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Estimating the non-price determinants of meat demand in South Africa

A Research Report submitted in partial fulfilment of the Degree of
Master of Commerce (Applied Development Economics)
in the School of Economics and Finance,
University of the Witwatersrand

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DECLARATION

I declare that this research report is my own unaided work. It is being submitted for the degree of Master of Commerce (Applied Development Economics) at the University of the Witwatersrand. It has not been submitted before for any degree or examination at any other University.



Alice Ruth Beghin
30 March 2023

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ABSTRACT

There is a pressing need to reduce our environmental footprint, mitigate food-related public health concerns, and ensure sustainable food systems. However, the overconsumption of meat directly undermines these needs. In order for policymakers to adapt policies to reduce the overconsumption of meat, an improved understanding of the drivers behind the demand for meat is required. Meat consumption per capita in developing economies has surpassed levels in developed countries, and is projected to continue increasing. We use South Africa as a case study, given that it is an emerging economy that is characterised by increased meat consumption since 1994. This trend correlates with (and is driven by) increasing per capita income and prices. South Africa's diverse population (with widely varying incomes and cultures) complicates the regulatory framework required to reduce excessive meat consumption. To support consumers in making environmentally sustainable dietary protein choices, this study aims to gain a deeper understanding of meat-consumption behaviour by consumers, segmented on the basis of their meat consumption. Results were obtained through a 2015 survey of 600 community-dwelling household heads in Gauteng, South Africa. Three segments of consumers were identified by means of a two-step cluster analysis: heavy, average, and low meat consumers. The segments differed significantly in several socio-demographic and background characteristics. The segmented evaluation of consumer groups was confirmed by analysis of variance (ANOVA), which found statistically significant differences of mean weekly meat consumption amongst the three groups. To evaluate the non-price determinants of meat consumption, OLS, Poisson, and negative binomial models were run, and average marginal effects of a negative binomial model were analysed for both the separate consumer groups and the consumers as a whole. It was found that the importance of sustainable living shaped meat consumption for low and average meat consumers. Heavy meat consumers were driven by their enjoyment of the taste of meat and the centrality of meat in their meals. Behavioural economics-based nudges could prevent the overconsumption of meat in South Africa such as using environmental concerns to frame a meat reduction strategy, and challenging the link between meat consumption and gender identity.

Keywords: count models; meat consumption; Negative Binomial model; Johannesburg
JEL Codes: Q18; Q58

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1. Introduction

The consumption of meat, particularly red meat, is associated with increased direct risk of developing health complications (Wolk, 2016). In addition, livestock negatively affects the natural environment and advances anthropogenic climate change (Ndlela & Murcott, 2021). In turn, these environmental changes may affect human health indirectly by contributing to (among other outcomes) the pollution of air and drinking water, the rise in antimicrobial resistance, and the spread of vector-borne diseases (Gonzalez et al., 2020). While the potential health and environmental benefits of reducing excessive meat consumption are well established in the literature, concerns about consumer backlash and poor understanding on the part of policymakers regarding how to promote this behaviour change have contributed to a general lack of action.

Reducing meat consumption is considered to have great potential for mitigating food-related greenhouse gas (GHG) emissions (Kurz, 2018). Interventions targeting conscious determinants of human behaviour, such as those providing information, are generally perceived to be acceptable approaches to promote health behaviours by the public in developed countries, and might therefore help to overcome this state of inaction (see Bianchi et al., 2018). This approach has spread to emerging and developing economies, but is undermined by strategies that treat meat consumers as a homogeneous group.

Sustainable food consumption is a globally pressing issue, and it is plausible that these issues will be exacerbated if current projections continue for the population growth, urbanisation and rising per capita income that are driving growth in the 'middle classes' in emerging and developing countries (Rask & Rask, 2010). Reducing meat consumption is one approach that would promote food sustainability and security, while helping to address the problematic environmental outcomes associated with intensive agricultural production – assuming that at some point, a reduction in meat consumption would be reflected in a shift in farming and production practices.

Looking for ways to reduce meat consumption is an area of research that has been receiving much attention (see Bianchi et al., 2018). But most of the literature concentrates on developed countries, where consumption has historically been very high (see Milford et al., 2019; Bereznicka & Pawlonka, 2018; Sans & Combris, 2015; Kearney, 2010). By using South Africa

as a case study, this study contributes to the limited literature on determinants of meat consumption and policy-intervention alternatives in emerging and developing countries. South Africa has had a particularly high level of meat consumption since 1994, and (as has been the case in other developing countries) this is projected to increase over time.

The per capita level of meat consumption rose to just over 53kg per person per year in 2022 (Organisation for Economic Co-operation and Development [OECD], 2023). By comparison, the world average in the same period was 34kg per person. Overconsumption places undue pressure on production systems, and meat as a consumption item is distinctive in that production is geographically contained. The high costs of transporting meat across international borders and the associated tariffs result in predominantly domestic production. As a consequence, meat production turns to more intensive measures, which place pressure on the environment through various mechanisms and can harm animal welfare. Overconsumption of meat also damages the health of the individual consumer, which in turn increases the demand for health services and could overload the already strained South African health system.

There is an established body of literature on meat consumption and the determinants of the demand for meat. Some studies have examined the economic determinants of demand through an analysis of the price-demand relationship (see Janse van Rensburg et al., 2020; Desiere et al., 2018; Aepli & Finger, 2013; Poonyth et al., 2001). Although these studies provide some illumination as to the dynamics of meat demand, they are limited as the determinants of consumption extend beyond the price-income relationship. Meat may be linked to an individual's sense of identity, beliefs, and culture. Consumers eat meat because of the intrinsic value they place on the meat product, as well as the extrinsic meanings attached to meat, such as it being a signal of wealth and success.

There are several ways to reduce the various form of damage linked to meat consumption and production, such as the existing legislation to regulate production, and the introduction of a meat tax to regulate consumption. However, production regulations are insufficient for alleviating the environmental effects of intensive production, and do not address the health concerns of overconsumption. A meat tax would be regressive in nature, restricting those who are food insecure from being able to afford meat. South Africa, like many other developing countries, faces a double burden of malnutrition – there is the issue of food insecurity and scarcity of nutrients for some, but also overconsumption and excess on the other end of the

scale (Food and Agricultural Organisation [FAO], 2022). The goal should thus not be the total elimination of meat consumption, but a reduction in the overconsumption of meat products, especially red meat.

This study is an attempt to uncover the drivers for meat consumption in South Africa, to assist in achieving this goal of meat reduction. Through treating consumers as heterogenous in their reasons for meat consumption, we can explore the determinants that drive high meat consumers. Furthermore, the use of a Gauteng sample means an overrepresentation of consumers who eat an excess of meat.

Section 2 presents the crux of the question; section 3 provides the background to meat consumption in South Africa; and section 4 covers the existing literature and studies, as well as consumption theory and nutritional guidelines. After this, section 5 introduces the dataset used in the study, while section 6 outlines the theory of the methodologies used in the analysis, including post-estimation tests. Section 7 provides a description of the data used and discusses the results from the empirical analyses. Finally, section 8 concludes with the limitations of the study, and an exploration of areas for further research.

2. Problem statement

One of the main challenges posed by excessive consumption of meat is the production practices adopted by livestock producers to meet the ever-increasing demand. Unsustainable production practices worsen the already very high levels of GHG emissions, land degradation, impacts on ecosystem processes, biodiversity loss and unsustainable water requirements for meat production, particularly in water-scarce countries such as South Africa (Simo-Kengne et al., 2018).

