-price elasticity of demand (CED) reflects demand changes for a good when prices of other related goods vary (Andreyeva *et al.,* 2010). In this context, economic models like both Rotterdam and AIDS for agricultural markets rely on these elasticities. Elasticities of these models are conditional, meaning they depend on a consumer's spending for a good. Other studies estimated that demand models are based on prices and total expenditure on goods or total income (Mustafa *et al.,* 2022). Moreover, according to Vochozka *et al.* (2022), the concept of elasticity was developed by Alfred Marshall. Up to now, the position of elasticities is important for demand analysis applied by most economists (Vochozka *et al.*, 2022).

2.1.2 Theories of Demand for Goods

The economic theory of the Law of Demand stands out when it comes to the demand for goods. It states that holding all other factors constant (*ceteris paribus*), demand for a good increase with a decrease in its price and that it decreases with an increase in its price (Arida *et al.,* 2015). In short, it shows an inverse relationship (Aribo, 2024). According to Wu (2023), economic theory explains the demand and price relations. This consumer demand is affected by several determinants, which lead to price changes that affect socioeconomic changes (Wu, 2023).

Consumers' needs are unlike for various goods. In the economy, willingness to pay (WTP) is the amount of money an individual consumer is willing to spend on certain goods (Armington, 2010). This is actually a representation of the highest price that a buyer is willing to pay for a good (Wu, 2023).

The concept of the Law of Demand demonstrates connection between quantity demanded and price. Moreover, Hovhannisyan *et al.* (2019) asserted that its curve is typically reflecting a negative relationship between the two variables and that quantity purchased varies inversely with price (Hovhannisyan *et al.,* 2019). According to Wu (2023), it is well depicted by utility theory, the utility and quantities consumed are inversely related, as it is for demand. As understood in terms of WTP, Danso *et al.* (2017) point out that initially, with a higher price, a few consumers will be willing to pay. According to Armington (2010) and Wu (2023), when prices decline, consumers become more inclined to consume, leading to gradual increases.

The demand for goods relationship is usually described by the demand function. Thus, it involves the relationship between quantities demanded and their price. The law of demand states that quantity demanded decreases when a good's price increases, holding other factors (prices of other related goods, consumers' incomes, etc.) unchanged. When demand for a good and its price is expected to exhibit an inverse relationship and this does not apply to Giffen goods, which are positively related to price.

According to the Law of demand, quantity demanded for a good depends on its price, price of related goods, consumers' income, and other factors. Some consumers prefer luxury one, while others choose less-priced goods. Prices of coffee also depend on crop type and weather (Alsaad *et al.,* 2021). The poor harvesting techniques entail a lack of quality coffee and its price rise, whereas its prices fall in surplus (Burghauserová *et al.,* 2024). Price of a good assumes that holding other factors constant, with a rise in price of a good, reduces its demand, and with a fall in price, its demand increases (Pedini *et al.,* 2017).

Thus, in terms of elasticity of demand concept, when the own-price elasticity of demand for a good is great than zero but less than one, the good's demand is inelastic, meaning that their quantity demand will increase by small proportion in response to a larger proportion decrease in prices ceteris paribus. In addition, when the own-price elasticity of demand for a good is greater than one, the good is elastic, meaning that their quantity demand will increase by a larger proportion in response to a smaller proportion decrease in prices ceteris paribus (Alston & Green, 2008; Clements & Gao, 2015).

Moreover, Wooldridge (2016) considers two types of related goods, namely substitute goods and complementary goods. The same author defines substitute goods as those goods that can be used in place of each other (for instance, coffee and tea) (Terry & Marsh, 2000). In turn, complementary goods refer to those that have a complete demand for each other and that are demanded together (for instance, coffee and sugar). In the case of complementary goods, "a decrease in the price of one leads to an increase in demand for the other, whereas a rise in the price of one leads to a decrease in demand for the other." (Mustafa *et al.,* 2022).

"The consumer income is vital since growing retirement benefits will stimulate the demand for a good." (Burghauserová *et al.,* 2024). Definitely, demand is also influenced by consumers' income. Thus, income changes affect consumers' demand for goods.

However, consumer demand may vary for dissimilar goods, namely, normal and inferior goods. More precisely, when income rises, demand for normal goods will increase, and conversely, when income falls, demand for goods will decrease (Nduka *et al.,* 2015). In this context, normal and inferior goods differ based on the income elasticity of demand, if greater than zero for the former and less than zero for the latter (Alston & Green, 2008; Clements & Gao, 2015).

More empirically, following Clements & Gao (2015), normal goods are referred to as necessities. Luxury goods are also normal goods, whose demand increases as income increases. Again, according to Wu (2023), when consumers' income increases, they will be willing to spend a bigger percent of their income on luxury goods. The income elasticity of demand (YED) implies that when the YED is less than zero, the good is said to inferior, Additionally, when the YED lies between 0 and 1, the good is luxury one, and when YED (β_i>0<1) the good is a normal good and necessity one.

2.1.3 Modeling Demand for Goods

The demand system models have been estimated, based on assumption that either quantities or prices are predetermined (Wong & Park, 2007). Originally, many researchers have been using several demand systems. The existing models are Rotterdam and Almost Ideal Demand System (AIDS), which have been important by most economists.

The theories of demand described in previous sections are directly aligned with both the Rotterdam and AIDS models (Barten, 1964; Deaton & Muellbauer, 1980; Theil, 1965). These models are mostly used for econometric analysis by economists, relating to consumer demand for goods and market dynamics.

The "Rotterdam model was introduced by Barten (1964) and Theil (1965)", as cited by Holt (2002); Paraguas & Kamil (2005) and Barnett & Serletis (2008). According to these authors, this model relates expenditure share of commodities to logarithm of total expenditure and to relative prices. Following Barten and Theil's reasoning, the model can be specified in a share form equation as follows:

$$w_{i,t}\Delta lnX_{i,t} = \alpha_i \Delta z + \sum_j b_{ij} \Delta lnP_{j,t} , \quad (2.1)$$

where, according to those authors, $w_{i,t}$ is expenditure share given the time periods t ($t = 1, 2, \ldots, T$) for commodity i $(i=1,\ldots,n)$, Δ is the first difference operator, $X_{i,t}$ is quantity demanded of a good at time, $P_{j,t}$ stands for goods price j, $\Delta z = \Delta lnY_t - \sum_j w_j \Delta lnP_j$ denotes logarithmic change in total expenditure as a proxy for income minus all logarithmic change in price response, Y_t is total expenditure on n goods at time t, α_i, and b_{ij} are parameters to be estimated. Therefore, $\Delta lnP_{j,t}$ as well as $\Delta lnX_{i,t}$ represents $\Delta P_{j,t}/P_{j,t}$ and $\Delta X_{i,t}/X_{i,t}$, respectively.

Also, following the (Paraguas & Kamil, 2005)'s reasoning, the variables included in the above model can be defined as follows:

$$w_{i,t} = \Delta lnE_t \,/\, \Delta lnP_{j,t}, \quad (2.2)$$

where E= $\sum_j P_{j,t}X_{j,t} = Y_t$, denotes total expenditure on amounts of goods either imported or exported in terms of goods price, and Y_t is the total expenditure as a proxy for the income variable during each period t, respectively, and many researchers have also used a proxy of prices (Onyeneke *et al.,* 2020) and income (Kumar *et al.,* 2011), as this model assumes that demand for a good relies on both prices and income, and that consumers spend their income to buy a good only, and all other variables, parameters and subscripts are defined as previously.

Also, following the same author's reasoning, in equation (2.1), Δz is defined as follows.

$$\Delta z = \Delta lnY - \sum_j \mathrm{w}_j\, \Delta lnP_j = \sum_j \mathrm{w}_j\, \Delta lnX_j, \quad (2.3)$$

where Δz denotes the change in total expenditure as a proxy for the income minus logarithmic change in price response, and $w_j\,\Delta lnX_j$ logarithmic change in quantity responses, and all other variables, parameters, and subscripts are defined as previously. $w_j = P_jX_j/Y$, $j= 1,\dots,n$, where denotes expenditure share of the j^{th} good, X_j represents quantities demanded of a good and all other variables, parameters and subscripts are defined as previously.

Again, following the same authors, plugging equation (2.3) into equation (2.1) yields:

$$w_{i,t}\, \Delta lnX_{i,t} = \alpha_i\, (\Delta lnY - \sum_j \mathrm{w}_j\, \Delta lnP_j) + \sum_j b_{ij}\, \Delta lnP_j \quad (2.4)$$

where α_i and b_{ij} are parameters, as well as all other variables, parameters and subscripts are defined as previously. This model assumes that demand for a good relies on both prices and income, and that consumers spend their income solely to buy such a good. This model is specified in the estimate form of first-difference to represent simultaneous demand equations for a good.

In turn, the concept of the AIDS model and the linear approximation of such model (LAIDS) was presented by Deaton & Muellbauer (1980). Following these two authors, the theoretical specification of the LAIDS model can be defined in a shared form as:

$$w_{i,t} = \sum_j \delta_{ij}\, \Delta lnP_j + \beta_i\, (lnY - lnP), \quad (2.5)$$

where P denotes the price aggregator, and δ_{ij} and β_i are parameters, and all other variables, parameters, and subscripts are defined as previously.

The reason for the AIDS model's fame is that price aggregator P can be substituted by the price index to obtain a linear demand system at stage of estimation (Moschini, 1998). To implement the LAIDS, Deaton and Muellbauer's reasoning suggests replacing P in equation (2.5) by Stone price index P^* that follow.

$$ln(Pt^*) = \sum_i w_i \, ln(P_i), \quad (2.6)$$

where indexes time *t (= 1, ..., 30)*. As such, the LAIDS model is now specified as shown below:

$$w_{i,t} = \sum_j \delta_{ij} \, \Delta lnP_j + \beta_i \, (lnY - \sum_j \mathrm{w}_j \, \Delta lnP_j) \quad (2.7)$$

where the parameters δ_{ij} , and β_i, to be estimated, and all other variables, parameters and subscripts are defined as previously.

According to studies by Moschini (1998); Waripas (2011) and Hovhannisyan *et al.* (2019), they used the LAIDS and such stated index during demand analysis. However, in several studies, the LAIDS has been estimated in the form of first-difference to minimise serial correlation effects across observations; that is to say, the estimation in first-difference form may change the nature of the serial correlation, but cannot eliminate it (Waripas, 2011). To make it consistent with the Rotterdam model (Alston & Green, 2008, 2016). This study specifies the LAIDS model given by equation (2.7), in first-difference form, indicated below:

$$\Delta w_{i,t} = \sum_j \delta_{ij} \, \Delta lnP_j + \beta_i \, [\Delta \, lnY - \sum_j \Delta(\mathrm{w}_j \, \Delta lnP_j)], \quad (2.8)$$

where once again, Δ denotes the first-difference operator and all other variables, parameters, and subscripts are defined as previously. According to Waripas (2011) and Alston & Green (2016) argument mentioned in section (2.2), the last term of the LAIDS model given by equation (2.8) can be accurately approximated as:

$$\sum_j \Delta(\, P_j) \approx \sum_j \delta_{ij} \, \Delta lnP_j, \quad (2.9)$$

By doing so, the LAIDS model becomes as indicated below:

$$\Delta w_{i,t} \approx \sum_j \delta_{ij} \, \Delta lnP_j + \beta_i \, (\Delta lnY - \sum_j \mathrm{w}_j \, \Delta lnP_j) \, , \quad (2.10)$$

where the parameters δ_{ij} , and β_i, to be estimated, Δ denotes the first-difference operator, and all other variables, parameters, and subscripts are defined as previously.

The resulting LAIDS model given by equation (2.10) has the same right-hand side (RHS) structure as the discrete Rotterdam model given by equation (2.4). Note further that the two models have different left-hand-side (LHS) structures by Terry & Marsh (2000).

Furthermore, the estimation of the simultaneous goods equations of the demand system is usually conducted using procedures under the Full Information Maximum Likelihood (FIML) (Wooldridge, 2016). As such, one of the good equations can be estimated and adding-up restrictions can also be used to find the parameter estimates for the other equation(s). Such restrictions consist of constraining the parameters of the two models as indicated below:

$$\sum_i \alpha_i = 0: \qquad \sum_i \delta_{ij} = 0: \qquad \sum_i \beta_i = 0 , \forall, \tag{2.11}$$

where the parameters δ_{ij} , and β_i, to be estimated, Δ denotes the first-difference operator, and all other variables, parameters, and subscripts are defined as previously.

Therefore, this study includes a demand model estimation consisting of two equations, covering three goods: Arabica coffee, Robusta coffee, and inclusive of tea prices. Besides modeling demand for goods, this study entails a comprehensive review of empirical studies, which is presented in the subsequent section (2.2) below.

2.2 Empirical Studies

Many authors over the years have attempted to undertake empirical studies on the demand for coffee. Among the existing studies such as those undertaken by Zin (2022); Ategeka (2022); Durevall (2007); Onyeneke *et al.* (2020) and Aribo (2024). Appendix A presents the summary of these studies. In addition, there are other existing ones, like those undertaken by Burghauserová *et al.* (2024); Mussatto *et al.* (2011); Nduka *et al.* (2015); Chai (1972); Mohanty *et al.* (1999); USDA (2024); Karagiannis & Mergos (2002); Yu *et al.* (2003); Yu & Fang (2009); Chintagunta *et al.* (2018); Jinghua & Myrland (2018) and Shim *et al.* (2021).

2.2.1 Relevant Demand for Goods Studies

One of the empirical studies on food demand analysis in general highlights the ongoing application of demand system models like AIDS and Rotterdam, which help inform policy and understand consumer behavior in agricultural economics. Most recent articles demonstrate the sustained importance of demand system models in agricultural economics. For instance, the Rice demand in Nigeria used quadratic AIDS model that analysed demand for the imports. Findings revealed that both imported and local rice were normal goods and local rice a necessity (Onyeneke *et al.,* 2020).

The evidence from global studies, like a study entitled "Demand and Supply of Coffee," points out income as an important determinant affecting the demand for coffee. In many aspects, this is not shocking, especially when coffee is perceived mostly as a luxury commodity in low-developing countries (Hrishika, 2014). Thus, it is evident that demand is highly dependent on income levels. Coffee is a lifestyle, a health, and competing drinks, whereas the price and incomes play an important role in influencing demand for coffee, it is so hard to overlook the effect other factors may have on the overall consumption, for instance, competing beverages like tea, and the addition of sugar (Hrishika, 2014).

In Japan, coffee is gaining ground at the expense of other beverages. The price is a major factor in the shift to alternative beverages like tea, but health concerns and advertising also provide strong motivations to switch to other beverages (Demanda *et al.,* 2020). Over the years, several studies have suggested that coffee, in fact, invariably contains caffeine of 79.9%-86.5%, but the stigma attached to coffee rather than to all beverages containing caffeine is linked in some way to some cancers (Demura *et al.,* 2013).

According to Durevall (2007), who evaluates the belief that final consumer prices are high, and that less prices would significantly increase coffee exports of low developing nations. The same author estimated the AIDS demand system and Rotterdam models using a demand function and, together with statistics on coffee import prices, replicated the oligopoly model (Torga & Spers, 2020). The revealed that the price decrease effect would be low due to coffee demand in the long run being conquered by change in population structure, together with varying preferences (Durevall, 2007). Thus, a reduction in consumer prices only has slight effect on coffee demand.

Moreover Luciana & Eduardo (2020) revealed that coffee consumption by high-income nations had stabilized in 20th century and high growth rates of consumption is observed in Asia, driven by rapid population and income expansion. Furthermore, the study used time series approach. The study results show a great demand forecasting method that can help processors of coffee to make rational strategic decisions, such as production, marketing, and financial management (Bacci *et al.,* 2019).

A study that highlighted the coffee consumption in Brazil by Arruda (2009) found that young people consumes lowest quantities of coffee, and that the Aroma is the most preferred coffee. According to Bonnet & Villas-Boas (2016) studied whether price-cost is symmetric, that is, whether prices inversely answer to both signs of cost shocks as cited in Torga & Spers (2020). The results showed that buyers react differently to both negative and positive in terms of price changes. In fact, these authors concluded that the demand curve can explain observed symmetric price transmission of cost shocks. Also, similar findings are evident by Torga & Spers (2020).

According to Alston & Green (2016), who applied their statistical test to quarterly consumption per capita and retail prices of selected livestock products in the US. They presumed weak functional separability between meat and other commodities without testing, and estimated the meat sub-system as a complete demand system with total expenditure on meat as the income variable. To do so they estimated and compared several versions of the LAIDS and the Rotterdam models in first difference form. It was found that the null hypothesis that the Rotterdam model was correct, failed to reject at 5% significance level. It was also found that the elasticities were remarkably the same in the two models, suggesting that they would generate a similar economic interpretation (Alston & Green, 2008).

In Norway, a study used such models revealed the application of the extended model to the household consumption data of salmon, Findings show that prices had a greater impact on attracting new clients than on retaining existing one to consume more (Jinghua & Myrland, 2018).

In a study on the food commodities in Tulungagung regency, which also used AIDS model to analyze factors influencing demand. The findings indicated that the selected food crops prices and household total expenditure significantly affect demand (Habiibaturrohmah *et al.,* 2020). According to Yu *et al.* (2003) studied importance of considering fluctuations in composition of world's food demand, driven by income growth when projecting future demand. Authors noted shifts in the patterns of consumption from grains to livestock products signifies a low-income level.

A paper by Lafrance *et al.* (2002), a novel approach was used to test and estimate the rank and functional form of income terms in an IDS equation. The study used annual time series data on quintile and top five percentile ranges and mean income on U.S. consumption and retail prices from 1919 to 1995, without World War II's 1942-1946. The empirical findings indicate that this data set strongly rejects all variations of the AIDS-IDS in favour of a complete rank 3 QPIGL-IDS, which is numerically similar to a prolonged QES-IDS (Lafrance *et al.,* 2002).

Another study in the US on quarterly expenditure for meat used data on quantities per capita consumed to determine one compound model, HIDS, and four other nested models (ILDS, IAIDS, ITLDS, and INLES). The results show that the compounded model (HIDS) is ideal for both goodness-of-fit and statistical measures across its model specifications (Holt, 2002).

In 2011, a study by Muzayyanah & Maharjan (2011) investigated demand for livestock products in Indonesia, specifically meat, eggs, and milk, using AIDS and Rotterdam models. A study employs a joint model approach to determine the most suitable demand model, finding that both the first-difference LAIDS model and the Rotterdam model are appropriate. The same authors used the first difference LAIDS model that demonstrated superior performance with a higher adjusted R^2 and lower RMSE, indicating better fit and elasticity adjustment compared to the Rotterdam model. Conversely, expenditure on livestock products, including meat, eggs, and milk, shows an increase of 2.01% during the same period (Muzayyanah & Maharjan, 2011).

Following both AIDS and Rotterdam models that have been extensively used to determine own-price, cross-price and income elasticities of demand. Usually, the said elasticities are estimated consistently, but cross-price impacts have proven much more difficult to identify (Habibulah *et al.,* 2023). In the elasticity context by Vochozka *et al.* (2022) price elasticity of demand is used to obtain valuable information on coffee demand (Bonnet & Villas-Boas, 2016). The same authors found that perfectly inelastic demand for coffee is dominant in most of EU nations. The income elasticity of demand regarded coffee as an inferior one with exception nations like Belgium, Denmark and Malta. This is statistically natural in view (Vochozka *et al.*, 2022).

More precisely, following findings reported by Alsaad *et al.* (2021), asserted a positive own-price elasticity of demand (=0.161). Also, such positive elasticity findings were reported by Burghauserová *et al.* (2024). Empirical results of cross -price elasticity of demand by Aljohani *et al.* (2025) were negatively signed, but the results were positive signed (=0.9443) reported by Habibulah *et al.* (2023).

However, according to Capps *et al.* (2023), and following their study that updated the US on elasticities of demand. The own-price elasticity of demand (=-1.93), tea was a substitute good to coffee and that income elasticity of demand equals to 0.20 (Capps *et al.,* 2023). Following the same author's still, coffee was considered a necessity good. Moreover, a study by Aljohani *et al.* (2025), who emphasized on the findings that coffee being a luxury good, Deaton & Muellbauer (1980), produced findings that such good was normal one and luxury one, that is consistent with the demand theory. Another study on income elasticity of demand for coffee indicated that coffee is a normal good (0.877) (Torga & Spers, 2020). Waripas (2011) study produced results for necessary good in the global market.

Finally, following Karagiannis & Mergos (2002) who used time series cointegration and error correction models to estimate demand systems that determine the issue of violating theoretical restrictions of homogeneity. The grounded on a linearized AIDS model, indicate that size of the sample, model specification, and schemes aggregation give the impression of being significant factors in estimation of theoretically consistent demand system. According to the two authors in this study, they noticed that theoretical restrictions were rejected at 5% significance level, only when a time trend is inclusive in such a model. The study also demonstrated that homogeneity is susceptible to size of the sample (Karagiannis & Mergos, 2002).

2.2.2 Demand for Coffee Exports

According to WB (2023), Uganda's exports 60% of its coffee to the EU and has recently reached almost US$1.4 billion of exports revenue by the end of 2023. The graphical trend of Uganda's coffee exports below supports the above World Bank statistics as follows.

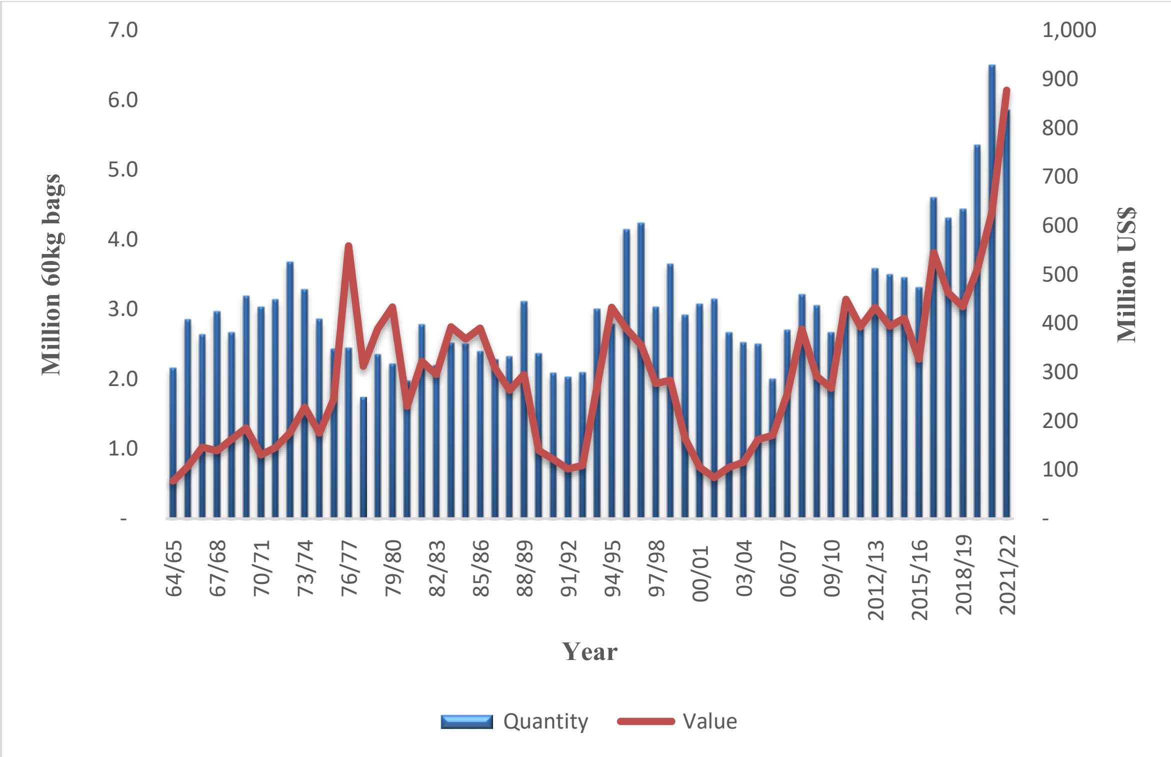

Figure 2.1: Coffee exports, 1964-2021

Source: Author's computation based on UCDA (2025) data

From the figure above, the year 2021/2022 has the highest coffee exports value of US$877 million, as compared to the value of coffee exports in 1964/1965 of the post-independence period. In Africa, Coffee is largely produced in Uganda and consumed in the US, Canada, Australia, Argentina, and the European Union. Coffee is the leading agricultural exports, contributing 15-17% of its foreign exchange earnings (Torga & Spers, 2020).

Moreover, current production stands at approximately 4.2 million bags, of which 80% is Robusta and the remaining percentage is for Arabica, whose average productivity of clean coffee per tree per year is 0.3 kg. Arabica coffee has superior quality and generally attracts better prices, thus it is more competitive on the international market as compared to Robusta Coffee in Uganda (WB, 2023).

Robusta coffee usually grows in wet regions, while Arabica coffee is produced in drier and highland regions in Uganda. Uganda's coffee role in the global economy is not overstated, as one of most valuable goods in foreign trade markets (Durevall, 2007; ICO, 2023). In Uganda, right from the coffee production, processing, trading, transportation, and marketing processes have created more employment for millions of people countrywide (Aribo, 2024).

Also, a figure of coffee quantities demanded over time stretches the trends as shown below.

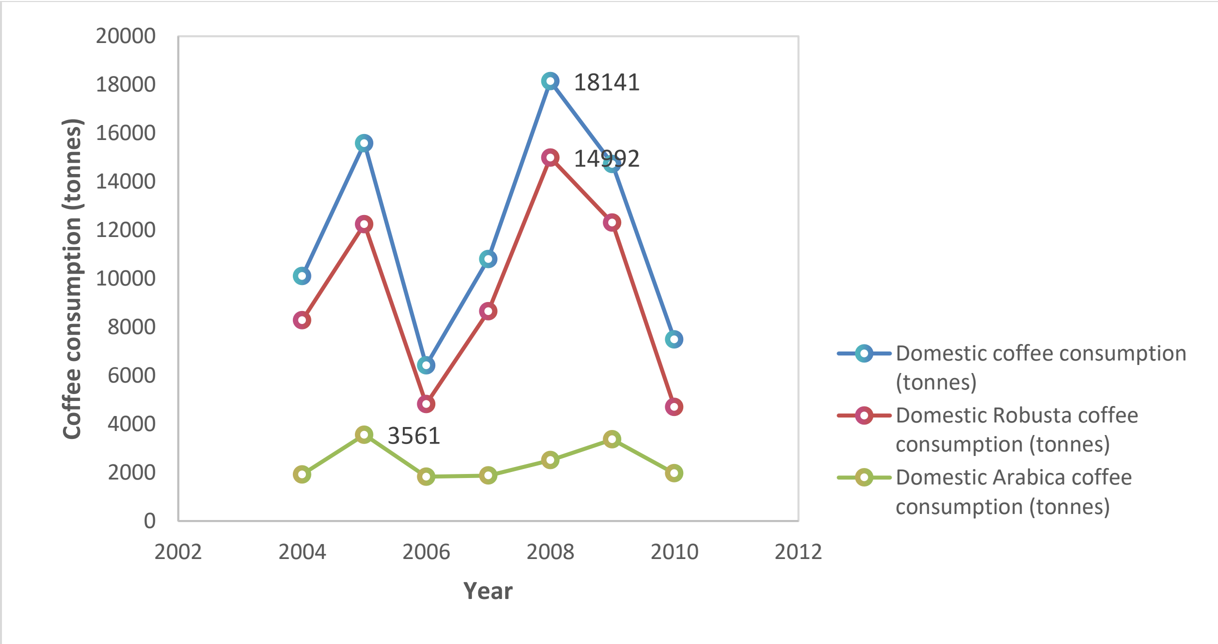

Figure 2.2: Uganda's coffee consumption behavior, 2004-2010

Source: UBOS

Figure above show consumption quantity trend for each of the two selected coffee classes in Uganda. On average, domestic coffee consumption was much higher in 2008, accounting for 18,141 tons of coffee. The highest coffee per class consumption was evident in 2006, 2008, with 3561 and 14992 metric tons for Arabica and Robusta coffee, respectively

2.2.3 Demand Models used in Agricultural Economics

When most Agricultural economics, they applied demand systems models and their empirical analysis, namely the Rotterdam and AIDS models. Most of the models used in existing empirical research on demand for goods were developed based on what the demand and supply theory predicts. Results of some research on coffee demand and related issues have shown that markets do not adjust instantaneously to changes in market conditions. As such, the normally expected properties of demand, such as homogeneity, may not hold in the short run. This may happen because factors such as consumer inertia, habit formation, and habit persistence can also account for slow adjustments in coffee market prices and quantities.

The empirical evidence of food demand analysis studies in general that applied the AIDS and Rotterdam which help in informing policy and understanding consumer behavior in agricultural economics, are: (Yu *et al.,* 2003; Durevall, 2007; Chintagunta *et al.,* 2018; Onyeneke *et al.,* 2020 and Shim *et al.,* 2021). For instance, these models were used to help quantify the licensing impact promises on equilibrium prices and firms' profits (Chintagunta *et al.,* 2018). In a study that estimated demand for green coffee imports also used AIDS, adapting single and simultaneous equation techniques (Aljohani *et al.,* 2025).

Moreover, these models are attractive based on the following reasons, but not limited to: flexibility, easy to estimate, as well as consistent with demand theory (Alnafissa & Alderiny, 2020; Alston & Green, 2008; Barnett & Seck, 2007; Haq *et al.,* 2011; W. Yu *et al.,* 2003). The flexibility means that both models are observed as approximations to randomly specified demand systems globally. Both models can be specified as linear in parameters for ease of estimation, whereas restrictions generated by the utility maximisation postulate can be easily imposed.

In a short time, the comparison, LAIDS model was presented by Deaton & Muellbauer (1980), also cited by Karagiannis & Mergos (2002). "This model has been used by economists, to the point that it here and now is one of the most commonly used demand systems" (Chintagunta *et al.,* 2018). The AIDS model has enjoyed popularity in the modelling of consumer preferences, especially for meats (Aljohani *et al.,* 2025; Durevall, 2007; Fulponi, 1989; Tarrega *et al.,* 2020).

In turn, the Rotterdam model introduced by Barten and Theil is also cited in (Barnett & Serletis, 2008 and Clements & Gao, 2015). This model is locally flexible in variable space, as is the AIDS (Barnett & Serletis, 2008). According to Jinghua & Myrland (2018), the Rotterdam model continues to enjoy substantial popularity among practitioners. The prediction of the Rotterdam model being main alternative to AIDS model in next few years, which raised its popularity, was stated by Alston & Green (2008). Furthermore, both the AIDS and the Rotterdam models are usually testing demand theory restriction of homogeneity. Often, tests of demand restrictions within the two models have led to mixed results. More precisely, demand theory restriction of homogeneity has been rejected in all but a few isolated cases, yet demand theory continues to be used to specify demand systems.

The fact that agricultural economists mostly use both models and that, in some cases, the choice between the two models is considered important to be able to distinguish between them econometrically (Clements & Gao, 2015). Thus, the two authors have developed a statistical test for such a purpose. This test has come to be known in literature as the "LAIDS versus Rotterdam test". Through their test, they demonstrate that the two models can be manipulated to have identical Right-hand side (RHS) structure but differ in the Left-hand side (LHS) structures (Karagiannis & Mergos, 2002).

Many researchers have explored factors influencing coffee shop market purchase intention and customer value. According to Yu & Fang (2009), the relative impacts of a good, and experience quality on customer perceived value to buy at coffee shops. Another study observed the background of purchase intention during COVID-19 (Shim *et al.,* 2021).

Following Mergos & Donatos (1989), who conducted a study under theoretical perspective of AIDS model, as also cited (Mustafa *et al.,* 2022). They used the yearly time series data. Their findings showed that consumers are likely to rise their demand during high-income growth periods, as also cited in Mustafa *et al.* (2022). Thus a positive relationship is evident between income and demand (Mergos & Donatos, 1989). In addition, a study analysed demand in the case of South Africa for 1970–2000 period , it applied the LAIDS model, and findings point out that demand for chicken is inelastic and that such good is a necessity (Taljaard *et al.,* 2003). Further results show that mutton is a luxury one, and all these food commodities had elastic demand by Taljaard *et al.* (2003) and as also cited in Mustafa *et al.* (2022).

In the study entitled "The semiflexible AIDS", the authors indicate that AIDS model is given away to hold most of properties preferred in the analysis of consumer demand (Moschini, 1998). For instance, the AIDS model is a representation of an arbitrary demand system and this is because it satisfy precise aggregation for consumers (Barnett & Seck, 2007). To do so in the way not matched by a single competing system (Alnafissa & Alderiny, 2020). Most agricultural economists have often adopted these models to a varied series of studies on the demand for food commodities, thus regarded as a flexible and widely used framework (Aljohani *et al.,* 2025; Haq *et al.,* 2011; Mustafa *et al.,* 2022; Taljaard *et al.,* 2003).

A study by Lafrance *et al.* (2002) exploits the fullness of the Incomplete Demand Systems (IDS) to expand aggregation in non-linear functions of income. Also, following the same authors, they developed methods to fully cover weakly integrable AIDS versions, the LAIDS, the Quadratic AIDS (QAIDS), Price Independent Generalized Linear (PIGL), including Price Independent Generalized Logarithmic form, quadratic PIGL (QPIGL), prolonged version of linear expenditure system, and an extended Quadratic Expenditure System (QES) (Lafrance *et al.,* 2002). These methods allow for estimating rank and functional form of income in aggregate AIDS (Lafrance *et al.,* 2002).

Moreover, in a study by Holt (2002) suggests a hybrid consumer demand model that covers many popular specifications. Indeed, the study considers a demand system that encompasses the linear demand system, Translog Linear Demand System (TLDS), AIDS, and the Non-separable Linear Expenditure System (NLES). Still, he considers such advanced model as representative of a potentially useful demand system, so his emphasis is on a hybrid Inverse Demand System (HIDS). The study used an application on quarterly U.S. demand data for meat (Holt, 2002).

2.3 Critical Evaluation of the Literature

The critical analysis of the literature based on the coffee results, research gaps, methods, scope, and data-related studies that used demand system models is described as follows. According to the findings by Durevall (2007) on the coffee preferences versus prices suggest that changing preferences of the consumer, instead of just price variations, are seen as the main demand for coffee factors in the long run. Also, the global coffee consumption has increased substantially in recent decades (Torga & Spers, 2020). The demand system models are important for estimating many aspects of the coffee industry, such as the import demand, single-serve coffee systems, and consumer behavior in coffee shops (Aljohani *et al.,* 2025; Alnafissa & Alderiny, 2020; Chintagunta *et al.,* 2018; Shim *et al.,* 2021; Yu & Fang, 2009).