Food security is a pressing global and national issue, with increasingly unstable food and commodity markets. The Food and Agriculture Organisation of the United Nations (FAO) warns of unstable food security and increased pressures on global land and water supplies, especially in a time of climate change (FAO, 2022). Global food-productive capabilities are being stretched to their limits, and extending production beyond current boundaries will be unsustainable.

The main drivers for the growing demand for meat are the increasing world population and increased per capita consumption. Relatively higher income in both developed and developing countries has made it possible for consumers to purchase better quality foods. This means a shift from inexpensive foods such as wheat, maize meal and rice to saturated-fat meat products such as beef, pork and poultry. Overall, consumption habits are changing quickly, around the world, towards high protein consumption as part of a general diet. However, the world is highly diverse, encompassing regions and countries that vary widely in income level, market maturity, demographics, religion, dietary preferences and culture. Even among different meat types, preferences vary widely between markets.

There is general consensus that meat consumption correlates positively with income to some degree. However, the evidence suggests there are important factors other than income that influence meat consumption patterns (Taljaard et al., 2006). The dynamics of the factors of meat consumption differ considerably between developed and developing countries. There is an emerging trend in developed countries such as Germany, Poland and other Western European countries, where a decrease in meat consumption has been observed with an increase in income (Van Wezemael et al., 2010; Kayser et al., 2013). This decrease in meat consumption is attributed to consumer concerns about meat safety, animal welfare, health concerns, and environmental and climate change concerns.

Although per capita meat consumption is still relatively low in Africa, South Africa is an exception, with levels above world averages. South African meat consumption is the highest on the continent (Ndlela & Murcott, 2021). Globally, South Africa has the eighth-highest level of poultry consumption per capita, and the 16th-highest level of beef consumption. And despite consensus that meat is a vital source of essential nutrients, it also provides large amounts of saturated fat, which is known to increase the risk of obesity and of a number of diseases such as stroke, breast cancer and colon cancer (Wolk, 2016).

Following South Africa's move to democracy in 1994, major shifts in dietary habits have occurred and continue to occur. Accompanying the increases in food consumption, which include more meat intake, are considerable health, environmental and climate-change consequences. A comprehensive understanding of the underlying drivers behind excessive meat demand is required so that effective programmes to reduce domestic meat demand can be

designed. To achieve this, surveys were undertaken in and around Johannesburg, in the Gauteng province of South Africa in 2015.

So far only a few studies have explored how the different types of consumer differ in their involvement in meat (Koch et al., 2019; Kayser et al., 2013). In this study, individual meat consumption patterns among the Johannesburg consumers were observed. Based on their stated meat consumption patterns, three consumer segments were identified ('heavy consumers', 'average consumers' and 'low consumers'), and their various socio-economic factors, attitudes, and beliefs were used to shed light on the determinants of their weekly meat consumption. The results from this study may potentially contribute towards meat reduction strategies.

3. Background

An immediate reduction in meat consumption is vital to protect the environment, animal welfare, and the health of individuals. In 15 years, meat consumption in South Africa increased by 18kg per person per annum, from 40.3kg in 1994 to 58.7kg in 2009 (Ronquest-Ross et al., 2015). This increase has continued over the years since, a pattern seen both globally and in Sub-Saharan Africa (Desiere et al., 2018; Mathijs, 2015). Indeed, Figure 1 below, based on Organisation for Economic Co-operation and Development (OECD) data, shows how annual South African meat consumption per capita has increased over the last three decades and is predicted to increase further. The values from 2021 onwards are forecasted estimates of annual per capita consumption.

The annual per capita consumption of chicken in South Africa far exceeds the world average, and its steep rise starts from the mid-1990s. South African beef consumption also exceeds the world average, but pork, fish, and mutton per capita values fall below the world averages. The sharp increase in chicken consumption could be because of its low and accessible price per kilogram, in a country with high inequality and poverty levels. On average, chicken is the cheapest meat available in the South African retail market, on a Rand per kilogram basis, followed by pork, beef, and finally mutton (Delport et al., 2017).

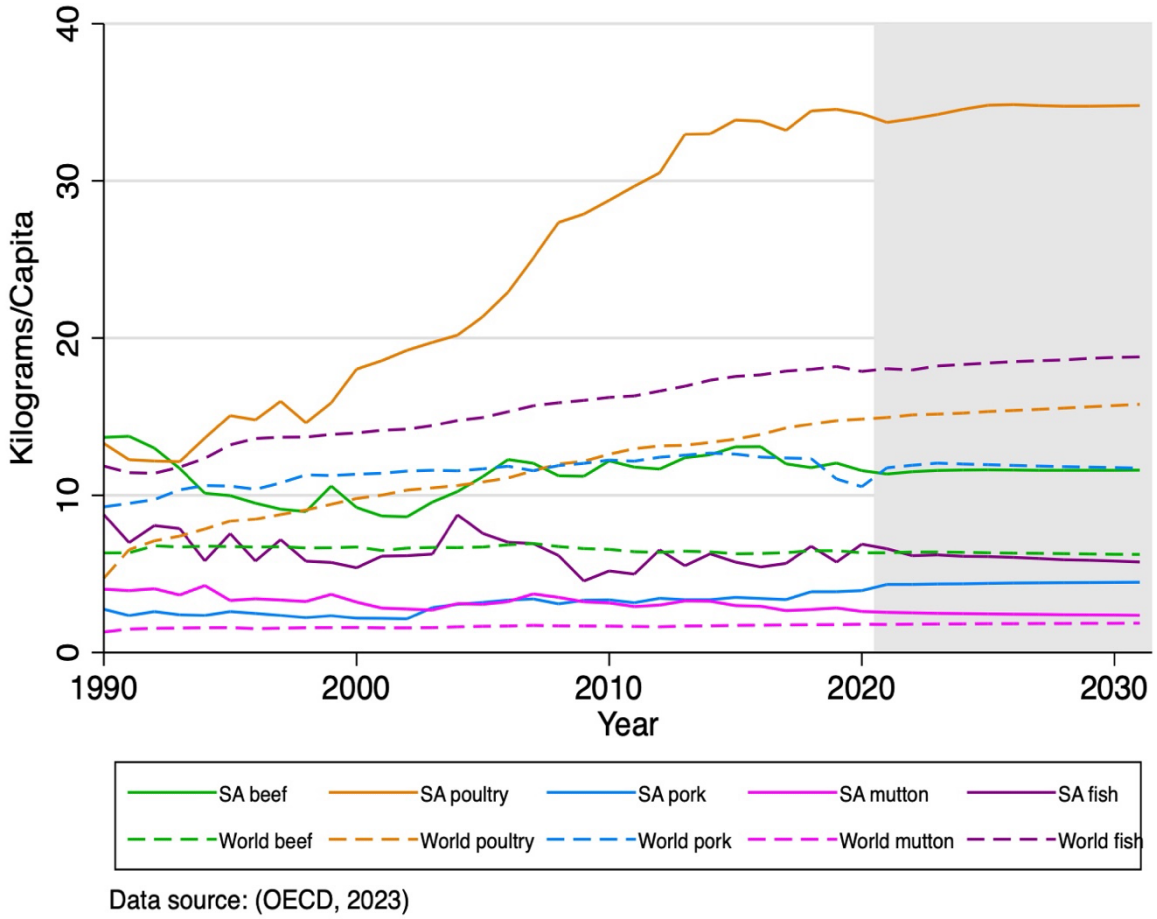


Figure 1: South African and world average annual per capita meat consumption

The regulation of meat consumption is only one facet of promoting a healthy and diverse diet in South Africa, just as meat consumption is only one aspect of a healthy diet. The country faces a double burden of malnutrition; some people suffer from undernutrition, but others suffer from overnutrition, caused by high consumption levels of energy-dense but nutrient-poor foods. Diversity in the dietary patterns of individuals results in higher degrees of nutrition, compared to a monotonous diet which is associated with malnutrition (Labadarios et al., 2011). The less diverse a diet is, the less likely it is that an individual is receiving all the required nutrients in their diet; such an individual is thus at risk of malnutrition and food insecurity.