Furthermore, the research gaps indicate that limited data availability can deter the advanced demand models and their applications (Xiaodan *et al.,* 2021). Also, the many unseen factors influencing demand require large datasets as well as sophisticated models to capture all of them (Xiaodan *et al.,* 2021). As indicated by Moraes-Oliveira *et al.* (2017), supply-side considerations have been limited; that is to say, more focus is on demand-side factors. However, for many studies to integrate economic and climatic models to estimate coffee supply that links production factors to demand models requires a comprehensive and diverse study.

Many methods related to this study, demand system models such as Rotterdam and Almost Ideal Demand, have been employed (Onyeneke *et al.,* 2020). These econometric techniques of the single and simultaneous equations are used to determine import demands (Parikh, 1973). Also, the multiple linear regression analysis is used to standardize models, testing economic and climatic variables (Moraes-Oliveira *et al.,* 2017). These models are emerging as a means to advance demand forecasting (Xiaodan *et al.,* 2021). Thus, this study will adopt the Rotterdam and LAIDS models for analysis due to their reliability, flexibility, and consistent for the demand for coffee analysis in Uganda.

The scope of the geographic focus points out most studies that cover various regions, like the United States (Zin, 2022), Europe (Parikh, 1973), Saudi Arabia (Aljohani *et al.,* 2025), and specific countries like Sweden (Durevall, 2007) and Nigeria (Onyeneke *et al.,* 2020) (though the latter focuses on rice). Thus, this study on the demand for coffee purposely focuses on the case of Uganda. Moreover, about the market segments, the research analyzed the total coffee market (Torga & Spers, 2020), as well as specific segments or niches such as single-serve systems (Chintagunta *et al.,* 2018) and coffee shops (Yu & Fang, 2009) and Shim *et al.,* 2021).

Coffee demand factors mostly analyzed are the prices, consumer preferences, product quality, service quality, and external factors like the COVID-19 pandemic, which can explore the impact (Yu & Fang, 2009 and Shim *et al.,* 2021). This study looks at the interactions of the coffee demand quantities, the prices, and the total expenditures in Uganda as a case study.

The data on prices, income, rural credit, and production value are used in models (Moraes-Oliveira *et al.,* 2017). Data on consumer behavior, purchase intentions, and preferences were collected through surveys and sales data (Shim *et al.,* 2021; Yu & Fang, 2009). Time series data on coffee supply, demand, and related economic indicators were used for analysis and forecasting (Moraes-Oliveira *et al.,* 2017). However, this study will use specific time series data to maintain study focus, such as coffee demand by the rest of the world, prices, and expenditure.

This research seeks to adopt the use of the STATA 17 software tool, which was not used by Nduka *et al.* (2015); Demanda *et al.*(2020); Aljohani *et al.* (2025). This aims to produce precise, empirical findings into the demand for coffee by class from the perspective of Uganda using the Rotterdam and AIDS method, which was frequently used by many studies in the USA, Thailand, Sweden, and Saudi Arabia (Aljohani *et al.,* 2025; Alnafissa & Alderiny, 2020; Barnett & Seck, 2007; Durevall, 2007; Jinghua & Myrland, 2018; Terry & Marsh, 2000). The evident gap is that both models have not been commonly applied in the Ugandan context for food commodities, especially on the demand for coffee by class. Such methodology analyzes the effect of price elasticities, quantity demanded responsiveness, and expenditure on demand for a commodity. These two methodological models are flexible and consistent, which makes results reliable and applicable to policy making.

Also, the areas for this research are to adopt dynamic demand system models that account for trending consumer demand for coffee, price, expenditures, and growing market conditions. The study utilizes more disaggregated data to include heterogeneity of the two major coffee classes in Uganda. This research addresses the above specific demand for coffee gaps, the case of Uganda, which is essential to contextualize demand for coffee both locally and internationally in terms of consumption quantities, prices, and expenditures of the two major classes of Arabica and Robusta coffee.

Moreover, it seeks to identify influencing aspects of the demand for Ugandan coffee, providing valuable insights into the demand system's dynamics. Furthermore, addressing these gaps is crucial for developing targeted policies and interventions that promote equitable demand for coffee. This study employed a framework used to analyze interactions of key fundamental question. These two models are flexible functional forms and widely used by agricultural economists each time they need to estimate demand elasticities, test demand theory restriction, as it is explained subsequently in Sections (2.1) and (3.3).

CHAPTER III
METHODOLOGY

The sections that follow specify the econometric model, formulate the tested hypotheses, present the estimation procedures, and describe the data and sources, following the quantitative research design given the time series data in this study.

3.1 Specification of the Econometric Model

To assess whether Uganda's coffee exhibits heterogeneous demand patterns, and to estimate Uganda's coffee demand elasticities in the international coffee market, this study employed an econometric method based on regression analysis. More precisely, it adopted and estimated the Rotterdam and LAIDS model, developed by Barten (1964) & Theil (1965) and Deaton & Muellbauer (1980), respectively.

In this context, to empirically examine the demand for Uganda's coffee by class, it is assumed in this study that coffee is a heterogeneous good. This is because the key concern of this study is the analysis of the interaction between demanded quantities on one hand, and prices and income on the other hand. Thus, this study uses a commonly used framework in agricultural economics to assess this relation. In the same context, following Barten and Theil's reasoning, this study first redefined a complete price version of such Rotterdam model, specified below.

$$w_{i,t}\,\Delta lnX_{i,t} = A_i\,(\Delta lnP_{1,t}) + B_i\,(\Delta lnP_{2,t}) + C_i\,(\Delta lnP_{r,t}) + E_i(Sum_t), \tag{3.1}$$

where, according to those authors, w is expenditure share in terms of prices between time periods ($= \Delta lnE_t \,/\, \Delta lnP_{j,t}$) as given by equation 2.2, the subscript i $(=1, 2)$ represents Arabica coffee (AC) and Robusta coffee (RC). The subscript t (= 1, 2,…,n where n=30) is the time dimension that represents years, X_i denotes the quantity demanded for good i, the parameters A_i, B_i, C_i, and E_i are model parameters to be estimated. Δ is first difference operator, ln is natural logarithm, P_1 is AC price, P_2 is RC price, P_r is price of related good (r = tea), Sum is real expenditure ($=\Sigma_j w_j\, \Delta\, lnX_j$), and $w_{i.t}\, X_{i,t} = w_{i,t}\,\Delta lnX_{i,t}$, and all other variables, parameters, and subscripts are defined as previously.

Then, two separate demand equations (1 for AC and 2 for RC) were estimated, namely Equation 1:AC and Equation 2:RC, and adding-up restrictions were used to find the parameter estimates for both demand equations. Note that the Rotterdam model is specified in first-difference estimate form and also in logarithmic functional form. So, the partial regression coefficients should be interpreted as elasticities. Further, this model represents simultaneous demand equations for AC and RC. To do so, and following the new parameters of the model were constrained as indicated below.

$$\sum_i A_i = 0: \quad \sum_i B_i = 0: \quad \sum_i C_i = 0: \quad \sum_i E_i = 0, \tag{3.2}$$

where C_i denotes the parameter for tea and all other variables, parameters, and subscripts are defined as previously.

Secondly, this study estimated the first difference of the LAIDS model. In this time series data context, this model usually is estimated in first difference form to minimise autocorrelation (Taljaard *et al.,* 2003). Thus, following these authors' reasoning and making it consistent with that of Rotterdam form given by equation (3.1), it is specified as follows.

$$\Delta w_{i,t} = A_i\,(\Delta lnP_{1,t}) + B_i\,(\Delta lnP_{2,t}) + C_i\,(\Delta lnP_{r,t}) + E_i(Sum_t)\,, \tag{3.3}$$

where, according to those authors, Δ is first difference operator and all other variables, parameters, and subscripts are defined as previously.

Then, two separate demand equations (1 for AC and 2 for RC) were estimated and adding-up restrictions were imposed to find the parameter estimates for both demand equations. Notably, the LAIDS model is specified in first-difference estimate form and also in logarithmic functional form. So, the partial regression coefficients should be interpreted as elasticities. Further, this model represents simultaneous demand equations for AC and RC. To do so, and following the parameters of the model were constrained as indicated below.

$$\sum_i A_i = 0: \quad \sum_i B_i = 0: \quad \sum_i C_i = 0: \quad \sum_i E_i = 0, \tag{3.4}$$

where all other variables, parameters, and subscripts are defined as previously. Note that $w_i\,\Delta lnX_i$ and Δw_i are still the dependent variables for the Rotterdam and LAIDS, respectively. Also, the ΔlnP_1, ΔlnP_2, and $\sum_j w_j\,\Delta lnX_j$ are the explanatory variables for both models.

This study examines the demand for coffee by class, focusing on key variables namely, quantities, prices, expenditure shares, and income. This study has adopted concepts and variable measurements, such as those used by Terry & Marsh (2000), Durevall (2007), Hrishika (2014) and Zin (2022). This study describes the primary variables used, including the expenditure shares (w_i) of each coffee class represent their relative importance within total coffee quantities demanded and are used to weight variables in the demand system, with shifts in shares indicating changes in consumer preferences or substitution patterns.

Moreover, this depicts the demand shifts ($w_iX_i = w_i\Delta lnX_i$) variable that denotes the Rotterdam model dependent variable, and the demand shifts ($w_iD_i = \Delta w_i$) variable is the LAIDS model dependent variable for both Arabica and Robusta coffee classes.

Price of each coffee class (P_j), which is expected to exhibit negative own-price elasticity of demand, indicating that demand decreases as prices increase. The choice of this variable is consistent with economic theory and empirical findings by Burghauserová *et al.* (2024).

Furthermore, the change in log coffee prices (ΔlnP_j) variable is measured in US$/kg. This variable depends on the demand decreases as the own price rises with the substitution effects. Also own-price coefficient is expected to be negative when the demand decreases as price increases. This choice of variable is based on empirical evidence (Aljohani *et al.,* 2025). Changes in price responses ($w_j\ lnP_j$). This represents real expenditure that is the demand response to changes in prices as it adjusts nominal expenditure for price changes over time, which traces the purchasing power of Uganda's coffee importers.

The total coffee expenditure (E) captures the overall rest of the world consumer spending on Uganda's coffee classes, which is anticipated to be positively related to demand, reflecting income effects (Deaton & Muellbauer, 1980). The change in total coffee expenditure (ΔlnE) variable denotes that demand for coffee generally increases with income. The positive expected sign for normal goods.

The reasons for the Rotterdam and AIDS demand system models in this study are that they are widely employed due to their flexibility, theoretical consistency, and ease of estimation. The AIDS model's ability to accurately represent consumer demand, satisfy aggregation, and estimate elasticities has made it popular among agricultural economists, especially for food commodities. The Rotterdam model offers similar local flexibility and is considered a strong alternative, with both models facilitating tests of demand theory restrictions. Their extensive empirical use in analyzing consumer behavior, market impacts, and policy effects.

The Rotterdam and LA/AIDS models differ from traditional demand models by offering greater flexibility, using linear or nearly linear functional forms, and better capturing consumer behavior while maintaining economic constraints like homogeneity and symmetry. Thus, Table 3.1 shows a summary of variables, symbols, descriptions, and measurements.

Table 3.1: Variables description and measurement

Variables	Symbols	Variables Description	Measurement Units
Quantity demanded	X_i	This indicates coffee quantities (X), which is the total Uganda's coffee demanded by the rest of the world, X_1 is the Arabica coffee quantity demanded outside in 10^6 kg, and X_2 is the Robusta coffee in 10^6 kg. The choice of the variables is consistent with the demand theory and a fundamental demand measure that is used for elasticities.	60-Kg bag
Price of coffee	P_j	P_j, (j=1,2). The market exports the unit price of each coffee class, where P stands for the average coffee unit price. P_1 is the AC prices, and P2 is the RC prices. The choice of this price variable is consistent with demand theory and the empirical elasticities (Durevall, 2007). These variables have parameters of A_1, B_2, with OPED (b_{i1} and b_{i2}) and (δ_{i1} and δ_{i2}) for Rotterdam and LAIDS models, respectively. Choice of price variables is consistent with empirical studies showing staple foods tend to have inelastic demand, and cross-price signs depend on relationships. Thus, the expected sign for own price is negative, and for YED is either positive or negative.	US$/kg
Price of tea	P_r	This is the annual tea exports price as measured using the simple average monthly prices. The expected sign depends on the substitution or complementary status of coffee by class. This variable is expected to have a model parameter of C_r with price elasticity of demand of b_{ir} and δ_{ir} for the Rotterdam and LAIDS models, respectively. The expected sign for OPED is negative, and for CED is positive or negative.	US$/kg
Total expenditure	E	This variable denotes total coffee expenditure on the j^{th} good for AC and RC. It is a proxy for the income variable that reflects the income effect for the foreign consumers.	10^6 US$
Total expenditure as a proxy for the income variable	Y	This variable refers to total coffee expenditure as a proxy for the income in 10^6 US$. The choice is consistent with the income elasticity for a good like coffee and is expected to be positive but less than one, indicating normal goods with an inelastic response to income changes. This variable has a parameter of E_i, which stands for estimates of α_i and β_i for the Rotterdam and LAIDS model, respectively. This implies that CED for the coffee class or tea good is expected to exhibit positive income elasticity for normal goods negative for inferior goods.	10^6 US$
Expenditure shares	w_{ij}	The w_i is the share of each class in total coffee expenditure in terms of goods price. Demand aggregation reflects substitution patterns, and this expenditure share is expressed as ($w_i = w_1 - w_2$). This variable is used to weight variables. The w_j variable is share of total coffee expenditure in terms of income (Y).	Proportion
Change in the log of expenditure proxy income	ΔlnY or ΔlnE	This variable reflects the income effect, expected to be positive for normal goods, and choice is based on the demand theory that predicts that demand increases with income. This denotes that demand for coffee generally increases with income. The sign is expected to be positive for normal goods,	10^6 US$
Change in quantity demanded of coffee class	(ΔlnX)	The total quantity variable denotes that demand for coffee generally increases with income. The sign is expected to be positive for normal goods, which indicate demand response to price and income changes.	$\Delta lnX>0$
Change in expenditure share of the good	($w_i \Delta lnX_i$)	This variable reflects changes in quantity responses. This is a real expenditure termed the demand response to changes in quantities. It adjusts nominal expenditure for price and quantity changes over time, providing a clearer picture of the true purchasing power and consumer spending behavior. The expected sign is either positive or negative.	$w_i \Delta lnX_i>0<0$
Change in expenditure share	(Δw_i)	This indicates shifts in demand patterns that depend on demand response to changes in price and income.	$\Delta w_i >0 <0$

Author's illustration 2026

3.2 Hypotheses

Based on specific objectives as defined in section (1.4), the following hypotheses were formulated and tested:

- Coffee is a heterogeneous good;
- Demand for coffee is elastic in coffee market abroad;
- Uganda's coffee and tea are substitute or complementary goods in consumption by the rest of the world; and
- Uganda's coffee is a normal or an inferior good for foreign consumers.

Furthermore, to analyze whether Uganda's coffee is a heterogeneous good, this study tested whether the chosen appropriate model holds the demand restriction of homogeneity (Ho, the model holds homogeneity demand restriction, H1 (otherwise)). This study tested the LR between two coffee classes and analyzed their P-values of the chi-square statistics. Following Holt (2002), also used the LR test statistics and analysed the results using the chi-square P-values.

To assess whether demand for Uganda's coffee is elastic, the own-price elasticity of demand (OPED) for appropriate model was derived and analyzed their sizes.

Moreover, to examine whether coffee and tea are substitute goods or complementary goods in consumption by the rest of the world. The cross-price elasticity of demand (CED) was derived. The analysis of such elasticity of demand was done in studies (Lee *et al.,* 2015; Zhu *et al.,* 2022). These authors also interpreted the substitutability or complementarity of goods relationships.

Finally, to determine whether Uganda's coffee is a normal or an inferior good for foreign consumers, the CED associated with each of the selected two classes was derived, and their signs were examined. According to Burghauserová *et al.* (2024), when the CED is positive, consumption demand for the good increases with income, so the good should be normal; whereas when the CED is negative, demand for the commodity reduces when income increases, and good should be inferior. A unitary CED means consumer continues to spend equal percentage of income on a good when its income increases. In this case, this study may conclude that different classes of coffee do substitute for one another, as assumed for the tea. Negatively signed cross-price elasticity of demand suggests that quantity responses to changes in price across classes move together in the same direction (Aljohani *et al.,* 2025). Table (3.2) presents the expected signs of the partial regression coefficient from the econometric model given by equations (3.1) and (3.5).

Table 3.2: Expected signs of partial regression coefficients

Variables	Symbols	Expected signs of the model parameter
Price of coffee exports by class	P_j,	$A_1<0$, and $B_2<0$
Price of tea exports	P_r	$C_i>0$
Total coffee expenditure on coffee exports	E	$E_i>0$
Expenditure share of good *j*	w_j	$w_j>0$
Expenditure shares in terms of price of a good *i*	w_i	$w_i>0<1$
Total expenditure as a proxy for income variable	Y	$Y>0$
Indexes	ij	$ij>0$
Price elasticity of demand coefficients in LAIDS	δ_{ij}	$\delta_{ij}>0$ or $\delta_{ij}<0$
Income elasticity of demand (YED) coefficients in LAIDS	β_i	$\beta_i>0$ or $\beta_i<0$
Change in expenditure share of a good	$w_i \Delta lnX_i$	$\Delta lnX_j>0$
Change in expenditure share	Δw_j	$\Delta w_j>0$

From table above, price elasticity of demand coefficients (δ_{ij}) was estimated, both own and cross; OPED is expected to be inelastic and negative while CED depends on substitutability and complementarity degree among coffee classes, supported by an empirical study by Durevall (2007). The YED coefficients (β_i) are expected to be positive for a normal good.