Diversity in an individual's diet is determined by the number of food groups eaten in a certain period, and in studies is estimated using the Dietary Diversity Score (DDS). The DDS is a scale from 1 to 9, and is a measure of how many food groups are consumed in a particular time period. Scores of less than 4 indicates poor diversity of diet. On average, South Africans eat a

monotonous diet, heavy in cereals, starches and meats, but low in fruit and vegetables. The national DDS was estimated as 4.02 (Labadarios et al., 2011). The province in which this study is based, Gauteng, had a DDS score of 4.22 and was the third most dietary diverse province, behind the Western Cape and the Free State.

4. Literature review

This research does not advocate the complete elimination of meat from diets, but rather a reduction in the excessive consumption of meat which places undue pressure on the environment and on the health of individuals. Below a certain level eating meat is nutritionally beneficial, as it provides consumers with important macro- and micro-nutrients (Parkasca & Qaim, 2022; Salter, 2018; Schonfeldt et al., 2013).

Red meat is nutritionally important as a source of fundamental vitamins and minerals, such as amino acids, vitamin B12, iron and zinc (Wolk, 2016). On average, meat protein is of a higher quality than plant protein, because the protein is sourced from an animal (Salter, 2018). In comparison to plant protein sources, meat proteins are generally more digestible and have more amino acids (Schonfeldt et al., 2013). The iron found in red meat is more bio-available than plant-based iron, which means that it can be absorbed and used more readily by the body. Meat proteins, especially fish, are a source of omega-3s and other fatty acids (Salter, 2018). In a country faced with food insecurity, meat can contribute to an individual receiving their required nutrition. However, there is one recommendation on which international food-based dietary guidelines (FBDGs) for meat agree: meat is recommended to be eaten only in moderation. Nevertheless, the specific measurement of a 'moderate' amount of meat varies from country to country. Some countries – South Africa, for one – merely recommend eating meat in moderation, but do not stipulate what that should entail (Schonfeldt et al., 2013). Other countries provide a maximum recommended weight of meat.

Although most guidelines agree that meat consumption should be moderated, the specific amount of meat recommended varies from country to country (Camara et al., 2021; Gonzalez Fischer & Garnett, 2016). In Europe, recommendations vary from less than 500g per week to 788g/week of cooked meat (Camara et al., 2021). Chinese guidelines stipulate 280 to 525g per week of lean meat. American FBDGs recommend 26 ounces (737g) per week of meat, poultry, and eggs (Camara et al., 2021). Recommendations from the studies and FBDGs can cause

confusion for consumers, as the quantity attached to the description ‘moderation’ may vary from person to person. Recommendations change over time; consequently, consumers need to keep up to date with contemporary guidelines. Serving sizes can vary, and the cooking method used also influences the nutritional composition. Further, the weight of a piece of meat changes during cooking, thus FBDGs must state whether their recommendations are for cooked or raw meat. Guidelines also often differentiate between red meats, lean meat, and fish.

The current South African FBDGs advise eating a moderate amount of meat, in line with international food-based dietary guidelines (Schonfeldt et al., 2013). The previous FBDGs were outlined in 2001; they suggested 2-3 fish portions per week at 80-90g per portion, and not more than 560g of red meat per week. In 2013, these guidelines were updated to remove the recommendation for red meat consumption and promote the consumption of lean meat – defined as meat that has had its visible fat trimmed off it (Schonfeldt et al., 2013). The current FBDGs recommend eating 2-3 portions of fish, at 90g per portion, and eating a maximum of 90g of lean meat per day. This amounts to a maximum consumption of between 180g and 270g of fish and 630g of lean meat per week.

As these are recognised nutritional benefits, the consumption of meat is associated with improving the nutritional status of children and offsetting nutritional deficiencies, especially in poorer and more rural areas (Salter, 2018). Livestock production for meat consumption also serves as a source of income, especially for people in rural areas where income-generating activities are limited (Parkasca & Qaim, 2022).

4.1. Excessive consumption

Meat consumption in excess of the guidelines mentioned is not healthy – for neither the individual nor the collective – and policymakers face a challenge in attempting to alter consumer behaviour. There are barriers to changing dietary habits; the solution, therefore, is not to push for the complete eradication of meat in people’s diets but to intimately understand the reasons why individuals eat meat, in order to implement interventions that will move people to reduce their consumption.

There are several reasons to be concerned about excessive meat consumption. Firstly, excessive meat consumption has been linked to long-term detrimental health consequences. Plant-based

diets are seen to be healthier on many levels, compared to meaty diets. Those who follow a plant-based diet have lower BMI, lower cholesterol and lower mortality rates from heart diseases (Lea & Worsley, 2001). The consumption of red meat is associated with increased risk of diabetes (Willett & Stampfer, 2013). Red meat is also widely recognised as a possible carcinogen, with consumption of red meat increasing the chances of cancers such as colorectal and prostate cancer (Gonzalez et al., 2020). Although consumers could consider the link between negative health indicators and meat consumption as an individual phenomenon, higher meat consumption increases the burden placed on the healthcare system in the long run, thus placing a burden on society (Bonnet et al., 2020).

Secondly, the increased demand for meat (and consequently, increased meat production) places more pressure on the producers of meat products, which in turn results in environmental degradation. Pressure is placed on meat production by higher demand for meat and meat products, especially since meat production is highly dependent on a country's natural endowments (Milford et al., 2019). The amount of meat produced in a country depends on the availability of domestic production, which depends on the country's natural endowments (Milford et al., 2019). International trading in meat is costly; thus, although meat and meat products are traded internationally, production takes place predominantly domestically.

As the demand for meat increases, farmers turn to more intensive practices in order to match the intensified demand, especially by urban consumers (Parlasca & Qaim, 2022; Gerber et al., 2015). Intensive meat production has several negative externalities (Katare et al., 2020). The price of meat does not reflect the external costs of meat production to the environment, or the health costs to individuals. Intensive farming practices such as feedlots result in greater natural resource efficiency, as livestock gain weight rapidly while using less land in comparison to other farming practices such as grazing or mixed farming systems (Gerber et al., 2015). Feedlots are a common solution to the high demand for meat products; they allow farmers to match the urban demand for meat with high performance levels, while producing the standardised carcasses demanded by supermarket retailers (Gerber et al., 2015).

These feedlots produce large amounts of water and air pollution, and infringe on the welfare of both livestock and local communities (Parlasca & Qaim, 2022). Livestock production has both direct and indirect effects on the environment. The animals release GHGs, which cause damage to the atmosphere. Livestock production, including of eggs and dairy products, is

responsible for over 14.5% of GHG emissions into the atmosphere (Gonzalez Fischer & Garnett, 2016). A high-meat diet contributes 7.19 carbon dioxide equivalents per day; a vegetarian diet releases almost half the emissions of a high-meat diet (Gonzalez et al., 2020).

Indirectly, the production of crops for animal feed makes use of environmentally harmful fertilisers and takes up more land than crops produced for direct human consumption (Parlasca & Qaim, 2022). Additionally, greater demand for meat degrades the quality and productivity of agricultural land, as production intensifies to keep up with demand (Falchetta et al., 2021). As a result of expansion in livestock production and land demand, deforestation occurs, in order to make space for both animal pastures and crop production.

Animal welfare is another concern linked to increases in meat demand. This concerns the treatment of animals for the production of meat (Perino & Schwirplies, 2022). Intensive farming measures can increase the risk of transmission of disease among the animals; an example is the current global avian influenza epidemic affecting chicken and egg production.

Interventions must be made in order to ensure that production can match demand, yet not degrade natural resources (FAO, 2022). Interventions in the meat value chain have mostly focused on production-side regulations, but there is an increased understanding that interventions on the demand side of the value chain can be valuable (Ndlela & Murcott, 2021; Gonzalez Fischer & Garnett, 2016). In order to implement effective demand-side interventions to regulate the overconsumption of meat, the drivers of said consumption must be recognised.

4.2. Consumption theory

Many previous studies on the price determinants of meat demand have used neoclassical economic theory as their point of departure (Delport et al., 2017; Taljaard et al., 2006). Alfred Marshall is credited as establishing neoclassical consumer theory in 1890, with his seminal work on the downward sloping demand curve (Tisdell & Hartley, 2008). The downward sloping demand curve represents the negative relationship between price and demand for a normal good by a consumer.

Neoclassical theory established two fundamentals of consumption – the income rule and the substitution rule. The income rule states that – all else constant – there is a positive relationship

between income and consumption, while the substitution rule states that there is a negative relationship between the price of a good and its consumption – as the price of a good increases, its consumption decreases as consumers switch to its substitutes (Drakopoulos, 2021). Non-price factors of demand such as socio-economic and demographic characteristics are often mentioned in the footnotes, or as exceptions to the price rule.

The aim of the neoclassical consumer is to maximise their utility and they are assumed to be rational, well-informed, and have exogenously determined preferences which shape their consumption decisions (Tisdell & Hartley, 2008). Market demand is calculated as the aggregate of individual consumers' demand functions. Consumers are seen as sovereign individuals within the neoclassical school, who act both logically and consistently. However, the assumption of consumer individualism is often critiqued. In actuality, consumption is a multi-faceted, socially-embedded process whereby culture, socio-economic characteristics, marketing, and the production process are all factors which shape consumption and in turn are shaped by consumption (Heiskanen & Laakso, 2019; Todorova, 2014; Fine, 1994).

Food is considered to be a 'normal' good, and follows neoclassical rules for the most part. In their study on South African meat demand, Taljaard et al. (2006) draws from neoclassical theory to establish a demand function whereby per capita meat consumption is a function of the price of meat, the relative price of meat in relation to similar products, consumers' income, and an error term. The error term captures a indeterminant amount of unspecified non-price factors affecting the demand for meat. The treatment of non-price determinants of demand in the 2006 study of Taljaard et al. is emblematic of the neoclassical approach.

Indeed, there is an established correlation between increased income and increased meat consumption internationally (Bereżnicka & Pawlonka, 2018; Desiere et al., 2018; Mathijs, 2015; Sans & Combris, 2015). Initially, as income rises, so too does meat consumption. The negative relationship between price and consumption asserts that if the price of a good rises, consumers reduce their demand for that item and switch to cheaper alternatives. Multiple papers have explored the relationship between income and meat consumption in South Africa. In one example, Marshallian price elasticities – the estimate of a change in demand of a good due to a change in its price – were estimated for chicken, beef, pork and mutton over the period 1970 to 2000 (Taljaard et al., 2004). All four of the elasticities were found to be negative, indicating that in South Africa, meat demand decreased with an increase in price.

Delport et al. (2017) updated the 2004 estimates for meat demand elasticities in South Africa, stating that class mobility, a change in policies, and the rapid increase in commodity prices between 2005 and 2009 could all have had an impact on meat demand. The updated short-term Marshallian own-price elasticities over the period January 2008 to September 2014 estimated that beef was the least price-responsive meat type, with an estimate of -0.38. Mutton was estimated to be the most price-responsive meat type, with an own-price elasticity of -1.04 (Delport et al., 2017). The Delport study identified two types of poultry products, individually quick-frozen (IQF) poultry pieces and other chicken products. Their Marshallian elasticities were -0.72 and -0.93 respectively, with demand for IQF pieces especially responsive to changes in price. Their estimates for the Marshallian own-price elasticities were measured over the short term, and are thus not directly comparable to the long-term estimates found in Taljaard et al. (2004).

Expenditure elasticities are defined as the percentage change in the quantity demanded of a meat product as a result of a 1 percent change in total expenditure on meat products. Mutton had an estimated expenditure elasticity of 1.07 – it is a luxury item, for which a 1 percent increase in total expenditure on meat products increases the expenditure on mutton by 1.07 percent (Delport et al., 2017). Beef and pork were classified as normal goods, based on their expenditure elasticities of 0.80 and 0.44 respectively (Delport et al., 2017). Contrary to expectations, a 1 percent increase in expenditure on meat increases expenditure on IQF poultry by 1.24 percent, and expenditure on other poultry by 1.17 percent. Based on their expenditure elasticities, both poultry products are classified as luxury goods. Delport et al. (2017) explain this by reasoning that for low-income households, poultry is a luxury item compared to other protein sources such as pulses and starches.

The different types of meat can act as substitutes for each other. For instance, Aepli and Finger (2013) found that sheep and goat meat are substitutes for other types of meat in Switzerland. Studies that focused on the price determinants of meat consumption in South Africa have shown that white meat is a substitute for red meat, and its demand is growing (Poonyth et al., 2001). Hosu et al. (2015) established that fish and vegetables are substitutes for meat consumption for university students in the Eastern Cape province of South Africa. Janse van Rensburg et al. (2020) showed that in South Africa, the average purchase price of a particular meat is influenced by the prices of other meats.

Taljaard et al. (2006) expanded their 2004 study on the price-based demand function for meat by the use of an OLS function of price and income, through which non-economic factors are captured as the residual. They concluded that – due to the model's large residual value – non-economic factors are increasingly important to the demand for meat. However, they did not specify what these factors are or how they shift the demand for meat. This study is thus an expansion on these unidentified factors of demand for meat products.

Nonetheless, the interaction between income and meat consumption is more complex than the simple positive, linear relationship between income and other normal consumption goods. In high-income countries, there is evidence of a parabolic relationship between income and meat consumption: as income rises beyond a certain amount, there is a turning point where consumption stagnates despite a further increase in income, suggesting that there are other determinants of meat consumption (Parlasca & Qaim, 2022). Research suggests that this stagnation is due to changes in the demographics and preferences of consumers, as well as greater awareness of animal welfare, environmental and health concerns.

4.3. Beyond economic determinants of meat consumption

Meat consumption does not follow neoclassical consumption theory. While price and income somewhat influence the consumption of meat, there are also non-price influences of meat consumption. Alternative consumption theories posit that the factors of consumption extend beyond the price-income relationship; rather, they are a process shaped by society (Todorova, 2014). Consumption is also theorised to be situated within a system of provision, whereby production and consumption – on either end of the value chain – exist in flux with each other (Fine, 1994). Thus, consumption can be shaped not only by the price of a good, but also by societal influences, marketing, culture, and beliefs.