3.3 Estimation Procedures

Over the years, most researchers in agricultural economics have investigated the choice of superiority of both the Rotterdam and the LAIDS models to find out which of the two models fits the data better. They also tested whether the demand restriction of homogeneity holds with an appropriate model. According to Aljohani *et al.* (2025), they do that before the analysis for the specific objective.

The estimations of Rotterdam model, given by equation (3.1) and LAIDS model, given by equation (3.3), were carried out using version 17 of the STATA software. Moreover, following Holt's (2002) reasoning, the estimation of the simultaneous two-coffee equations system was conducted using procedure for FIML. As such, one of the two coffee equations (AC and RC) was estimated, and adding-up restrictions were used to find the parameter estimates for coffee equation (AC). Such restrictions consisted of constraining the parameters of the two models as indicated in equations (3.2) and (3.4).

The iterated structural equations model, which utilizes FIML, linear, and constrained linear regression procedures accessible in STATA were employed. The imposed restrictions for models were consistent with economic theory. The singularity in the covariance matrix is usually an issue during the process of estimation; to avoid such another equation was not included in the system, and deleted equation parameters were recovered using imposed restrictions.

Following the estimation procedures indicated in the previous paragraphs, this study also started with testing whether Rotterdam model is superior to LAIDS model. To do that, it first estimated both the unrestricted and restricted versions of the two models and compared the produced estimates based on their statistical significance. Also, include both the coefficient of determination (R^2) to test whether Rotterdam model is superior to LAIDS model, as well as whether one of the two models fits the data better. A higher R^2 indicates strong explanatory power, where a lower R^2 indicates weak explanatory power in the variation of the data. The model P-value of F-statistics for coffee by class: the smaller the P-value of F-statistics than 5% significance level, the stronger the superiority of the model. This is the simplest way to choice of the model used. However, this study also used Alston-Chalfant's test to further test whether one of the two models fits the data better by choosing whether the unrestricted or the restricted model.

Despite of LAIDS model being widely employed by studies Karagiannis & Mergos (2002); Lee *et al.* (2015); Alston & Green (2016) and Udoh (2013). Secondly, this study finds it most important to decide on the best model to be used. To decide which of the two models fits the data better. This study used Alston-Chalfant's test by Alston & Green (2008). This statistical test is evident where the economic theory do not offer a foundation for selecting between both models.

The study used a compound approach of the model to test two model alternatives, whereby on the RHS, the variables are similar then for dependent variables are not the same. To execute this, this study set up a compound model, which is an unspecified linear combination of both the Rotterdam and LAIDS models given by equations (3.1) and (3.3), respectively. Furthermore, the two models' comparison is difficult while using goodness-of-fit measure since they have diverse dependent variables. Thus, the Alston & Green (2016) test is used to find a model that best fits the data, as shown below.

$$\lambda \Delta w_{i,t} + (1-\lambda)\, w_{i,t}\, \Delta lnX_{i,t} = \textstyle\sum_j b_{ij} \Delta \mathrm{lnP}j + \alpha_i\, (\Delta \mathrm{lnY} - \sum_j w_j\, \Delta lnP_j), \qquad (3.5)$$

where following Deaton and Muellber's reasoning, λ represents model parameter that capture the Rotterdam model restriction and test for the validity of the Rotterdam model and all other parameters, variables and subscripts are defined as previously.

Using equations (3.1) and (3.3), the linear combination of the two models becomes:

$$\lambda w_{i,t} D_i + (1-\lambda) w_{i,t} X_{i,t} = A_i(PD_1) + B_i(PD_2) + C_i(PD_3) + E_i(\mathrm{Sum}), \qquad (3.6)$$

where *D* denotes the change operator and all other variables and subscripts are defined as before.

Using the version given by equation (3.6), in context, this study tested the following hypothesis: H_0: $\lambda = 0$ (the Rotterdam is the best model), and H_1: $\lambda \neq 0$ (otherwise). In this case, this study used the FIML estimation procedure and performed the following likelihood ratio test 1:

$$LR_1 = 2\,(lnL_u - lnL_r) \sim \chi^2{}_{(1)} \qquad (3.7)$$

where LR_1 is the likelihood ratio for Roterdam model, lnL_u is log likelihood of the unrestricted Rotterdam model, and the lnL_r also denotes log likelihood of restricted Roterdam model, and LR test follows a χ^2 distribution where (1) denotes the number of restrictions. Failing to reject above hypothesis means that such a model is the best or appropriate model.

In turn, the LAIDS model, once again, in this study, a compound model is set up, which is also a linear combination of both the Rotterdam and LAIDS models, given by equations (3.1) and (3.3), respectively, as shown below.

$$(1-\mu)\Delta w_{i,t} + \mu w_{i,t}\,\Delta lnX_{i,t} = \sum_j b_{ij}\Delta \ln Pj + \alpha_i\,(\Delta \ln Y - \sum_j w_j\,\Delta lnP_j), \quad (3.8)$$

where μ is a parameter that captures the LAIDS model restriction and tests for the LAIDS model validation, and all other parameters, variables, and subscripts are defined as previously. The choice of this technique is adopted from Barnett & Seck (2007)

Again, using equations (3.1) and (3.3), the unspecified linear combination of the two models becomes:

$$(1-\mu)\,w_{i,t}D_i + \mu w_{i,t}X_{i,t} = A_i(PD_1) + B_i(PD_2) + C_r(PD_r) + E_i(\text{Sum}), \quad (3.9)$$

where the subscript r denotes tea, and all other parameters, variables, and subscripts are defined as previously.

Using the version given by equation (3.9), the study tested the following hypothesis: H_0: $\mu = 0$ (the LAIDS is the best model) and H_1: $\mu \neq 0$ (otherwise). Then, this study also used the FIML estimation procedure and performed the following likelihood ratio test 2:

$$LR_2 = 2\,(lnL_u - lnL_r) \sim \chi^2_{(1)} \quad (3.10)$$

where LR_2 is the likelihood ratio for the LAIDS model, lnL_u is log likelihood of unrestricted LAIDS model and the lnL_r is log likelihood of restricted LAIDS model. This LR test also follows a $\chi^2_{(1)}$ distribution where, $_{(1)}$ denotes the number of restrictions. Likewise, failing to reject above hypothesis means that LAIDS model is the best or appropriate model.

Thirdly, despite of all the tests undertaken to choose a better or appropriate model, this study is likely to adopt the LAIDS model if the test confirms it is appropriate, as it is widely used and appears to be the one that fits data in several demand for goods studies. This is then tested to check whether it complies with the demand theory restriction of homogeneity and this study performed the homogeneity test (Aljohani *et al.,* 2025; Alnafissa & Alderiny, 2020; Alston & Green, 2008; Zin, 2022).

To do so, this study used the restricted versions of the model to be chosen as the better or appropriate one, simply the better is the one that fits data better and estimated them by Full Information Maximum Likelihood (FIML). The FIML advantage is that it is easier to impose and/or test cross-equation restrictions from demand theory (Holt, 2002; Holt & Balagtas, 2009). To test the imposed restrictions, this study applied likelihood ratio (LR) test.

Also, LR compares maximum value of restricted likelihood function under null hypothesis to unrestricted maximum of likelihood function and tested whether the reduction in the maximum value of the likelihood function is significant. To investigate whether Uganda's coffee is a heterogeneous good or not, this study analysed the LR test statistics for the two classes of coffee equations from the estimates for the chosen model i.e., a better model that fits data). Testing for homogeneity, this study imposed the following restriction on the chosen model, given by the equation below.

$$\sum_j \delta_{ij} = 0, \text{for all } i = 1{,}2 \text{ and } j = 1{,}2 \qquad (3.11)$$

where all other parameters, variables, and subscripts are defined as previously.

Based on the above restrictions, the new parameters of the model given by equation (3.3) were constrained as indicated below:

$$A_i + B_i + C_i + E_i = 0 \text{ for all } i = 1{,}2 \qquad (3.12)$$

where A, B, and C and E are model parameters and the subscripts i (1,2) denote Uganda's coffee classes (Arabica and Robusta coffee), except for parameter C, i denote Uganda's prices of related good, tea. Since a third equation is just a linear combination for the first two equations by imposing adding-up restrictions, then the corresponding null hypotheses are formulated as shown below:

$$H_0 = A_1 + B_1 + C_1 + E_1 = 0\,, \qquad (3.13)$$

$$H_0 = A_2 + B_2 + C_2 + E_2 = 0\,, \qquad (3.14)$$

where A, B, and C and E are also model parameters and the subscripts i (1, 2) denote Uganda's coffee classes (Arabica and Robusta coffee), except for parameter C, i (1,2) denote Uganda's prices of related good, tea. Based on the above restrictions, the study conducted the following likelihood ratio (LR) test:

$$LR_{1,2} = 2\,(\ln L_u - \ln L_r) \sim \chi^2_{(2)} \qquad (3.15)$$

where LR_1 is likelihood ratio for the Arabica coffee and LR_2 is the likelihood ratio for the Robusta coffee LAIDS model, lnL_u is log likelihood of each of unrestricted chosen model, the lnL_r is also log likelihood of each of such restricted chosen model, and this LR test also follows a χ^2 distribution where (2) denotes the number of restrictions. Also, following Holt (2002), to do so, a sequential process was followed in trying to estimate the model for the data, using the FIML algorithm.

The estimation procedures for estimating the Uganda's coffee demand elasticities in the international coffee market is that this study focused on chosen model (LAIDS) is specified in first-difference estimate form and also in logarithmic functional form. So, the partial regression coefficients should be interpreted as elasticities instead of computing the elasticities.

In short, this study first estimated the unrestricted Rotterdam and LAIDS models and discussed how to decide which of the two models is superior. Secondly, it estimated the restricted Rotterdam and the LAIDS model. Thirdly, it performed the test of the LAIDS versus Rotterdam models, more precisely Alston-Chalfant's test, proposed by Alston & Green (2008), to choose a model that fits data better. Then, this study also used the estimates from the better or appropriate model and tested the demand theory restriction of the chosen model: To achieve specific objectives defined in section (1.4), this study derived CED (to investigate whether coffee is a heterogeneous also to whether coffee and tea in Uganda are substitutes or complementary in consumption), own-price elasticity (to check whether or not the demand for Uganda coffee is elastic), and estimated income elasticity (to determine whether coffee is a normal or inferior good for Uganda's coffee consumers abroad).

To conduct the tests mentioned above, this study used the significance level of 5%. the choice of this significance level from the list (1%, 5%, and 10%) is explained by the fact that the author does not want neither to minimize nor to maximize the tested null hypothesis (Ho), if it is true.

3.4 Data Description

The estimation of both the Rotterdam and LAIDS models, given by equations (3.1) and (3.3), used time series data presented in Appendix B. These were annual time series data on the variables included in those models, covering a 30-year time span (from 1994 to 2024). Thus, secondary data were used and were obtained from the following sources, namely UCDA (2024), FAOSTAT (2023), and UBOS (2024).

This study covers only the two most important Uganda's coffee classes, namely Arabica coffee (AC), and Robusta Coffee (RC), and at least one close substitute good in consumption, namely tea. The choice for both classes and a substitute was also based on the availability of data. Hence, data on coffee variables are very limited, resulting in excluding a few other important Uganda's coffee classes from the models specified in section (3.1).

Annual data on prices and quantity demanded of Uganda's two coffee classes were gathered. Likewise, the expenditure share, price data, and income (or expenditure) variables were generated by the special STATA command "generate". This provides a clear picture of how data were described with the respective coding in software, as well as the analysis conducted in Chapter IV.

This study uses expenditure share of the j^{th} commodity (w_i) data, which were constructed as share of each class in total value of coffee exports in terms of goods prices. It assumes either price stability or that prices are correctly adjusted for inflation and exchange rate variations to reflect real expenditure shares. A higher expenditure share suggests that foreign consumers imply a relatively high importance on specific coffee class compared to other goods like tea, indicating a great demand for coffee and or its importance in Uganda's exports consumption choices. Moreover, expenditure share (w_j) is computed as a ratio of total value of coffee exports of each coffee class (or the value share of coffee in total foreign consumer expenditure) to total coffee exports value or revenue.

The annual coffee prices data were measured in US$ per kg (P_j). This study also constructed the P_j indicator by computing the aggregate of average monthly coffee prices over the number of months in a year (considering 12 months). This implies that annual price data were computed by taking the simple annual average of monthly coffee prices, likewise for the prices of tea (but P_j is not computed by the total exports value divided by total quantity exported for the specified period). The price computation using a simple annual average of monthly coffee prices assumes pricing variations across all exported units, including quality differences. It is also assumed that the prices of the chosen Uganda's coffee classes have evolved in this study due to inflation that embodies the country's economic situation. However, this is in contrast with Onyeneke *et al.* (2020), who used unit values as a proxy for prices, computed by in-between total expenditure by quantity of goods bought. In this study, such computation was applied to price of the related good.

In this study, the expenditure (E=Y) refers to the total coffee expenditure as a proxy for the income. This is commonly used to simplify demand models. In the absence of direct price data on the income of foreign consumers, this study used aggregate exports revenues as a proxy for expenditure on Uganda's coffee importer. This study uses unit values of expenditure as a proxy for the income variable, aligning with Kumar *et al.* (2011). Moreover, Appendix B presents a statistical summary of the data in question, and summarised in the table below.

Table 3.3: Statistics summary

Variables	Measurement Units	Observations (N)	Mean	Standard Deviation	Minimum	Maximum
Quantities (volume)						
X_1	60-Kg bags	30	40.048	13.223	20.428	66.829
X_2	60-Kg bags	30	178.080	60.183	84.499	348.447
X_r	60-Kg bags	30	47.039	19.395	8.073	77.718
X	60-Kg bags	30	216.158	63.958	120.139	389.937
Prices						
P_1	US$/Kg	30	2.287	0.893	0.753	4.140
P_2	US$//Kg	30	1.558	0.697	0.396	4.070
P_r	US$/Kg	30	1.186	0.177	0.891	1.663
P	US$/Kg	30	1.699	0.722	0.445	4.060
Values (Expenditure or as a proxy for the income variable)						
Y_1	10^6US$	30	96.680	56.928	19.440	245.339
Y_2	10^6US$	30	288.744	180.982	64.500	851.822
Y_r	10^6 US$	30	56.584	24.607	8.262	88.832
Y	10^6US$	30	442.007	242.571	113.761	1061.643
E	10^6 US$	30	442.007	242.571	113.761	1061.643
Expenditure share						
w_1	Proportion	30	0.219	0.058	0.099	0.362
w_2	Proportion	30	0.638	0.095	0.470	0.814
w_r	Proportion	30	0.142	0.055	0.043	0.272

Notes: X_1 is the Arabica coffee exports volume (60-Kg bags), X_2 is the Robusta coffee exports volume (60-Kg bags), and X is the total coffee exports volume (60-Kg bags). Y_1 is the Arabica coffee exports value (10^6US$), Y_2 is the Robusta exports value (10^6US$), and Y is the total coffee exports value (10^6 US$). P_1 is the Arabica coffee unit exports price US$/kg, P_2 is the Robusta unit exports price US$/kg, and P is the average unit coffee exports price US$/kg. X_r is the tea exports demanded (10^6) kg, P_r is the unit price of tea (US$/kg), and Y_r is the tea exports value (10^6US$). w_1 is the expenditure share for Arabica coffee, w_2 is the expenditure share for Robusta coffee, w_r is the expenditure share for tea. Subscripts $_1$ denote Arabica coffee, $_2$ for Robusta coffee, and $_r$ for tea.
Sources: Data from UCDA (2024), FAOSTAT (2023) and UBOS (2024)

Figures in the table show that the data have significant variations in demand for Uganda's coffee exports patterns across different classes, informing Uganda's coffee preferences and market dynamics. This means that no outliers based on the standard deviation for the two coffee classes.

In Uganda, previous empirical data show that Uganda's coffee exports on average were 40.04777 60-Kg bags and 178.0797 60-Kg bags of arabica and robusta coffee annually between 1994 to 2024, with an average price of 2.287 US$/Kg and 1.558 US$/Kg. Robusta coffee dominates Uganda's coffee exports, contributing 81% of total expenditure on Ugandan coffee exports.

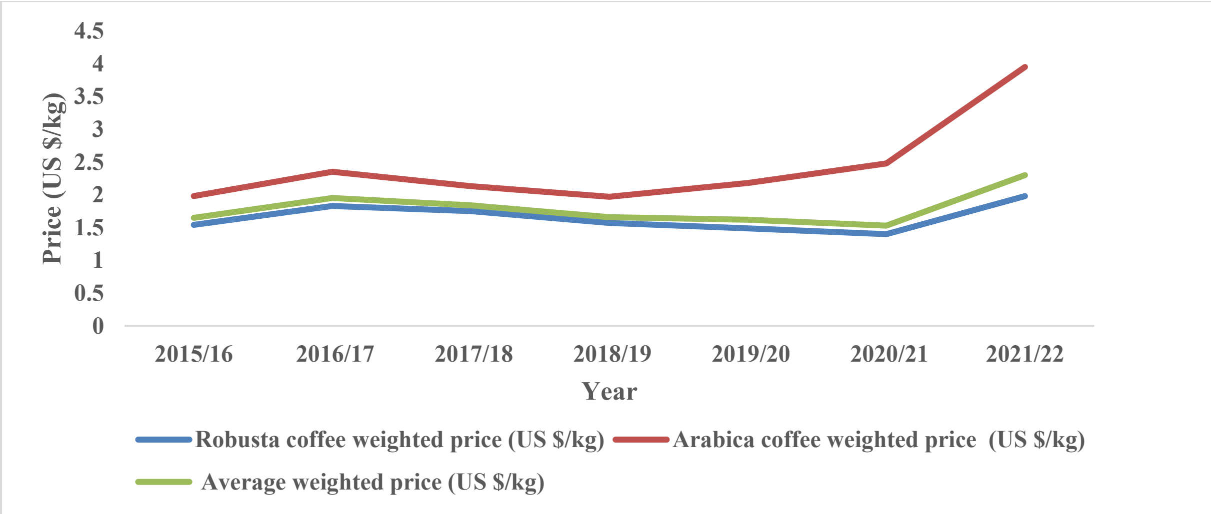

Figure 3.1: Average coffee exports prices by class, 2015/16-2021/22

Source: Extract from UCDA Statistics

The figures above show the average weighted price trend of the prices of the two selected coffee classes in Uganda for the period 2015/16-2021/22. Arabica coffee has a higher exports-weighted price of US$3.95 per kg in 2021/22 as compared to Robusta coffee.