Behavioural economic theory critiques the rationality assumption of neoclassical economics by acknowledging the irrationality of consumers. Behavioural economic theory posits that consumers can be nudged to make better consumption choices (Heiskanen & Laakso, 2019). These nudging methods to alter consumer behaviour can be shifting the framing of information, changing the default options, or changing the physical environment. With regards to meat consumption, Kurz (2018) found that rearranging a Swedish university cafetoria menu to

present vegetarian options first increased the sale of vegetarian meals by 6 percentage points. The field experiment highlights the impact of nudging since prices did not change, and increased vegetarian meal sales persisted after the intervention was removed (Kurz, 2018).

Meat holds great meaning beyond that of nutritional need; and as a developing country such as South Africa becomes more developed and integrated into the global economy, the composition of its consumption changes. There are several overarching themes regarding the drivers of meat consumption, including health concerns, animal welfare and environmental concerns, socio-economic factors, and the socio-cultural environment.

In both developed and developing countries, consumers are motivated to eat meat based on their belief in its health and nutritional benefits. Meat can provide important nutrients to undernourished individuals (Parkasca & Qaim, 2022). In Ethiopia, consumers eat more meat in order to obtain more nutrition during times of ill health (Lijalem et al., 2013). Health benefits were cited as the primary reason for meat consumption in a study on Indian meat consumption patterns (Eswara Rao et al., 2017). However, in Ghana, health was not a predominant motivation for eating meat among university students (Mensah et al., 2022). This difference in motivation highlights the contextual nature of the drivers of meat consumption.

A study in Holland revealed that overall, 41% of native Dutch respondents believed that it is healthier to eat meat frequently (de Boer et al., 2017). In Spain, the nutritional benefit gained from eating meat was a dominant driver for eating meat (Font-i-Furnols & Guerrero, 2022). A German-based study on the characteristics of meat consumers found that motivations for eating meat included that it was healthy (Koch et al., 2021). However, low, medium, and high meat eaters all had different beliefs concerning the healthiness of meat. The same study found that high meat consumers (i.e. those who ate in excess of 86g/day) had equal or less preferable health characteristics compared with low meat consumers.

Paradoxically, health is also a significant factor in consumers reducing or avoiding consuming meat (Perino & Schwirplies, 2022; Moons et al., 2018; Kayser et al., 2013; Lea & Worsley, 2001). This is expected given the controversy around the healthiness of meat (Font-i-Furnols and Guerrero, 2022). Consumers in Ireland reported that they reduced their meat consumption in order to improve their health status (Doherty et al., 2021). Similarly, self-reported vegetarians in the Netherlands had more favourable health statuses compared to regular meat

eaters (Gilsing et al., 2013). Health consciousness is a significant reason for adopting meat alternatives in Belgium (Moons et al., 2018). The same was found in a study in Germany on the reasons for reducing meat consumption (Perino & Schwirplies, 2022).

In the South African context, health was one of the primary reasons for respondents to purchase plant-based proteins or cultivated meat (i.e. meat grown in a lab) (Szejda et al., 2021). Szejda's study examined the drivers of consuming plant-based proteins or cultivated meat, and separated the nationally representative sample into early adopters and the general population. The study adds to the literature on implementing interventions to promote a healthier diet in South Africa, but neglects to explore why individuals consume meat. In a review of the existing literature on meat consumption in Oceania, USA, Canada, and Europe, health was one of the primary reasons for reducing meat consumption, in 17 studies (Valli et al., 2019). The same review found in 13 studies that the belief that meat was a component of healthier diets was one of the main reasons for eating meat.

Animal welfare is understood to relate to the treatment of animals: their quality of life, nutrition, environment, health, and behaviour (Font-i-Furnols & Guerrero, 2022; Parlasca & Qaim, 2022). The current livestock production system is guided mostly by the extrinsic value of livestock as instruments for trade and profit, rather than their intrinsic value as sentient beings (de Jong & van Trijp, 2013). Graça et al. (2015) noted that a 'meat paradox' exists in that consumers are disturbed by the idea of animals being killed, yet they still eat meat. A price premium is placed on meat products with better welfare conditions for livestock – consumers face a trade-off in their decision between the price of meat and the welfare of the animal (de Jong & van Trijp, 2013).

Interventions that educate consumers on the animal welfare impact of meat consumption are associated with a reduction in the intention of consumers to eat meat (Bianchi et al., 2018). Animal welfare was found to be a statistically significant reason for reducing meat consumption among consumers in Germany (Perino & Schwirplies, 2022). This was also the case in Australia (Lea & Worsley, 2001). Animal welfare is an important driver of the purchasing of plant-based proteins and cultivated meats in South Africa (Szejda et al., 2021).

There is scant research into the influence of South African consumers' environmental concerns on their level of meat consumption. Szejda et al. (2021) estimated that South African

consumers are highly motivated to purchase plant-based proteins and cultivated meats because they believe that these alternatives are better for the environment. However, in one study based in Belgium, environmental concerns were not considered a statistically significant reason for consumers adapting to meat alternatives (Moons et al., 2018).

Urbanisation is associated with higher levels of meat consumption. A difference-in-difference study of people who had migrated from rural areas to cities in Tanzania found that migrants increase their meat consumption by an average of 83.65kcal per person per day (Cockx et al., 2018). Milford et al. (2019) used national-level data in their global study on the drivers of meat consumption. They showed that an increase in the relative size of the urban population increases per capita annual meat consumption by 33.2kg. The global pattern of greater meat consumption in urban areas in comparison to rural areas holds true for South Africa as well. Labadarios et al. (2011) estimated that 89% of individuals living in urban, formal areas ate meat, poultry or fish. Contrastingly, only 65% of rural residents ate meat, poultry or fish. In Gauteng, 88% of individuals ate meat, poultry or fish, which made the province the second-highest consumer of meat products (Labadarios et al., 2011).

One reason behind the rise of meat consumption in urban areas is greater exposure to other cultures, global media, and transnational food corporations such as KFC and McDonalds (Kearney, 2010). In India, Hindu households that used media such as TVs, newspapers and radio had a 33% greater likelihood of having purchased meat in the last 30 days (Filippini and Srinivasan, 2019). Additionally, an increase in the social globalisation index – which includes the sharing of culture and norms, tourism, and migration – is associated with a 0.4kg per capita annual rise in meat consumption globally (Milford et al., 2019). In China, urbanisation affected both the level and the composition of meat consumption, with urban consumers eating proportionally less pork than rural consumers (Liu & Deblitz, 2007). The authors noted that the urban consumers were more exposed to Western recipes and cooking, thus they ate proportionally more beef and mutton than the rural consumers, who were influenced by traditional recipes based on pork.

The popularity of fast-food restaurants in South Africa is indicative of the Westernisation of diets, with traditional foods being replaced by transnational food corporation products (Kearney, 2010). Street and fast foods usually contain some form of processed meat; for instance, the popular *kota* contains a choice of processed meats such as polony, Russian

sausage and Vienna sausage (Feeley et al., 2009). Street foods and fast foods are a way for consumers to feed themselves quickly and cheaply, often with animal-based ingredients that are high in fats and oils (Steyn et al., 2011). This is especially important in urban areas, where individuals may not have the time to prepare food at home due to their work and commuting time constraints. A qualitative study into the socio-cultural factors influencing food consumption in Khayelitsha, Cape Town discovered that individuals associate both meat and fast foods with high socioeconomic status (Puoane et al., 2016). As people migrate into cities, they abandon more traditional foods such as vegetables and legumes in favour of meat and fast foods, as a signal of their wealth and status.

One national study found that 11.3% and 6.8% of South Africans eat street foods and fast foods respectively more than twice a week (Steyn et al., 2011). Another study found that in Soweto, 40.3% of adults visited street food and fast-food restaurants one to three times a week, and 35.3% of adults visited these restaurants four to 10 times per week (Feeley et al., 2009). However, although these food items are high in calories, they are low in nutrients. In South Africa, those who ate street foods more than twice a week had a lower DDS than those who seldom ate street food, which indicates the lack of diversity in street food options as well as their threat to food security (Steyn et al., 2011).

Like other food products, meat is culturally and socially important. In South Africa, meat is intrinsically linked to individuals' religious, racial and cultural identity (Daya, 2022; Moons et al., 2018; Erasmus & Hoffman, 2017). Daya (2022) noted that in South Africa, as in the rest of the world, food produces an emotional response. Eating meat can create contrasting feelings in diverse people – feelings of disgust or enjoyment, of connection to others as well as disconnection from others (Daya, 2022; Fessler et al., 2003). It is therefore inaccurate to determine levels of demand for meat using only measures of price.

Religion and culture are other significant determinants of meat demand, and are more apparent in the results of studies based in developing countries. Among university students in Ghana, religion was a motivator for reducing meat consumption (Mensah et al., 2022). The majority of students who stated that religion limited their meat consumption were students of the Muslim faith. They followed the Muslim teachings regarding *haram* and *halal* food, which state that certain meat types (notably pork) are to be avoided as they are believed to be unclean (Mensah et al., 2022). Other religious reasons for avoiding meat consumption included not wanting to

harm another one of God's creatures. Similarly in India, religion influences both the amount and type of meat consumed. India has one of the most vegetarian populations, with religions such as Jainism, Hinduism and Buddhism advocating vegetarianism (Filippini & Srinivasan, 2019). Filippini and Srinivasan (2019) concluded that on average, Hindus in India are less likely to eat meat compared to followers of other religions. Contrarily, religion can also be a reason for eating *more* meat, as found by Lijalem et al. (2013). In Hawassa City, Ethiopia, religious events and festivals were the greatest reason for meat consumption.

The composition and levels of meat consumption are also influenced by gender. Across countries, regions and socioeconomic statuses, women eat less meat than men on average (Drimie et al., 2013; Kayser et al., 2013; Labadarios et al., 2011). Hosu et al. (2015) estimated that among university students in the Eastern Cape province of South Africa, women have a reduced probability of eating meat compared to men on average. More often than not, women are the household members who plan, shop for and prepare food. Women cite health concerns as a reason to reduce meat consumption more so than men (Lea & Worsley, 2001). Meat is often depicted as a masculine food, and vegetarianism is seen to challenge conventional ideas of masculinity and maleness (Graça et al., 2015).

There are several reasons to segregate consumers into groups when undertaking an analysis. Lea & Worsley (2001) identified significant differences in the motivations for eating meat between women and men, and also between consumers of different age groups. Kayser et al. (2013) examined a consumer survey of German consumers. The respondents were ranked by their levels of meat consumption and then stratified into three relatively equal-sized groups: 'low', 'average' and 'heavy' meat consumers. The results showed statistically significant differences in the patterns of consumption among the three consumer groups. There were also significant differences in attitudes regarding animal welfare, health and environmental awareness.

As with Kayser et al. (2013), Koch et al. (2019) stratified their sample by consumption levels. Botha et al. (2012) also divided their sample in order to obtain greater accuracy and sensitivity of results. Apostolidis and McLeary found in their 2016 study on UK consumer preferences for meat that when consumers were segregated by their consumption patterns, differences in motivation were revealed. Arnaudova et al. (2022) established that consumers are at different stages of changing their consumption behaviour; thus, attempts to alter consumer consumption

patterns must target each stage of their behavioural change. Other studies that have stratified consumers by their levels of consumption and have employed an ANOVA to estimate differences in characteristics, behaviours and/or beliefs include Lacroix and Gifford, 2019; Malek et al., 2019; Weibel et al., 2019; Lentz et al., 2018; Gilsing et al., 2013; and de Carvalho et al., 2012.

Studies into South African meat consumption have focused predominantly on the economic relationship between price and demand, at the expense of socio-economic factors such as culture, beliefs and attitude (Janse van Rensburg et al., 2020; Desiere et al., 2018; Delport et al., 2017; Oyewumi and Jooste, 2006; Taljaard et al., 2006; Taljaard et al., 2004; Poonyth et al., 2001). However, evaluating meat demand using these methods ignores the myriad other factors that shape the demand for meat. Qualitative approaches to the drivers of meat consumption in South Africa include Daya (2022), Bisschoff and Liebenberg, 2017, Erasmus and Hoffman (2017) and Puoane et al. (2006). These studies are a valuable point of departure for analysing meat consumption; but their results cannot be used to model and forecast how various determinants affect meat consumption. The limitations of other studies on food consumption in South Africa are that they focus on fast foods, or dietary patterns, so meat consumption determinants must be inferred (Drimie et al., 2013; Labadarios et al., 2011; Steyn et al., 2011). Accuracy as to the determinants of meat consumption is lost in these studies. Hosu et al. (2015) measured meat consumption among students in the Eastern Cape using a binary variable for the probability of consuming the recommended amount of meat. A model with a binary dependent variable that captures whether or not a person has consumed or purchased meat cannot capture the *degree* of meat consumption. This study, which measured both the frequency and the level of meat consumption, provides a more accurate representation of meat consumption. Further, consumers in this study were treated as heterogenous. This allows for more nuance and accuracy as to the drivers of meat consumption in South Africa.

5. Study area and dataset

The data come from a collaboration project which falls within a research partnership between South Africa and Norway, entitled the South Africa-Norway Research co-operation on Climate Change, the Environment and Clean Energy (SANCOOP). The data is as-yet unpublished but was generously shared by Dr Johane Dikgang. The collaborative project is titled "Towards an Integrated Tailored Food Policy: Consumer-level mitigation using a hybrid analysis of meat

choice and behavioural change", and aimed to understand consumer behaviour as a way to mitigate climate change. After a successful pilot study, face-to-face interviews of randomly selected households were conducted around Johannesburg and surrounding areas in the Gauteng province of South Africa, from May to June 2015. Figure 2 below is a contextual map of Gauteng, showing both Gauteng's location within South Africa, and the major cities of Gauteng.



Figure 2: Contextual map of Gauteng within South Africa

Source: Mapbox, (2023); OpenStreetMap, (2023); DWS (n.d.)

Gauteng was selected as the study site due to its high levels of urbanisation and wealth, which makes it a forerunner in meat consumption for other provinces as they develop. Gauteng is the most populous province in South Africa, with a population of over 13 million, despite it being the geographically smallest province (StatsSA, 2016). It has the second-highest average annual household income of R193 771 which is above the national average of R138 168 and behind the average annual household income of the Western Cape at R22 959 (StatsSA, 2017). As we

begin to understand the determinants of meat demand for Gauteng, we can start to predict determinants in other provinces and implement early interventions to alleviate high consumption.