In this study, the data limitations from key variables and major assumptions are as follows. In the computation of price using a simple annual average of monthly coffee prices, assumed that prices vary across all exported units, including quality differences, and reduces potential biases that arise from market price distortions and seasonality changes. The expenditure share variable, when computing the share based on value of coffee exports that is relative to value of total exports, it assumes that the classification of goods is consistent and comparable over periods.

Furthermore, income or expenditure (Y/E) variables assume that the exports value share accurately proxies the expenditure or income in the global market, which may not fully cover the domestic consumption patterns and local demand for importer (s). This study also assumes that changes in total exports value (Y) correspond proportionally to changes in the foreign expenditure or income levels that influence demand for Uganda's coffee over time. Although it does not account for factors such as exchange rate and inflation in importing countries of Uganda's coffee importers. Moreover, the economic literature employs unit values as a proxy for income, constructed by a proxy's expenditure on the quantity exports purchased; these proxies were also used in the studies by Kumar *et al.* (2011). According to Onyeneke *et al.* (2020), there are criticisms for use of unit values for income proxies like measurement error. However, use of proxies remains common in empirical studies for a limited of best alternatives (Onyeneke *et al.,* 2020).

CHAPTER IV
ANALYSIS OF RESULTS

The sections that follow present and interpret the results from estimation from the unrestricted and restricted versions of both Rotterdam and LAIDS models, estimation of Alston-Chalfant's test to choose a better model, estimation of the chosen model (LAIDS), and testing for homogeneity and estimation of demand elasticities. Also analyse the major findings by discussing their implications on Uganda's coffee exports and to the economic performance.

4.1 Results from Estimation of Unrestricted Rotterdam and LAIDS Models

The estimation of the unrestricted Rotterdam and LAIDS models, given by equations (3.1) and (3.3) respectively, produced the results presented in Appendix C, summarised in table below.

Table 4.1: Estimates from unrestricted Rotterdam and LAIDS models

Dependent variables: $w_{i,t}\ \Delta lnX_{i,t}$ (Rotterdam)
$\Delta w_{i,t}$ (LAIDS).

Equations	Variables	Parameters	Estimates		P-values of t	
			Rotterdam	LAIDS	Rotterdam	LAIDS
Equation 1: AC						
	Price of AC	A_1	0.030	0.196*	0.382	0.000
	Price of RC	B_1	-0.047	-0.184*	0.106	0.000
	Price of tea	C_1	0.060*	0.021	0.034	0.413
	Real expenditure as a proxy for income	E_1	-0.008	-0.191*	0.849	0.000
		Constant	0.008	0.001	0.252	0.866
		P-values of F	0.226	0.000		
		R^2	0.140	0.655		
		n	30	30		
Equation 2: RC						
	Price of AC	A_2	-0.052	-0.177*	0.352	0.005
	Price of RC	B_2	0.051	0.286*	0.180	0.000
	Price of tea	C_2	-0.115*	-0.236*	0.013	0.000
	Real expenditure as a proxy for income	E_2	0.785*	0.102	0.000	0.343
		Constant	0.011	-0.001	0.413	0.908
		P-values of F	0.000	0.000		
		R^2	0.822	0.545		
		n	30	30		

Notes: The AC denotes Arabica coffee and RC indicates the Robusta coffee, asterisk * denotes the estimated coefficient, which is statistically significant at 5% significance level. n is the number of observations. R^2 denotes the coefficient of determination. A_1, B_1, C_1, and E_1 are the estimated parameters, and A_2, B_2, C_2, and E_2 are also estimated for both unrestricted models.

Figures in the above table show that in Equation 1:AC, the estimated unrestricted Rotterdam model is statistically significant because P-value of its F-statistics (0.226) is greater than 5% significance level. The unrestricted LAIDS model is statistically significant because P-value of its F-statistics (0.000) is smaller than 5% significance level. In Equation 2: RC the both estimated models of unrestricted Rotterdam and LAIDS are statistically significant because the P-value of its F-statistics (0.000) is smaller than 5% significance level.

Figures in the same table show that in Equation 1: AC, for the unrestricted Rotterdam model coefficient of determination (R^2) is equal to 0.140, meaning that about 14% of the variation in dependent variable are explained by variation independent variables and the remaining percentage (86%) is explained by other no observed factors captured by error term that also affect dependent variable. Figures in the same table show that the unrestricted LAIDS model coefficient of determination is 0.655, meaning that about 65.5% of the variation in dependent variable are explained by variation independent variables and the remaining percentage (34.5%) is explained by other no observed factors captured by error term that also affect dependent variable.

Figures in the same table show that in Equation 2: RC, for the unrestricted Rotterdam model coefficient of determination (R^2) is equal to 0.822, meaning that about 82.2% of the variation in dependent variable are explained by variation independent variables and the remaining percentage (17.8%) is explained by other no observed factors captured by error term that also affect dependent variable. Figures in the same table show that unrestricted LAIDS model coefficient of determination is 0.545, meaning that about 54.5% of the variation in dependent variable are explained by variation independent variables and the remaining percentage (45.5%) is explained by other no observed factors captured by error term that also affect dependent variable.

Based on the P-values[1] of t-statistics of estimated partial regression coefficients, figures in the above table show that in Equation 1: AC, the unrestricted Rotterdam model, produced only one significant variable (Price of tea) because the P-values of its t-statistics (0.034) is less than 5% significance level. For the unrestricted LAIDS model, only three estimated partial regression coefficients of the independent variables except for C_1 in Equation 1:AC are statistically significant at the 5% level because their P-values of t-statistics are smaller than the 5% significance level.

Also, on the basis of the P-values of t-statistics of estimated partial regression coefficients, figures in the same table show that in Equation 2: RC, the unrestricted Rotterdam model, produced only two significant variables (Price of tea and Real expenditure as a proxy for income) because the P-values of their t-statistics (0.013 and 0.000) respectively, are less than 5% significance level. For the unrestricted LAIDS model, only three estimated partial regression coefficients of the independent variables except for E_2 in Equation 2: RC are statistically significant at the 5% level because their P-values of t-statistics are smaller than the 5% significance level.

The next step involves estimating restricted Rotterdam and LAIDS models, taking into account the imposed restrictions specified by equations (3.2) for the former and (3.4) for the latter. The section that follows presents the estimation of both models.

[1] A p-value denotes the minimal probability of rejecting null hypothesis if it is true.

4.2 Results from Estimation of Restricted Rotterdam and LAIDS Models

This study also explored the findings when models are restricted as indicated in the equations (3.2) and (3.4). The estimation of the corresponding restricted Rotterdam and LAIDS models produced results presented in Appendix D and summarised in table below.

Table 4.2: Parameter estimates from the restricted Rotterdam and LAIDS Model

Dependent variables: $w_{i,t}$ $\Delta lnX_{i,t}$ (Rotterdam)
$\Delta w_{i,t}$ (LAIDS).

Equations	Variables	Parameters	Estimates		P-values of t	
			Rotterdam	LAIDS	Rotterdam	LAIDS
Equation 1: AC						
	Price of AC	A_1	0.027	0.208*	0.371	0.000
	Price of RC	B_1	-0.050	-0.168*	0.095	0.000
	Price of tea	C_1	0.049	0.074*	0.065	0.001
	Real expenditure as a proxy for income	E_1	-0.026	-0.114*	0.332	0.000
		Constant	0.009	0.0002	0.233	0.976
		P-values of F	0.146	0.000		
		R^2	-	-		
		n	30	30		
Equation 2: RC						
	Price of AC	A_2	-0.105	-0.175*	0.191	0.003
	Price of RC	B_2	-0.017	0.288*	0.714	0.000
	Price of tea	C_2	-0.336*	-0.227*	0.000	0.000
	Real expenditure as a proxy for income	E_2	0.458*	0.114*	0.000	0.010
		Constant	0.015	-0.002	0.419	0.899
		P-values of F	0.000	0.000		
		R^2	-	-		
		n	30	30		

Notes: AC denotes Arabica coffee and RC indicates Robusta coffee. Asterisk * denotes that the estimated coefficient, which is statistically significant at 5% significance level. n is the number of observations. R^2 is equal to the coefficient of determination. A_1, B_1, C_1, and E_1 are the estimated parameters, and A_2, B_2, C_2, and E_2 are also estimated for both restricted models.

Figures in the above table show that in Equation 1:AC, the estimated restricted Rotterdam model is statistically significant because P-value of its F-statistics (0.146) is greater than 5% significance level. Moreover, the restricted LAIDS model is statistically significant because P-value of its F-statistics (0.000) is smaller than 5% significance level. In Equation 2: RC the both estimated models of restricted Rotterdam and LAIDS are statistically significant because the P-value of its F-statistics (0.000) is smaller than 5% significance level.

Figures in the same table show that in Equation 1: AC, and in Equation 2: RC, for both restricted Rotterdam and LAIDS models respectively has no coefficient of determination (R^2) because of the impact of adding up restrictions during analysis.

Based on the P-values of t-statistics of estimated partial regression coefficients, figures in the same table show that in Equation 1: AC, the restricted Rotterdam model, produced no significant variable because the P-values of its t-statistics are greater than 5% significance level. For restricted LAIDS model, all estimated partial regression coefficients of independent variables are statistically significant at the 5% level because their P-values of t-statistics are smaller than the 5% significance level.

Also, on the basis of the P-values of t-statistics of estimated partial regression coefficients, figures in the same table show that in Equation 2: RC, the restricted Rotterdam model, produced only two significant variables (Price of tea and Real expenditure as a proxy for income) because the P-values of their t-statistics (0.000 and 0.000) respectively, are less than 5% significance level. For restricted LAIDS model, all estimated partial regression coefficients of independent variables are statistically significant at the 5% level because their P-values of t-statistics are smaller than the 5% significance level.

In addition, this study uses Alston-Chalfant's test to further check which of the two models fits the data better, and the results are presented in the subsequent section below.

4.3 Results from Alston-Chalfant's Test

The Alston-Chalfant's test produced the results presented in Appendix (E) and summarised in table below.

Table 4.3: Alston-Chalfant's test results

Model	Log likelihood	$\chi^2_{(1)}$
Unrestricted Rotterdam model	127.313	50.58
Restricted Rotterdam model	81.659	0.00
Unrestricted LAIDS model	127.313	50.58
Restricted LAIDS model	65.714	0.00
$\alpha = 5\%$		
$LR_1 = 2(\ln L_u - \ln L_r) = 2(127.313 - 81.659) = 2(45.654) = 91.309$		
$LR_2 = 2(\ln L_u - \ln L_r) = 2(127.313 - 65.714) = 2(61.599) = 123.199$		

Notes: LR = Likelihood ratio; LR_1 = LR test for Rotterdam model; and LR_2 = LR test for LAIDS model.

Figures in table above show that restricted models exhibit significantly lower log likelihoods of 36.00 and 4.11 for Rotterdam and LAIDS model, respectively.

Figures in the same table show that the null hypothesis that restricted Rotterdam model is the best or appropriate model is rejected at 5% significance level, because LR_1 (=91.309) > χ^2 (=50.58). These results indicated that the Rotterdam model is not the best (i.e., it does not fit the data better). In addition, such hypothesis that restricted LAIDS (i.e., is the best or appropriate model) is also rejected at 5% significance level, because LR_2 (=123.199) > χ^2 (=0.00). These results, in turn, indicated that the LAIDS model is not the best (i.e., it does not fit the data better).

Given the fact that the null hypothesis is rejected for two models, following Holt's (2002) reasoning, yet this study chooses the LAIDS model as the better or appropriate model since LR_2

(=123.199) > LR_1 (=91.309). Therefore, these LR test results indicate that the LAIDS model is the one that fits the data better.

As such, from now on, this study uses estimates from the chosen model (i.e., the LAIDS models) to test demand theory restriction of homogeneity, investigate whether coffee is a heterogeneous good, check whether coffee is elastic in Uganda's coffee exports market abroad, Uganda's coffee and tea are substitutes or complementary goods in consumption and examine whether Uganda's coffee is a normal and or an inferior good for rest of the world.

4.4 Results from Estimation of the Chosen Models (LAIDS)

As indicated in Sections (4.1) and (4.2), the estimation of chosen model (LAIDS) produced results, and summarised in table below.

Table 4.4: Results from estimation of unrestricted and Restricted chosen LAIDS model

Dependent variables: $\Delta w_{i,t}$ (LAIDS).

Equations		Parameters	Estimates		P-values of t	
			Unrestricted LAIDS	Restricted LAIDS	Unrestricted LAIDS	Restricted LAIDS
Equation 1: AC						
	Price of AC	A_1	0.196*	0.208*	0.000	0.000
	Price of RC	B_1	-0.184*	-0.168*	0.000	0.000
	Price of tea	C_1	0.021	0.074*	0.413	0.001
	Real expenditure as a proxy for income	E_1	-0.191*	-0.114*	0.000	0.000
		Constant	0.001	0.0002	0.866	0.976
		P-values of F	0.000	0.000		
		R^2	0.655	-		
		n	30	30		
Equation 2: RC						
	Price of AC	A_2	-0.177*	-0.175*	0.005	0.003
	Price of RC	B_2	0.286*	0.288*	0.000	0.000
	Price of tea	C_2	-0.236*	-0.227*	0.000	0.000
	Real expenditure as a proxy for income	E_2	0.102	0.114*	0.343	0.010
		Constant	-0.001	-0.002	0.908	0.899
		P-values of F	0.000	0.000		
		R^2	0.545	-		
		n	30	30		

Notes: AC denotes Arabica coffee and RC indicates Robusta coffee. Asterisk * means that estimated coefficient is statistically significant at 5% significance level. n is the number of observations. R^2 is equal to the coefficient of determination. A_1, B_1, C_1, and E_1 are the estimated parameters, and A_2, B_2, C_2, and E_2 are also estimated for both unrestricted and restricted LAIDS models.

Figures in the above table show that the unrestricted LAIDS model P-value of statistics F (0.000) for AC is smaller than 5% significance level. These results show that it rejected null hypothesis that all the RHS variables do not affect the dependent variable. The same results mean that the estimated unrestricted LAIDS model for AC (Equation 1:AC) is statistically significant at that significance level. The results in the above table show that the unrestricted LAIDS model P-value of statistics F (0.000) for RC is smaller than 5% significance level. These results show that it rejected the null hypothesis that all explanatory variables do not affect the dependent variable. The same results mean that the estimated unrestricted LAIDS model for RC (Equation 2:RC) is statistically significant at 5%. These results mean that both versions of the unrestricted LAIDS models are statistically significant at that significance level.

Figures in the table above also show that the restricted LAIDS model P-value of statistics F (0.000) for AC is smaller than 5% significance level. These results show that it rejected the null hypothesis that all RHS variables do not affect the dependent variable. The same results mean that the estimated restricted LAIDS model for AC (Equation 1:AC) is statistically significant at 5%. The results in the above table show that the restricted LAIDS model P-value for the F statistic (0.000) for RC is smaller than the 5% significance level. These results also show that it rejected the null hypothesis that all explanatory variables do not affect the dependent variable. The same results mean that the estimated unrestricted LAIDS model for RC (Equation 2:RC) is statistically significant at that level of significance. These results mean that both versions of the restricted LAIDS models are statistically significant at 5%.

Figures in the same table show that an unrestricted model coefficient of determination (R^2) is equal to 0.655 for AC (Equation 1:AC). These results show that about 65% of the variation in demand for Uganda's Arabica coffee (AC) by foreigners are explained by variation of exports price of AC, exports price of RC, exports price of tea, and foreign consumers' income, and the remaining percentage is explained by other no observed factors captured by error term that also affect the demand for Uganda's AC by foreigners. Moreover, the same figures also show that the coefficient of determination is 0.0545 for RC (Equation 2:RC). These results show that about 54.5% of the variation in demand for Uganda's Robusta coffee (RC) by foreigners are explained by variation of exports price of AC, exports price of RC, exports price of tea, and foreign consumers' income, and the remaining percentage is explained by other no observed factors captured by error term that also affect the demand for Uganda's RC by foreigners.

Figures in the above table show that the restricted LAIDS model P-value of statistics F (0.000) for AC is smaller than 5% significance level. These results show that it rejected null hypothesis that all RHS variables do not affect the dependent variable. The same results mean that the estimated restricted LAIDS model for AC (Equation 1:AC) is statistically significant at 5%. The results in the above table show that the restricted LAIDS model P-value of statistics F (0.000) for RC is smaller than 5% significance level. These results show that it rejected null hypothesis that all explanatory variables do not affect the dependent variable. The same results mean that the estimated restricted LAIDS model for RC (Equation 2:RC) is statistically significant at that significance level. These results mean that both versions of the restricted LAIDS models are statistically significant at 5% level of significance.

Figures in the above table also show that the restricted LAIDS model P-value of statistics F (0.000) for AC is smaller than 5% significance level. These results show that it rejected the null hypothesis that all explanatory variables do not affect the dependent variable. The same results mean that the estimated restricted LAIDS model for AC (Equation 1:AC) is statistically significant at that significance level. The results in the above table show that the restricted LAIDS model P-value for the F statistic (0.000) for RC is smaller than the 5% significance level. These results also show that it rejected the null hypothesis that all explanatory variables do not affect the dependent variable. The same results mean that the estimated restricted LAIDS model for RC (Equation 2:RC) is statistically significant at that significance level. These results imply that both versions of the restricted LAIDS models are statistically significant at the 5% level.

Figures in the same table for a restricted LAIDS model show that the STATA output gave no values of R2 for both AC (Equation 1:AC) and RC (Equation 2:RC) presented in Appendix D. These results are explained by the restrictions imposed on the LAIDS model given by equations (3.2, (3.4), (3.13), and (3.14).

Based on the P-values of t-statistics of estimated partial regression coefficients, figures in the above table show that in the unrestricted LAIDS model, all estimated partial regression coefficients are statistically significant at the 5% level because their P-values of t-statistics are smaller than the 5% significance level except for C_1 (in Equation 1:AC) and E_2 (in Equation 2:RC).

Figures in the same table also show that in the restricted LAIDS model, all the estimated partial regression coefficients are statistically significant because the P-values of their t-statistics are smaller than the 5% significance level, in both Equation 1:AC and Equation 2:RC.

The individual significance test results discussed in the previous two paragraphs indicate that the restricted LAIDS model has produced more significant estimated coefficients than its counterpart (the unrestricted LAIDS model). In this context and given the fact that the restricted LAIDS model estimation has not produced any figure for the coefficients of determination (R^2), in the sections that follow, the analysis is conducted based on this model only.

In short, following the results from Table 4.4, figures from both estimated unrestricted and restricted versions of the LAIDS models were compared with the model statistical significance level of 5% and this study found that the restricted version of the LAIDS model has a higher statistical significance level (for all parameter estimates) and better fit statistics for both coffee classes. This suggests the LAIDS model better fits the data. These results are similar to those reported by Muzayyanah & Maharjan (2011) and Durevall (2007), but different from Alston & Green (2016).

4.5 Results of the Test for Homogeneity

The test for homogeneity produced results presented in Appendix F and summarised in table below.

Table 4.5: Testing for Homogeneity results

Model	Log likelihood	$\chi^2_{(2)}$	Prob > chi^2
Unrestricted LAIDS model for homogeneity (for both goods)	117.906	18.61	0.000
Restricted LAIDS model for homogeneity (AC)	76.575	4.49	0.034
Restricted LAIDS model for homogeneity (RC)	60.175	0.04	0.849
Restricted LAIDS model for homogeneity (for goods)	115.661	23.10	0.000
LR1 = 2 (ln L_u – ln L_r) = 2 (117.906– 76.575) = 41.331			
LR2 = 2 (ln L_u – ln L_r) = 2 (117.906– 60.175) = 57.731			
$LR_{1,2}$ = 2 (ln L_u – ln L_r) = 2 (117.906 – 115.661) = 2 (2.245) = 4.490			

Notes: Number of observations is equal to 30 and significance level = 5% . LR = Likelihood ratio; the subscripts 1 and 2 denote Arabica coffee (AC) and Robusta coffee (RC), respectively; Prob > chi^2.= P-values of chi-square, and computed Chi-squared critical =0 .103 as indicated in Appendix F.

Figures in the above table show that the P-value of LR_1 statistics (0.034) for AC is less than 5% significance level and that the P-value of LR_2 statistics (0.849) for RC is more than 5% significance level. The first results indicate that this study rejects the formulated null hypothesis that AC is a heterogeneous good in favor of the alternative hypothesis that the class in question is a homogenous good. The second result indicates that this study fails to reject such a hypothesis. The above results mean that Uganda's AC is a heterogeneous good and that the country's Robusta Coffee (RC) is a homogeneous good. These results show that Uganda is mainly exporting Arabica coffee as a heterogeneous good and Robusta coffee as a homogeneous good.

Moreover, Uganda mainly exports Robusta coffee as a homogeneous good. This indicates that this good (RC) is the same as the rest of the world. Figures in the above table also show that the P-value of the LR_1 (= 41.331) > χ^2 (=4.49) and that is statistically significant at 5% significance level, thus the null hypothesis is rejected that the LAIDS version of the model for AC holds the demand restrictions of homogeneity. They also show that LR_2 (= 57.731) > χ^2 (0.04), which is not statistically significant. Therefore, failed to reject the null hypothesis that the LAIDS version of the model for RC holds the demand restrictions of homogeneity. These findings are similar to Karagiannis & Mergos (2002), who asserted that theoretical restrictions are rejected at the 5% level of significance, given the inclusion of a time trend, and presented in Section (2.2). The results are also related to those reported by Holt (2002).

Following decision criteria presented in Section (4.4), this study from now on, uses estimates from the chosen (i.e., the restricted LAIDS model) to achieve the specific objective (To estimate Uganda's coffee demand elasticities in the international coffee market.) by checking whether coffee is elastic in Uganda's coffee exports market abroad, testing whether Uganda's tea and coffee are substitutes or complementary goods in consumption by the rest of the world and examine whether Uganda's coffee is a normal or an inferior good for the foreigner consumers. This is presented in the subsequent sections that follow.

4.6 Results from Estimation of Demand Elasticities

The estimation of demand elasticities produced the results presented in Table 4.4 and summarised in Table 4.6 below.

Table 4.6: Results from estimation of elasticities of demand

	Estimated demand elasticities			
Equations	A_i	B_i	C_i	E_i
Equation 1: AC	0.208	-0.168	0.074	-0.114
Equation 2: RC	-0.175	0.288	-0.227	0.114

Notes: In Equation 1, A_i = OPED for AC; B_i = CED for AC with regards to RC; C_i = CED for AC with regards to Tea (r), and E_i = YED for AC and in Equation 2, A_i = CED for RC with regards to AC; Bi = OPED for RC; C_i = CED for RC with regards to r, and E_i = YED for RC, AC denotes Arabica coffee, and RC denotes Robusta coffee.

Figures in the above table show that own-price elasticities of demand (OPED) of (0.208 and 0.288 for AC and RC, respectively), cross-price elasticities of demand (CED) of (-0.168 (this indicates a weak complementary relationship) and -0.175 (this indicate a strong complementary relationship) for AC and RC, respectively), and income elasticities of demand (YED) of (-0.114 and 0.114 for AC and RC, respectively).

Figures in the same table show that in Equation 1:AC, the OPED for AC (0.208) lies between 0 and 1, meaning that the demand for AC is inelastic (i.e., quantities demanded are less sensitive to price changes). This indicates that foreign consumers purchase similar quantities of coffee regardless of price changes. This result implies that Uganda's coffee exporters have greater control over their prices because consumers are less likely to reduce their purchases in response to a price increase. This result also implies that during this period of study (1994-2024), a 1% increase in the price of AC led to a decrease in quantity demanded for AC of about 0.21%, *ceteris paribus* (i.e., holding all other factors constant). Given the fact that the OPED for AC is positively signed, this means that Uganda's AC tends to be a Giffen good[2] in the coffee market abroad. This result is similar to those reported by Alsaad *et al.* (2021) and Burghauserová *et al.* (2024).

[2] Note that in this context, the Price of AC is positively related, a result that is under certain income and substitution effects an increase in price causes foreign consumers to buy more of AC because they no longer afford better alternatives and that increases consumption of the inferior good. Thus, this result indicate that AC class is a Giffen good.

The same figures show that the CED for AC with regard to RC (-0.168) is negative, as expected (i.e., consistent with the law of demand). The fact that this elasticity of demand is negative meaning that AC and RC are complementary goods, and that they are consumed simultaneously in order for the consumer to achieve some utility level. Thus, these results indicate that different international consumers have varied tastes; some consumers may prefer aromatic, flavour-rich coffee (AC), while others may prefer the more traditional, straightforward taste of RC and exporting both coffee classes meets a broad range of preferences. These results imply that during this study period, an increase of the price of RC by 1% led to a decrease in demand for Uganda's AC exports by about 0.17%, ceteris paribus. These results are similar to those reported by Aljohani *et al.* (2025), but different from Habibulah *et al.* (2023), who asserted CED (0.9443).

Again, figures in the same table show that CED for AC with regard to tea (0.074) is positively signed as expected, i.e., this positive sign is consistent with economic theory (law of demand), meaning that during this study period, AC and tea were substitute goods. More precisely, an increase in the price of tea by 1% led to an increase in demand for Uganda's AC exports by 0.07%, *ceteris paribus*. These results different from Habibulah *et al.* (2023) and similar to those by Capps *et al.* (2023).

Finally, figures in the table in question show that YED for AC (-0.114) is negatively signed, meaning that Uganda's AC class is an inferior good. More precisely, during this study period, an increase of 1% in foreign consumers' income led to a decrease of their demand for Uganda's AC exports by 0.11% *ceteris paribus*. These findings align with those by Vochozka *et al.* (2022) and contrast with Aljohani *et al.* (2025).

Figures in Table 4.6 also show that in Equation 2:RC, the OPED for RC (0.288) lies between 0 and 1, meaning that the demand for RC is inelastic (i.e., quantities demanded are less sensitive to price changes). This result indicates that during this period of study (1994-2024), a 1% increase in price of RC led to decrease in quantity demanded for RC of about 0.29%, *ceteris paribus*. This result is similar to those reported by Alsaad *et al.* (2021) and Burghauserová *et al.* (2024) but different from Capps *et al.* (2023).

Figures in the same table also show that in Equation 2:RC, the CED for Uganda's RC with regard to AC (-0.175) is negatively signed, meaning that Uganda's RC and AC are complementary goods, by offering both RC and AC, Uganda can target multiple market segments simultaneously, thus maximizing export opportunities and foreign exchange. These results implies that during this study period, an increase in price of AC by 1% led to a reduction in demand for Uganda's RC exports by about 0.18%, *ceteris paribus*. These results are different from those reported by Habibulah *et al.* (2023) but are similar to Aljohani *et al.* (2025).

Figures in the same table show that CED for RC with regard to tea (-0.227) is negatively signed, meaning that Uganda's RC class and tea are substitute goods. More precisely, during this study period, an increase price of tea by 1% led to a reduction in demand for Uganda's RC exports by 0.23%, *ceteris paribus*. These findings different from those by Capps *et al.* (2023) and similar to those by Aljohani *et al.* (2025).

Finally, figures in the table in question show that YED for RC (0.114) is positively signed, meaning that Uganda's RC class is a normal good. The fact that the same elasticity between zero and one indicates that the coffee class in question is a necessity good. More precisely, during this study period, an increase by 1% in foreign consumers' income led to an increase in demand for Uganda's RC exports by 0.11%. Based on the demand theory, such positive sign of RC is consistent with what was expected. These findings differ from those by Vochozka *et al.* (2022) and Aljohani *et al.* (2025), who asserted that coffee is a luxury good. The results are similar with Nduka *et al.* (2015) who asserted that coffee was a normal good. These results also align with demand theory and those reported by Deaton & Muellbauer (1980), Torga & Spers (2020) and Waripas (2011).

4.7 Implications of the Major Findings

In subsections that follow , the results associated with first specific objective of this study and second objective of this study are discussed.

4.7.1 Assessment of whether Uganda's coffee exhibits heterogenous demand pattern

The major findings indicate that Uganda's AC class is a heterogeneous good, meaning that the coffee class in question is different in quality and features. This result implies that demand patterns are likely to vary by both quality and flavour. In this case, Uganda's economy earns more exports revenue from a more differentiated coffee class. The good in question can be sold at higher exports price because of strong quality, branding and or innovation. This signifies high profits for exporters and generates more national income from exports, thus better economic performance.

The same major findings indicates that Uganda's RC class is a homogeneous good, meaning that the coffee class in question is similar to the rest of the world. This implies that it generates less income from Uganda's coffee exports for RC (because many countries trade similar goods and would be bought cheaply by foreign consumers) and the revenues become unstable (due to goods price fluctuations). It also implies that slower economic growth.

4.7.2 Estimation of Uganda's Arabica coffee demand elasticities in market abroad

The major findings indicate that Arabica coffee in market exhibits inelastic demand. This means that AC is less sensitive to price changes and that Uganda's coffee foreign consumers consider AC as a less stable good in consumption choice. This result implies that during this period of study (1994-2024), a 1% increase in price of AC led to a decrease in quantity demanded for this class of about 0.21%, *ceteris paribus*. This result also implies that higher exports prices for Uganda's AC increase domestic demand, which potentially boosts farmers' incomes and that an increase in demand for AC class exports contributes to a fair-trade balance. Moreover, the demand estimates highlights that Uganda's coffee exports particularly Arabica coffee are less sensitive to both price effects in the global market. The anomalous positive own-price elasticity for Arabica coffee suggests unique market dynamics, possibly driven by premium segmentation and quality preferences, which aligns with findings by Aljohani *et al.* (2025).

The same results show that AC and RC are complementary goods in consumption, meaning that they are consumed simultaneously in order for the consumer to achieve some utility level. These results indicates that the two goods (AC and RC) are complementary because AC often commends higher prices due to aromatic qualities, while RC can be more affordable, allowing Uganda to compete across different price points. These results implies that by exporting both AC and RC, Uganda can diversify its export returns which, in turn, reduce dependence on a single coffee class. This diversification can stabilize national income and protect the economy from price shocks affecting one class.

The same results also indicate that AC and tea are substitute goods in consumption, meaning that in the absence of Uganda's AC, foreign consumers can consume Uganda's tea to maximise the same utility level. This result implies that increased demand for Uganda's AC exports can motivate producers and exporters to develop new, innovative, or organic alternative tea and coffee products. This adds value and appeals to niche markets like health-conscious consumers in the global market.

Finally, the same results also indicate that AC class is an inferior good, meaning that demand for it decreases as consumers' income increases, holding all other factors constant. This result implies that foreign exports demand for Uganda's AC as an inferior good increases during economic depression by the importing countries, which can stabilise Uganda's economy by generating higher export revenues. This reliance on foreign economic conditions means that Uganda's economic growth can improve given a fall in the global consumers' incomes, offering a buffer during tough economic times. However, as foreign economies recover and incomes rise, demand for Uganda's coffee may decline, thus reducing exports earnings.

4.7.3 Estimation of Uganda's Robusta coffee demand elasticities in market abroad

The major findings indicate that Robusta coffee in market also exhibits inelastic demand. This means that RC is also less sensitive to price changes and that Uganda's coffee foreign consumers consider RC as a less stable good in making consumption choice. This result implies that during this period of study (1994-2024), a 1% increase in price of RC led to decrease in quantity demanded for this class of about 0.29%, *ceteris paribus*. Moreover, this result also implies that during the period of this study, Uganda experienced higher exports revenues that strengthened the national economic growth.

The major findings indicate that both RC and AC are complementary goods in consumption by the rest of the world's consumers. This is because Uganda's coffee consumers and roasters abroad, may purchase both AC and RC classes to create blends or meet preferences by exporting both RC and AC, Uganda can also diversify its exports turnover, reducing single coffee class dependence. This diversification can also make national income stable and protect the economy from price volatility affecting one class. In addition, the same results implies that demand for both coffee classes rises simultaneously, stabilizes prices and provides predictable producers' income streams and Uganda's market power leverage for this complementary demand helps exporters to negotiate better prices and terms of trade.

The same findings also indicate that Uganda's RC and tea are complementary goods in consumption by the rest of the world's consumers. This is because exporters such as those who export to café, hotels, and restaurants abroad often serve both coffee and tea together, encouraging consumers to choose both RC and tea depending on their preferences. These results implies that this complementarity could enhance market competitiveness through increased global demand for one can boost the demand for another, leading to higher Uganda's coffee and tea exports.

Finally, the same results also indicate that RC class is a normal good, meaning that its demand increases as consumers' incomes also increase, ceteris paribus. In addition, they also indicate that this RC is a necessity good, implying that when foreign consumers' incomes increase, their demand for this coffee class will also rise. This also implies that during the periods of economic growth abroad, Uganda can benefit from higher RC exports revenue. Moreover, as demand grows with income, Uganda's coffee exports become more stable and an increase in income.

Then, the latter result views RC as a necessity meaning that foreign buyers continue to purchase it regardless of changes in their income, although demand might still increase slightly as incomes rise). This implies that as the expenditure share as a proxy for income allocated to Uganda's RC increases, it potentially reflects higher coffee exports revenue, and the exports demand may change. This implication has consistently demanded that Uganda be provided with a steady source of exports earnings, helping to stabilize its economy. Since necessities are essential goods, Uganda's RC exports would be less sensitive to economic fluctuations abroad.

CHAPTER V
CONCLUSIONS

The sections that follow, concludes this paper, gives policy recommendations and rephrase some limitations of this study.