In total, 600 community-dwelling household heads were interviewed using electronic instruments, of which 39 identified as vegetarian. Given the aim of our study, they were omitted from the analysis, as the sample was deemed too small to perform any meaningful analysis on this segment. As part of the study, respondents were asked almost 100 in-depth questions on their dietary habits, their understanding of nutrition, the environment, animal welfare, and farming practices. Questions also covered their opinions on their preferences for and relationship with meat and vegetables, as well as their personal and household characteristics. Respondents had to answer questions about their values and principles in relation to their dietary choices, their perceptions of the environment, and their own impact thereon. Questions regarding the price of meat were not included in the survey, due to people's unreliable guesses regarding prices.

Respondents were asked about their consumption of meat in several different questions. The meat types included were beef, chicken, lamb, pork, fish, and other meats. If respondents ate other types of meat, they were asked to name the meat type. Common types of other meat included ostrich, turkey and game meats. Respondents were asked individual questions on the number of pieces of meat eaten per meal as well as the frequency of meals eaten per week. A portion was defined as 100g of meat, and described as the size of a playing card. The questions on the quantity and frequency of meat consumption required integer answers.

The dependent variable – total meat consumed in a week – was calculated as the sum of each type of meat eaten in a week. First, the number of portions of meat consumed per meal was multiplied by the number of meals per week for each meat type. The variables that form the dependent variable were all measured on a Likert scale as approximations of weight to the nearest 100 grams, and are thus not exact measures of the amount of meat eaten in a week. As the generated variable was a manipulation of non-negative integer variables, total meat consumption is a count of the number of 100g portions of meat consumed per week.

An aggregation of the different types of meat consumed in a week provides a more complete picture of meat consumption, rather than an analysis of consumption frequency, as portion size

per meal can vary wildly. In this regard, the generated dependent variable improves on studies focused either on consumption frequency (with the amount eaten per event unknown) or on the amount of meat eaten per meal (with the frequency unknown).

The methodology for determining meat consumption patterns varies from study to study. A common methodology is to stratify the sample by consumption levels, in order to estimate differences in the characteristics, beliefs or behaviours of the various groups. This division is undertaken with the understanding that meat consumers are not homogenous. Dividing the sample allows for comparison between those who overconsume meat and those who eat more in line with nutritional guidelines (Koch et al., 2019). Weibel et al. (2019) noted the importance of dividing consumers in order to develop effectively targeted strategies.

There are several reasons for dividing the sample by levels of meat consumption. The first is to allow for greater sensitivity when estimating the determinants of meat consumption. The second rationale for dividing consumers by meat consumption levels is the need to isolate high meat consumers, but not at the expense of other meat consumers who might be highly dependent on meat for their food security and food supply. Such a division will also allow for easy perception of the differences in beliefs and behaviours among consumers (Kayser et al., 2013).

Following the convention set out in Kayser et al. (2013) and Koch et al. (2019), respondents were ranked by their level of overall meat consumption, then divided into three groups, labelled 'low', 'average' and 'heavy' meat consumers. In order to ensure replicability, the sample was divided according to FBDGs on total weekly consumption of meat, measured in grams per week.

As previously detailed, Schonfeldt et al. (2013) recommended eating an aggregate maximum of 900g of fish and lean meat per week. In 2015 – the year the study took place – the average per capita weekly consumption of meat and fish was 1 138.46g (OECD, 2023). Low meat eaters were classified as those who ate below the lowest end of the recommendation range, which was 600g per week (N = 54). Average meat eaters were those who ate between 600g and 1 000g of meat per week, which is the range of recommended meat consumption (N = 123). Heavy meat eaters were those who ate more than 1 000g meat and fish per week (N = 257). Division of the sample according to FBDG, as opposed to dividing the sample into thirds,

is preferable, to ensure replicability of the study as well as to follow the FBDG recommendations as closely as possible.

6. Empirical approach

6.1. Analysis of variance (ANOVA)

An analysis of variance (ANOVA) is used to compare differences in means for a variable across different groups. This method of comparison has been undertaken in multiple meat consumption studies (Lacroix & Gifford, 2019; Malek et al., 2019; Weibel et al., 2019; Lentz et al., 2018; Gilsing et al., 2013; Kayser et al., 2013; De Carvalho et al., 2012). If there is no significant difference in consumption, then one model may be used for the entire sample. However, if there are statistically significant differences in consumption, it is worthwhile to undertake regression analysis of the separate groups in order to obtain more accurate results.

The one-way ANOVA model determines whether there is a statistically significant difference in the mean values of the three levels of meat consumption described above by producing an F-statistic. It compares the mean of one group to those of the other two groups in order to determine whether or not the difference between them is statistically significant. In a sample of k groups, a group i can contain n_i values and the population and sample means are given by μ_i and $\bar{x}_i$ respectively, where $i = 1 \dots k$ (Gurvich & Naumova, 2021). ANOVA also tests for equality of means. That is, the null hypothesis can be given by:

$$H_0: \mu_1 = \cdots = \mu_k \qquad (1)$$
$$H_1: not\ all\ \mu_j\ are\ equal, where\ j = 1 \dots k$$

In order to decide whether to reject the null hypothesis, the one-way ANOVA compares the $F_{statistic}$ to the $F_{critical}$ value. The $F_{statistic}$ is the mean square of the treatment ($MS(Tr)$) – the variance of the group means – over the mean of the within-group variances – the mean square error (MSE) (Gurvich & Naumova, 2021). The $F_{statistic}$ is shown mathematically below:

$$F_{stat} = \frac{MS(Tr)}{MSE} \qquad (2)$$

Thus, the one-way ANOVA rejects the null hypothesis with significance α if and only:

$$F_{stat} > F_{crit}(\alpha, k-1, n-k) \tag{3}$$

The numerator and denominator degrees of freedom for F_{crit} are k-1 and n-k respectively. Using the $F_{statistic}$ identity, the decision rule above can be rewritten as:

$$MSE < (n(k-1)F_{crit}(\alpha, k-1, n-k))^{-1} \sum_{i=1}^{k} \sum_{j=i+1}^{k} n_i n_j (\bar{x}_i - \bar{x}_j)^2 \tag{4}$$

One drawback to ANOVA analysis is that it does not identify the specific differences between group means (Driscol, 1994). A post-hoc Tukey honestly significant difference (HSD) adjustment test is able to identify the particular differences between means. The Tukey HSD method assumes that the sizes of the groups are balanced, in that $n_i = n_j$ (Stoline, 1981). However, it is not always the case that group sizes are balanced; thus the Tukey-Kramer test builds on the Tukey HSD test to allow for unequal sample sizes. The test hypothesis for the Tukey-Kramer method is:

$$\begin{gathered} H_0(i,j): \mu_i = \mu_j \\ H_1(i,j): \mu_i \neq \mu_j \\ for\ all\ i \neq j \end{gathered} \tag{5}$$

The null hypothesis is equal means between two groups – repeated for all groups – with the alternative hypothesis being unequal means between the groups. The test statistic used in the Tukey-Kramer test is the studentised range statistic, given by:

$$Q = \frac{\bar{y}_{max} - \bar{y}_{min}}{\sqrt{\frac{MSE}{n}}} \tag{6}$$

where $\bar{y}_{max}$ is the largest sample mean and $\bar{y}_{min}$is the smallest sample mean (Gurvich & Naumova, 2021). The rejection rule for the Tukey-Kramer test is:

$$\left|\bar{x}_i - \bar{x}_j\right| > CR(\alpha, k, n, i, j) \tag{7}$$

where the critical range (CR) is given by:

$$CR(\alpha, k, n, i, j) = Q(\alpha, k, n-k) \sqrt{\frac{MSE}{2}\left(\frac{1}{n_i} + \frac{1}{n_j}\right)} \tag{8}$$

With the Tukey-Kramer test, the critical value at significance level α is now $Q(\alpha, k, n-k)$. The numerator and denominator degrees of freedom are defined as k and $n-k$ respectively.