5.1 Conclusions

Uganda's coffee falls into two main classes, namely AC and RC. Given significant coffee production, Uganda's local coffee market is remain small even large increase in coffee consumption domestically will not exhibit an impact that influence the global coffee demand and consumption. Thus, no effect on the world's price. This is the reason why this study is restricted to the demand for Ugandan coffee by the rest of the world. Thus, the research problem examined was that despite Uganda's role as a major coffee producer, with high production levels, the country faces a critical challenge of low consumption domestically, in spite of having the European Union as the leading Ugandan coffee exports destination. The high total coffee exports of 553,529 60-kg bags were evident in June 2023 of the season. Furthermore, only a total of 300,000 bags of coffee were consumed domestically against four million bags annual exports. This disparity between significant production levels for exports consumption and narrow domestic consumption makes economic vulnerable as Uganda becomes more dependent on an unstable international market. Currently, what is exported is not good enough on the international market. Nevertheless, the low coffee consumption by Ugandans locally weakens economic potential, such as an increase in farmers' income, economic growth, and preservation of culture.

In this context, an attempt was made in this dissertation to analyze the demand for coffee by class, taking Uganda as a case study. More specifically, it assessed whether Uganda's coffee exhibits heterogeneous demand patterns and estimated Uganda's coffee demand elasticities in foreign market.

This study covered a 30-year time-span, from 1994 to 2024. The choice of this study period is explained for structural policy shifts in Uganda's coffee sector, such as Uganda's liberalisation policies (post-early 1990s), global market policy reforms (end of International Coffee Organization quota system in 1989, with effects felt into the 1990s), and major policy interventions affecting demand for coffee and trade (for instance restructuring of UCDA back into mother ministry (MAAIF) to fulfil the Coffee Act, with effects felt into the 2024) has typically influenced the demand for Uganda's coffee exports abroad.

To achieve the study objectives defined in the previous paragraph, an econometric method based on regression analysis was employed. More precisely, this study estimated the Rotterdam and LAIDS models, which are widely used by most agricultural economists when they need to test for demand theory restrictions and estimate demand elasticities. The estimation of the two models used time series data covering a 30-year time-span, from 1994 to 2024.

There are three major groups of conclusions of this study. The first one concludes that Uganda's AC is a heterogeneous good, meaning that the coffee class in question is different in quality, and implying that demand patterns are likely to vary by both quality and flavour. It also indicates that the country's RC is a homogeneous good, meaning that the coffee class in question is similar to the rest of the world, and implying that it generates less income from Uganda's coffee exports (because many countries trade similar goods and would be bought cheaply by foreign consumers).

The second group of the major conclusion is that demand for AC is inelastic, meaning that quantity demanded for it increases as the price decreases, and implying that higher exports prices for Uganda's AC potentially boosts farmers' incomes.

It also indicates that both AC and RC are complementary goods in consumption, meaning that price increase in one lead to decrease in demand for both AC and RC. This study concludes that foreign coffee consumers often purchase them together in certain contexts, and changes in their prices influence each other's demand. In addition, these results indicate that AC and tea are substitute goods in consumption, meaning that when Uganda's AC is absent, foreign consumers can consume Uganda's tea to achieve the same level of utility, and implying that increased demand for Uganda's AC exports can add value to it and appeal to niche markets. This study concludes that foreign consumers often enjoy consuming both AC and tea and that exporters often them together in hospitality settings.

Finally, it indicates that AC is an inferior good, meaning that demand for it decreases as consumers' income increases, and implying that foreign exports demand for it increases during economic depression in the importing countries.

The last group of the major conclusion is that demand for RC is also inelastic, implying that higher exports prices for Uganda's RC increase domestic demand and potentially contribute to a fair-trade balance. It also indicates that both RC and AC are complementary goods in consumption, implying that by exporting both classes, they make national income stable and protect the economy from price volatility. In addition, it indicates that RC and tea are complementary goods in consumption, implying that this complementary demand enhances market competitiveness through increased global demand for one, which can boost the other. Finally, it indicates that RC is a normal good and that is a necessity one, meaning that its demand increases as consumers' incomes also increase. The former result implies that Uganda can benefit from higher RC exports revenue, leading to a rise in economic growth, while the latter implies that Uganda has a steady source of exports earnings and that this class is less sensitive to economic fluctuations abroad.

The fundamental conclusion in light of the fundamental research question is that Uganda's AC is a heterogeneous good and RC is a homogeneous good. In addition, the two classes of the Uganda's coffee exhibit inelastic demand. Furthermore, AC and tea are substitute goods in consumption, while RC and tea are complementary goods in consumption. Finally, AC is an inferior good, while RC is both a normal good and a necessity.

5.2 Recommendations

The first major finding associated to the first specific objective of this study indicate that Uganda's AC is a heterogeneous good, implying that a good in question can be sold at a higher exports price because of strong quality, branding, and innovation. This generates more national income from exports, thus better economic performance. In this context, the Government of Uganda should develop more strategies to enhance the quality and branding for AC class, tapping into niche markets (e.g., especially for instant coffee).

Furthermore, the stakeholders, such as exporters and producers, should be encouraged to improve more on the coffee quality through good agricultural practices, processing techniques, and certifications to close the gap in increasing demand for quality coffee all over the world.

Moreover, the Government of Uganda should also produce, process a more unique good of the AC, and encourage more AC processing companies to be innovative, through tax incentives. In order to led to a more increased demand for Uganda's AC exports by foreign consumers and their increased expenditure share on such good in question.

Nevertheless, the Uganda Export Promotion Board (UEPB) should organize more diaspora exhibitions for Uganda's coffee, especially the AC (in the UK, USA, Russia, and Canada) to boost the strong exports power over other countries. This would promote the coffee's uniqueness in the brand to compete for better prices internationally.

Another implication of the results discussed in previous paragraph is Uganda's RC homogeneity generates less income from Uganda's RC coffee exports and slower economic growth is due to competitiveness over substitutes like tea on the world market. In this context, the stakeholders (such as MAAIF) and farmers in the coffee sector should also explore differentiation strategies and increase this class of coffee exports. More precisely, the importers of Uganda's RC should prioritize trading it due to a high degree of responses.

The first major results associated with the second objective of this study indicate that demand for RC is inelastic, meaning that foreign consumers purchase similar quantities of coffee regardless of price changes. In this context, RC exporters should maintain Uganda’s exports stable and at a competitive price since this coffee class is less sensitive to both price and substitution effects in the global market. In addition, policymakers such as MAAIF and the government in general should consider reducing trade exports tariffs for stable access to both coffee classes.

The RC producers and exporters should stabilise the prices of this class so that it is attractive to potential consumers abroad. This makes RC even more unique stable prices in market dynamics driven by prices of the related good tea, and its preferences.

Finally, but not least, given the fact that the YED show that coffee exhibits strong income responsiveness, as consumers' incomes rise, the demand for coffee increases, especially for RC. Therefore, exporters should also be encouraged to improve their coffee through good agricultural practices, processing techniques, and certifications to meet the growing demand for high-quality coffee products. Moreover, given the YED for RC, producers and MAAIF should emphasize on increasing coffee production so that coffee satisfies the demand for coffee in the foreign market.

Those recommendations could improve demand for exports distribution, foster consumer welfare, and create a sustainable and competitive trade environment. Also, they are very crucial for informing policymakers and exporters aiming to optimize exports revenues, manage price risks, and develop market strategies aligned with global demand trends.

5.3 Limitations of the Study

There are three limitations associated with this study. The first one arises from the fact that despite this study provides valuable insights into demand for coffee by class, its results are constructed on time series data and some theoretical assumptions, which may not comprehensively explore the demand dynamics, such as domestic coffee demand.

The second limitation arises from the fact that this study has only 30 observations based annual data. A timeseries analysis usually requires a longer timeseries. In this context, this study recommends that future research on same research topic should use sufficiently longer time series.

The last limitation arises from the fact that it only focuses on Uganda’s demand for coffee exports. In this context this study, recommends that future research on same topic should be applied in Uganda's coffee evolution, both domestic, imports, and exports trade dynamics, but not only by rest of the world. In addition, it should enhance the emerging coffee trade trends namely, model taking into account exogenous factors such as geopolitical shifts, climate change, and agroecology.

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APPENDICES

Appendix A: Summary of previous empirical studies

Author (s)	Years	Time Horizons	Methods	Type of Data	Key Findings
Emad S. Aljohani , Benaissa Chidmi, Alaa Kot, Mahmoud Alderiny , Abdullah Aldakhil and Yusuf Krimly	2025	1999 to 2021	Almost Ideal Demand System model	Pannel data	Findings indicate that Ethiopian coffee dominates the Saudi market and is considered a luxury good with high income elasticity. Brazilian and other coffees exhibited characteristics of necessities, with relatively stable demand.
Chelsea Noela Aribo	2024	Not specified	Demand analysis using regression analysis method. (using descriptive statistics, correlation, and regression analyses).	Primary data	Findings revealed no significant relationship between income/price and coffee consumption (an adjusted R-square of 4.4%,p>0.05).
Stewart Ategeka	2022	Not specified	A mixed methodology approach involving the use of qualitative and quantitative methods.	Time Series data. Secondary data was extracted from FAOSTAT and the Uganda Coffee Development Authority	Results indicated a significant positive increase in coffee production and exports value (p= 0.0001, Slope = 1736.67 tons and p=0.001, Slope =US$4.44million), respectively. Uganda presented third worst unstable coffee exports value with a 20.1% coefficient of variation.
Monika Burghauserová, Pavel Rousek, Filip Petrách	2024	Not specified	Demand function estimation using content analysis, price elasticity, and income elasticity calculations.	Secondary data	The quantity demanded is independent of changes in coffee prices, indicating that the quantity demanded does not change despite price fluctuations (no elasticity). The study concluded that there is a perfectly inelastic demand for coffee.
Dick Durevall	2007	1968-2002	Demand system models using a single-equation autoregressive and an oligopoly model.	Time series data	The impact of a price decrease would be small because long-run coffee demand is dominated by changes in the population structure in combination with different preferences across age groups. Hence, a change to perfect competition would only have a negligible effect on bean imports.
Leo Kyaw Zin	2022	2000 to 2020	Linear Approximation Almost Ideal Demand System (LAIDS) method	Time-series data	Compensated and uncompensated own-price, cross-price, and YED were statistically significant at p<0.001. Vietnamese coffee was Results show that increasing Vietnamese coffee prices could increase revenue.

Appendix B: Data

Year	X_1	X_2	X	P_1	P_2	P	Y_1	Y_2	Y=E	X_r	P_r	Y_r
1994	533,245	2,471,960	3,005,205	2.54	1.30	1.52	81.35	192.31	273.66	42.76	1.20	51.44
1995	507,644	2,284,109	2,791,753	3.08	2.47	2.58	93.73	338.76	432.49	42.78	1.20	51.44
1996	386,456	3,762,347	4,148,803	1.89	1.53	1.56	43.78	345.14	388.92	42.77	1.20	51.44
1997	448,101	3,789,013	4,237,114	2.46	1.27	1.40	66.27	288.86	355.13	17.34	0.93	16.14
1998	340,460	2,691,878	3,032,338	2.40	1.41	1.52	49.11	227.36	276.47	22.89	1.23	28.18
1999	356,449	3,291,540	3,647,989	1.64	1.26	1.29	35.13	247.88	283.01	22.10	0.97	21.43
2000	526,575	2,390,682	2,917,257	1.36	0.85	0.94	42.90	121.87	164.764	26.39	1.40	37.05
2001	459,911	2,614,862	3,074,773	0.91	0.51	0.57	25.07	79.70	104.77	18.22	0.89	16.23
2002	430,376	2,716,005	3,146,381	0.75	0.40	0.44	19.44	64.50	83.94	30.38	1.03	31.30
2003	443,386	2,239,766	2,663,888	0.86	0.61	0.66	23	83	105.499	8.07	1.02	8.26
2004	543,689	1,979,353	2,523,042	1.01	0.70	0.76	33.1	82.61	82.61	36.86	1.01	37.26
2005	516,530	1,988,360	2,504,890	1.82	0.89	1.08	56.26s	105.88	162.14	36.53	0.94	34.28
2006	594,010	1,408,314	2,002,324	1.87	1.23	1.42	66.47	103.87	170.34	30.59	1.66	50.88
2007	559,754	2,144,482	2,704,236	1.90	1.50	1.58	63.80	192.78	256.58	44.02	1.08	47.63
2008	497,105	2,713,498	3,210,603	2.43	1.94	2.02	72.34	316.06	388.40	46.02	1.03	47.23
2009	648,551	2,405,137	3,053,688	2.03	1.47	1.59	78.91	212.85	291.76	44.45	1.34	59.76
2010	711,571	1,957,400	2,668,971	2.42	1.39	1.67	103.33	163.80	267.13	55.08	1.24	68.27
2011	665,410	2,484,013	3,149,423	3.86	1.98	2.38	154.28	294.61	448.89	55.65	1.30	72.13
2012	822,073	1,904,176	2,726,249	3.42	1.96	2.40	168.72	223.98	392.70	55.21	1.34	73.90
2013	801,151	2,781,478	3,582,629	2.39	1.90	2.01	114.96	317.73	432.69	62.02	1.38	85.60
2014	764,809	2,735,020	3,499,829	2.36	1.74	1.88	108.31	285.61	393.92	59.70	1.42	84.74
2015	733,216	2,722,636	3,455,852	2.78	1.77	1.98	122.16	288.39	410.55	53.32	1.32	70.32
2016	880,407	2,435,160	3,315,567	1.95	1.53	1.64	103.02	223.66	326.68	56.29	1.27	71.51
2017	986,527	3,618,631	4,605,158	2.36	1.86	1.97	139.73	404.86	544.59	59.21	1.35	79.75
2018	1,113,815	3,190,306	4,304,121	2.09	1.68	1.79	139.98	322.22	462.21	70.10	1.27	88.83
2019	967,918	3,472,050	4,439,968	1.96	1.54	1.63	113.54	320.42	433.96	69.10	1.13	77.96
2020	965,341	4,394,629	4,394,629	2.24	1.45	1.59	129.48	382.85	512.33	72.46	1.09	78.67
2021	691,494	5,807,447	6,498,941	2.63	1.48	1.61	109.04	517.37	626.41	77.10	1.10	84.96
2022	987,677	4,871,280	5,858,957	4.14	2.16	2.5	245.63	631.72	877.34	76.03	1.16	88.44
2023	1,003,497	4,758,052	5,761,549	3.66	2.19	2.45	220.50	625.51	846.02	77.72	1.06	82.48
2024	669,980	3,488,214	4,158,244	3.94	4.07	4.06	147.99	675.46	823.45	42.76	1.20	51.44

Notes: X_1 = Arabica coffee exports volume (60-Kg bags), X_2 = Robusta coffee exports volume (60-Kg bags), and X = Total coffee exports volume (60-Kg bags). Y_1 = Arabica coffee exports value (10^6US$), Y_2 = Robusta exports value (10^6US$), and Y = Total coffee exports value (10^6 US$). P_1 = Arabica unit exports price US$/kg, P_2 = Robusta unit exports price US$/kg, and P = average unit exports price US$/kg. X_r= Tea exports quantity demanded (10^6) kg, P_r = Unit price of tea (US$/kg), and Y_r = Tea exports value (10^6US$).

Sources: Data from UCDA (2024), FAOSTAT (2023), and UBOS (2024)

Appendix C: Results from Estimation of Unrestricted Rotterdam and LAIDS Models

```
. //ROTTERDAM MODEL
. //ARABICA COFFEE (AC)
. // Regress for Arabica Coffee (Equation 1: AC)
. //UNRESTRICTED
. regress w1_ΔlnX1 d_lnP1 d_lnP2 d_lnPr sum_wj_dlnXj, vce(robust)

Linear regression                               Number of obs     =         30
                                                F(4, 25)          =       1.52
                                                Prob > F          =     0.2261
                                                R-squared         =     0.1402
                                                Root MSE          =     .03912
```

w1_ΔlnX1	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
d_lnP1	.030132	.0338941	0.89	0.382	-.0396742	.0999382
d_lnP2	-.046521	.0277431	-1.68	0.106	-.103659	.0106171
d_lnPr	.0604712	.026941	2.24	0.034	.0049851	.1159572
sum_wj_dlnXj	-.0084159	.0438165	-0.19	0.849	-.0986577	.081826
_cons	.0084311	.0071964	1.17	0.252	-.0063901	.0232523

```
. //ROBUSTA COFFEE (RC)
. // Regress for Robusta coffee (Equation 2: RC)
. //UNRESTRICTED
. regress w2_ΔlnX2 d_lnP1 d_lnP2 d_lnPr sum_wj_dlnXj, vce(robust)

Linear regression                               Number of obs     =         30
                                                F(4, 25)          =     126.12
                                                Prob > F          =     0.0000
                                                R-squared         =     0.8215
                                                Root MSE          =     .07347
```

w2_ΔlnX2	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
d_lnP1	-.0517209	.0545756	-0.95	0.352	-.1641215	.0606798
d_lnP2	.0513564	.0372338	1.38	0.180	-.0253281	.1280409
d_lnPr	-.114858	.0428644	-2.68	0.013	-.2031389	-.0265771
sum_wj_dlnXj	.7853642	.110642	7.10	0.000	.5574928	1.013236
_cons	.0108211	.0129941	0.83	0.413	-.0159407	.037583

Appendix C: Results from Estimation of Unrestricted Rotterdam and LAIDS Models (Cont'd)

```
. //LAIDS MODEL
. //ARABICA COFFEE (AC)
. // Regress for Arabica
. //UNRESTRICTED
. regress Δw1 d_lnP1 d_lnP2 d_lnPr sum_wj_dlnXj, vce(robust)
```

Linear regression

Number of obs	=	30
F(4, 25)	=	21.41
Prob > F	=	0.0000
R-squared	=	0.6553
Root MSE	=	.03871

Δw1	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
d_lnP1	.1958142	.0359249	5.45	0.000	.1218254	.269803
d_lnP2	-.1838475	.0301117	-6.11	0.000	-.2458638	-.1218312
d_lnPr	.0212781	.0255808	0.83	0.413	-.0314065	.0739627
sum_wj_dlnXj	-.1914127	.0442921	-4.32	0.000	-.2826339	-.1001914
_cons	.0011806	.0069337	0.17	0.866	-.0130995	.0154608

```
. //ROBUSTA COFFEE (RC)
. // Regress for Robusta
. regress Δw2 d_lnP1 d_lnP2 d_lnPr sum_wj_dlnXj, vce(robust)
```

Linear regression

Number of obs	=	30
F(4, 25)	=	37.92
Prob > F	=	0.0000
R-squared	=	0.5451
Root MSE	=	.07203

Δw2	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
d_lnP1	-.1768444	.0570282	-3.10	0.005	-.2942961	-.0593927
d_lnP2	.2857004	.041989	6.80	0.000	.1992224	.3721783
d_lnPr	-.2358202	.0426763	-5.53	0.000	-.3237136	-.1479268
sum_wj_dlnXj	.1015511	.1050363	0.97	0.343	-.1147753	.3178775
_cons	-.0014955	.0127595	-0.12	0.908	-.0277742	.0247833

Appendix D: Results from Estimation for Restricted Rotterdam and LAIDS Models

```
. //ROTTERDAM MODEL
. //ARABICA COFFEE (AC)
. //RESTRICTED
. cnsreg w1_ΔlnX1 d_lnP1 d_lnP2 d_lnPr sum_wj_dlnXj, constraints(1) vce(robust)

Constrained linear regression                   Number of obs     =         30
                                                F(   3,      26)  =       1.95
                                                Prob > F          =     0.1463
                                                Root MSE          =     0.0385

 ( 1)  d_lnP1 + d_lnP2 + d_lnPr + sum_wj_dlnXj = 0
```

w1_ΔlnX1	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
d_lnP1	.0273199	.0300339	0.91	0.371	-.0344157	.0890556
d_lnP2	-.0501617	.028933	-1.73	0.095	-.1096343	.009311
d_lnPr	.0487036	.0252868	1.93	0.065	-.0032741	.1006813
sum_wj_dlnXj	-.0258619	.0261531	-0.99	0.332	-.0796204	.0278967
_cons	.0086472	.0070764	1.22	0.233	-.0058985	.0231929

```
. //ROBUSTA COFFEE (RC)
. //RESTRICTED
. cnsreg w2_ΔlnX2 d_lnP1 d_lnP2 d_lnPr sum_wj_dlnXj, constraints(2) vce(robust)

Constrained linear regression                   Number of obs     =         30
                                                F(   3,      26)  =      26.23
                                                Prob > F          =     0.0000
                                                Root MSE          =     0.0968

 ( 1)  d_lnP1 + d_lnP2 + d_lnPr + sum_wj_dlnXj = 0
```

w2_ΔlnX2	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
d_lnP1	-.1045573	.077845	-1.34	0.191	-.26457	.0554554
d_lnP2	-.0170496	.0459977	-0.37	0.714	-.1115993	.0775001
d_lnPr	-.3359606	.0476234	-7.05	0.000	-.4338519	-.2380694
sum_wj_dlnXj	.4575675	.0632988	7.23	0.000	.327455	.58768
_cons	.0148817	.0181057	0.82	0.419	-.0223352	.0520986

Appendix D: Results from Estimation for Restricted Rotterdam and LAIDS Models (Cont'd)

```
. //LAIDS MODEL
. //ARABICA COFFEE (AC)
. //RESTRICTED
. cnsreg Δw1 d_lnP1 d_lnP2 d_lnPr sum_wj_dlnXj, constraints(1) vce(robust)

Constrained linear regression                   Number of obs   =         30
                                                F(   3,      26)  =      18.42
                                                Prob > F          =     0.0000
                                                Root MSE          =     0.0409

 ( 1)  d_lnP1 + d_lnP2 + d_lnPr + sum_wj_dlnXj = 0
```

Δw1	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
d_lnP1	.2082847	.0360256	5.78	0.000	.1342331	.2823363
d_lnP2	-.1677022	.0309273	-5.42	0.000	-.2312743	-.1041302
d_lnPr	.0734631	.0194663	3.77	0.001	.0334496	.1134766
sum_wj_dlnXj	-.1140456	.0256208	-4.45	0.000	-.1667099	-.0613813
_cons	.0002223	.0074281	0.03	0.976	-.0150465	.015491

```
. //ROBUSTA COFFEE (RC)
. //RESTRICTED
. cnsreg Δw2 d_lnP1 d_lnP2 d_lnPr sum_wj_dlnXj, constraints(2) vce(robust)

Constrained linear regression                   Number of obs   =         30
                                                F(   3,      26)  =      40.02
                                                Prob > F          =     0.0000
                                                Root MSE          =     0.0707

 ( 1)  d_lnP1 + d_lnP2 + d_lnPr + sum_wj_dlnXj = 0
```

Δw2	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
d_lnP1	-.1748407	.0527778	-3.31	0.003	-.283327	-.0663545
d_lnP2	.2882945	.0432429	6.67	0.000	.1994074	.3771816
d_lnPr	-.2274355	.0275309	-8.26	0.000	-.2840261	-.170845
sum_wj_dlnXj	.1139818	.0411673	2.77	0.010	.0293611	.1986025
_cons	-.0016495	.0128875	-0.13	0.899	-.0281402	.0248413

Appendix E: Results from Alston-Chalfant's Test

LR test results from unrestricted full model (both λ and μ parameters free) for AC and RC: Rotterdam and LAIDS model

```
Structural equation model                       Number of obs      =         30
Estimation method   = ml
Log likelihood      =  127.31343
```

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
wi_ΔlnXi						
lnP1	-.0556728	.0346342	-1.61	0.108	-.1235546	.012209
lnP2	.0076383	.0322532	0.24	0.813	-.0555767	.0708534
lnP3	-.0020077	.0437015	-0.05	0.963	-.087661	.0836457
sum_wj_dlnXj	.9605078	.0334612	28.71	0.000	.894925	1.026091
_cons	.0731504	.0185356	3.95	0.000	.0368212	.1094796
Δwi						
lnP1	-.08589	.05893	-1.46	0.145	-.2013908	.0296107
lnP2	.0044523	.0548787	0.08	0.935	-.103108	.1120127
lnP3	-.0179937	.074358	-0.24	0.809	-.1637327	.1277453
sum_wj_dlnXj	-.0315564	.0569342	-0.55	0.579	-.1431454	.0800326
_cons	.1105065	.0315384	3.50	0.000	.0486925	.1723206
var(e.wi_ΔlnXi)	.0009639	.0002489			.0005811	.0015989
var(e.Δwi)	.0027906	.0007205			.0016824	.0046289

```
LR test of model vs. saturated: chi2(1)   =      50.58, Prob > chi2 = 0.0000
```

LR test results from Restricted Rotterdam model

```
Fitting target model:

Iteration 0:   log likelihood =  81.659177
Iteration 1:   log likelihood =  81.659177

Structural equation model                       Number of obs      =         30
Estimation method   = ml
Log likelihood      =  81.659177
```

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
wi_ΔlnXi						
lnP1	-.0556728	.0346342	-1.61	0.108	-.1235546	.012209
lnP2	.0076383	.0322532	0.24	0.813	-.0555767	.0708534
lnP3	-.0020077	.0437015	-0.05	0.963	-.087661	.0836457
sum_wj_dlnXj	.9605078	.0334612	28.71	0.000	.894925	1.026091
_cons	.0731504	.0185356	3.95	0.000	.0368212	.1094796
var(e.wi_ΔlnXi)	.0009639	.0002489			.0005811	.0015989

Appendix E: Results from Alston-Chalfant's Test (cont'd)

LR test results for the restricted LAIDS model

```
Fitting target model:

Iteration 0:   log likelihood =  65.713897
Iteration 1:   log likelihood =  65.713897

Structural equation model                        Number of obs     =         30
Estimation method  = ml
Log likelihood     =  65.713897
```

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
Δwi						
lnP1	-.08589	.05893	-1.46	0.145	-.2013908	.0296107
lnP2	.0044523	.0548787	0.08	0.935	-.103108	.1120127
lnP3	-.0179937	.074358	-0.24	0.809	-.1637327	.1277453
sum_wj_dlnXj	-.0315564	.0569342	-0.55	0.579	-.1431454	.0800326
_cons	.1105065	.0315384	3.50	0.000	.0486925	.1723206
var(e.Δwi)	.0027906	.0007205			.0016824	.0046289

```
. di "Test for Rotterdam model (H0: λ=0):"
Test for Rotterdam model (H0: λ=0):

. di "LR statistic = " %9.3f LR_λ
LR statistic =    91.309

. di "p-value = " %9.3f p_λ
p-value =     0.000

.
. di "Test for LA/AIDS model (H0: μ=0):"
Test for LA/AIDS model (H0: μ=0):

. di "LR statistic = " %9.3f LR_μ
LR statistic =   123.199

. di "p-value = " %9.3f p_μ
p-value =     0.000
```

Appendix F: LR Test Results from Testing for Homogeneity

```
. //UNRESTRICTED LAIDS MODEL: ARABICA COFFEE (AC)AND ROBUSTA COFFEE (RC)
. sem (Δw1 = d_lnP1 d_lnP2 d_lnPr sum_wj_dlnXj)(Δw2 = d_lnP1 d_lnP2 d_lnPr sum_wj_
> dlnXj), method(ml)
```

```
Structural equation model                       Number of obs     =         30
Estimation method  = ml
Log likelihood     =   117.9063
```

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
Δw1						
d_lnP1	.1958142	.033182	5.90	0.000	.1307786	.2608497
d_lnP2	-.1838475	.0318258	-5.78	0.000	-.246225	-.1214701
d_lnPr	.0212781	.0347391	0.61	0.540	-.0468092	.0893654
sum_wj_dlnXj	-.1914127	.0421288	-4.54	0.000	-.2739835	-.1088418
_cons	.0011806	.0065279	0.18	0.856	-.0116137	.013975
Δw2						
d_lnP1	-.1768444	.0617403	-2.86	0.004	-.2978531	-.0558357
d_lnP2	.2857004	.0592169	4.82	0.000	.1696374	.4017633
d_lnPr	-.2358202	.0646374	-3.65	0.000	-.3625072	-.1091332
sum_wj_dlnXj	.1015511	.0783871	1.30	0.195	-.0520849	.255187
_cons	-.0014955	.0121461	-0.12	0.902	-.0253014	.0223104
var(e.Δw1)	.001249	.0003225			.000753	.0020717
var(e.Δw2)	.0043239	.0011164			.0026068	.0071723

```
LR test of model vs. saturated: chi2(1)   =     18.61, Prob > chi2 = 0.0000
```

```
Structural equation model                       Number of obs     =         30
Estimation method  = ml
Log likelihood     =  76.575181

 ( 1)  [Δw1]d_lnP1 + [Δw1]d_lnP2 + [Δw1]d_lnPr + [Δw1]sum_wj_dlnXj = 0
```

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
Δw1						
d_lnP1	.2082847	.0352358	5.91	0.000	.1392238	.2773456
d_lnP2	-.1677022	.0333759	-5.02	0.000	-.2331178	-.1022867
d_lnPr	.0734631	.0273637	2.68	0.007	.0198312	.127095
sum_wj_dlnXj	-.1140456	.0250273	-4.56	0.000	-.1630983	-.0649929
_cons	.0002223	.0070195	0.03	0.975	-.0135358	.0139803
var(e.Δw1)	.0014506	.0003746			.0008745	.0024063

```
LR test of model vs. saturated: chi2(1)   =      4.49, Prob > chi2 = 0.0341
```

Appendix F: LR Test Results from Testing for Homogeneity (cont'd)

```
Structural equation model                        Number of obs     =         30
Estimation method   = ml
Log likelihood      =  60.174751

 ( 1)   [Δw2]d_lnP1 + [Δw2]d_lnP2 + [Δw2]d_lnPr + [Δw2]sum_wj_dlnXj = 0
```

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
Δw2						
d_lnP1	-.1748407	.0608702	-2.87	0.004	-.2941442	-.0555373
d_lnP2	.2882945	.0576572	5.00	0.000	.1752884	.4013005
d_lnPr	-.2274355	.0472711	-4.81	0.000	-.3200851	-.1347859
sum_wj_dlnXj	.1139818	.043235	2.64	0.008	.0292428	.1987208
_cons	-.0016495	.0121263	-0.14	0.892	-.0254166	.0221177
var(e.Δw2)	.0043292	.0011178			.0026099	.007181

```
LR test of model vs. saturated: chi2(1)   =      0.04, Prob > chi2 = 0.8493

. //Step 10.3: Estimate the homogeneity-restricted model
. //Σjδij = 0, for all i = 1,2 and j = 1,2
. //RESTRICTED LAIDS MODEL: ARABICA COFFEE (AC)AND ROBUSTA COFFEE (RC)
. sem (Δw1 = d_lnP1 d_lnP2 d_lnPr sum_wj_dlnXj)(Δw2 = d_lnP1 d_lnP2 d_lnPr sum_wj_
> dlnXj), constraints(6 7)

Structural equation model                        Number of obs     =         30
Estimation method   = ml
Log likelihood      =  115.66082

 ( 1)   [Δw1]d_lnP1 + [Δw1]d_lnP2 + [Δw1]d_lnPr + [Δw1]sum_wj_dlnXj = 0
```

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
Δw1						
d_lnP1	.2082847	.0352358	5.91	0.000	.1392238	.2773456
d_lnP2	-.1677022	.0333759	-5.02	0.000	-.2331178	-.1022867
d_lnPr	.0734631	.0273637	2.68	0.007	.0198312	.127095
sum_wj_dlnXj	-.1140456	.0250273	-4.56	0.000	-.1630983	-.0649929
_cons	.0002223	.0070195	0.03	0.975	-.0135358	.0139803
Δw2						
d_lnP1	-.1768444	.0617403	-2.86	0.004	-.2978531	-.0558357
d_lnP2	.2857004	.0592169	4.82	0.000	.1696374	.4017633
d_lnPr	-.2358202	.0646374	-3.65	0.000	-.3625072	-.1091332
sum_wj_dlnXj	.1015511	.0783871	1.30	0.195	-.0520849	.255187
_cons	-.0014955	.0121461	-0.12	0.902	-.0253014	.0223104
var(e.Δw1)	.0014506	.0003746			.0008745	.0024063
var(e.Δw2)	.0043239	.0011164			.0026068	.0071723

```
LR test of model vs. saturated: chi2(2)   =     23.10, Prob > chi2 = 0.0000
```

Appendix F: LR Test Results from Testing for Homogeneity (cont'd)

```
. scalar ll_homogeneity = e(ll)

. display "Homogeneity LAIDS Model Log-Likelihood: " ll_homogeneity
Homogeneity LAIDS Model Log-Likelihood: 115.66082

. // Step 10.4: Perform LR tests
. scalar LR_homogeneity = 2 * (ll_unrestricted - ll_homogeneity)

. display "LR test for Homogeneity: " LR_homogeneity
LR test for Homogeneity: 4.4909643

. display "Chi-squared critical : " = invchi2tail(2, 0.95)
Chi-squared critical : .10258659

. display "Critical value at 5% (χ²(2))(df= number of homogeneity constraints):" =
>  invchi2tail(2, 0.95)
Critical value at 5% (χ²(2))(df= number of homogeneity constraints):.10258659

. //if LR_homogeneity > invchi2tail(2, 0.95) {
. //   display "Reject null hypothesis of homogeneity at 5% level."
. //} else {display "Fail to reject null hypothesis of homogeneity."}
.
```

Appendix G: Results from Deriving Demand Elasticities for the Chosen Model

```
. //LAIDS MODEL
. //ARABICA COFFEE (AC)
. //RESTRICTED
. cnsreg Δw1 d_lnP1 d_lnP2 d_lnPr sum_wj_dlnXj, constraints(1) vce(robust)

Constrained linear regression                   Number of obs   =         30
                                                F(   3,     26) =      18.42
                                                Prob > F        =     0.0000
                                                Root MSE        =     0.0409

 ( 1)  d_lnP1 + d_lnP2 + d_lnPr + sum_wj_dlnXj = 0
```

Δw1	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
d_lnP1	.2082847	.0360256	5.78	0.000	.1342331	.2823363
d_lnP2	-.1677022	.0309273	-5.42	0.000	-.2312743	-.1041302
d_lnPr	.0734631	.0194663	3.77	0.001	.0334496	.1134766
sum_wj_dlnXj	-.1140456	.0256208	-4.45	0.000	-.1667099	-.0613813
_cons	.0002223	.0074281	0.03	0.976	-.0150465	.015491

```
. //ROBUSTA COFFEE (RC)
. //RESTRICTED
. cnsreg Δw2 d_lnP1 d_lnP2 d_lnPr sum_wj_dlnXj, constraints(2) vce(robust)

Constrained linear regression                   Number of obs   =         30
                                                F(   3,     26) =      40.02
                                                Prob > F        =     0.0000
                                                Root MSE        =     0.0707

 ( 1)  d_lnP1 + d_lnP2 + d_lnPr + sum_wj_dlnXj = 0
```

Δw2	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
d_lnP1	-.1748407	.0527778	-3.31	0.003	-.283327	-.0663545
d_lnP2	.2882945	.0432429	6.67	0.000	.1994074	.3771816
d_lnPr	-.2274355	.0275309	-8.26	0.000	-.2840261	-.170845
sum_wj_dlnXj	.1139818	.0411673	2.77	0.010	.0293611	.1986025
_cons	-.0016495	.0128875	-0.13	0.899	-.0281402	.0248413