6.2. Count data models

Most studies that focus on the economic determinants of meat consumption use Tobit models or LA-AIDS models to estimate income and expenditure elasticities of demand. These models make use of income, weight and price data to estimate the economic relationships of meat demand. Such demand models produce estimates of Marshallian and Hicksian demand systems. Studies on the non-economic determinants of demand have employed econometric techniques such as chi-squared tests of independence, choice models, and difference-in-difference estimators. Most studies that do not make use solely of price and income data generate a binary dependent variable which represents whether or not a person is a meat eater, or has/has not consumed meat, or has consumed a particular amount of meat. These studies make use of linear probability models, logit models, probit models and variations thereof to estimate the probability of consuming meat.

In this dataset, however, the dependent variable is a generated variable, combining the frequency and quantity of meat consumption in a week. The dependent variable can be understood as a count of the number of 100g portions of meat eaten in a week. As such, the dependent variable is a non-negative integer, and in the way of Einhorn (2020) can be treated using a count model.

Count variables represent the count of an event and can only take on positive, discrete, and integer values (Hayat & Higgins, 2014; Coxe et al., 2009). Analysing this type of data with ordinary least squares (OLS) regression methods is problematic, for several reasons. OLS regression models assume normal distribution, and a continuous outcome variable (Hayat & Higgins, 2014). The underlying normal distribution equation specifies two independent parameters: mean and variance (Coxe et al., 2009). However, count data variables are often heteroskedastic, with conditional variance, and are positively skewed; thus they do not follow a normal distribution. Given this restriction, OLS estimation techniques are unsuitable for the analysis of count variables. OLS econometric methods are incapable of accurately reporting

the coefficients and standard errors of the parameters, due to the excess zeros and heteroskedasticity often present in count data (Hayat & Higgins, 2014).

Count data models are used in cases of a dependent numerical count variable (Winkelmann, 2015). The primary count data model is the Poisson model. Poisson regression is part of the generalised linear model group, which allows for flexibility in the structure of errors (Coxe et al., 2009). A Poisson regression model is useful when the dependent outcome uses count data with a relatively low mean. The model deals with issues of nonconstant error variance and non-normal conditional distribution of errors (Coxe et al., 2019). It is a Generalised Linear Model with a flexible error structure, which allows for non-normality of errors. This is an improvement over the OLS model assumption of normal distribution of errors. The underlying distribution of errors is the Poisson distribution, which is better suited for count data as it only takes a probability value for non-negative numbers – unlike the normal distribution, which is continuous and can take on all values. The function for the Poisson probability distribution is as follows:

$$P(Y = y|\mu) = \frac{\mu^y}{y!} e^{-\mu} \tag{9}$$

This probability distribution is the probability of observing a given count value y of a variable Y. The factorial $y!$ is equal to $y(y-1)(y-2)$. Under a Poisson distribution, there is only one parameter, μ, which represents both the mean and variance of the model.

A Poisson distribution also only takes on probability values for non-negative integers, which is a substantial advantage over other models such as OLS in the case of count variables (Hayat & Higgins, 2014; Coxe et al., 2019). The model's parameters are calculated using Maximum Likelihood Estimation (MLE), where the parameters are those which are most likely to have yielded the observations present (Coxe et al., 2019). The Poisson regression model in its general form is presented below:

$$\ln(\hat{y}) = \beta_0 + \beta_1 X_1 + \cdots + \beta_m X_m \tag{10}$$

The dependent variable is transformed from a count variable to a natural log of the count variable, $\ln(\hat{y})$. The coefficients β_1 to β_m are linear, and can be interpreted as causing a β_m log count change in the dependent variable**.** The interpretation of the dependent coefficients is

that for a one-unit increase in *x,* there is an expected log count change in *y*. The direct interpretation of a raw log count coefficient is not thought to be meaningful or conventionally understood (Hayat & Higgins, 2014; Coxe et al., 2019). In order to conventionally understand variables in a log count form, the coefficient can be exponentiated to produce a multiplicative estimate of the effect.

However, the Poisson regression model has several limitations; one is that in the presence of excessive counts of 'zeros' and/or overdispersion, the assumption of equal conditional mean and variance is violated (Coxe et al., 2019). Overdispersion comes about when the variance is greater than the mean. Overdispersion in Poisson models can also occur in the case of omitted variable bias. The consequences of using a Poisson model in the presence of overdispersion include too-small standard errors, and overestimation of parameter values. This issue may be tested using a likelihood ratio test, which assesses overdispersion in the model and is discussed below.

In a case where there is overdispersion, a negative binomial regression model is recommended. Similar to the Poisson model, the negative binomial model is also used in cases of count data; however, the model relaxes the equal variance and mean assumption. A negative binomial model can produce better predictions of outcome probabilities than a Poisson model in the presence of overdispersion, as it allows for heterogeneity of individuals (Winkelmann, 2015; Coxe et al., 2009). Like the Poisson model, the negative binomial model makes use of Poisson distribution, but combines it with gamma distribution. And though it uses Poisson distributions, it allows individuals to be represented by different mean parameters, rather than one mean value for all observations (Coxe et al., 2009).

Variance in the negative binomial model is estimated by $\mu + \alpha\mu_2$. The alpha term captures overdispersion in the model. When $\alpha = 0$, there is no overdispersion, and the variance term reverts to the Poisson variance term (μ). When $\alpha > 0$, there is overdispersion in the model, and the variance is greater than the mean (Coxe et al., 2009).

If there are excessive zeros in the data, improvements on the Poisson and negative binomial count data models that may be employed include hurdle models and zero-inflated models, which would account for these excess zeros (Hayat & Higgins, 2014). Excess zeros in this case

would be respondents who eat 0g meat per week. Zero-inflated models isolate the population of interest and allow for lower than expected values (Coxe et al., 2009). However, these models are not applicable to this dataset, insofar as there are no zero-count observations – vegetarians are excluded from this analysis.

Count data models also allow for analysis at the intensive margin; that is, the effect on the mean. Analysis of average marginal effects is noted for its usefulness in policy impact assessment especially as there is no meaningful interpretation of coefficients in the log-count form. (Winkelmann, 2015). Furthermore, it can be simpler to analyse the marginal effects of the coefficients, rather than to exponentiate the estimated coefficients since the marginal effect result is in units rather as opposed to a multiplicative estimate. The average marginal effect is calculated as the average of the marginal effect at each $x = x_i$ (Cameron & Trivedi, 2009).

6.3. Post-estimation tests

Both Poisson and negative binomial models use MLE to estimate parameters; thus, GLM post-estimation tests such as R^2 cannot be used. There are two methods for measuring goodness of fit for a Poisson model: the deviance statistic, and the Pearson chi-squared goodness-of-fit measure (Hayat & Higgins, 2014). The deviance statistic is a measure of how poorly a fitted model performs compared to a perfectly fitted model, with smaller deviance test statistics indicating a better-fitting model. The Pearson chi-squared goodness-of-fit is the ratio between the sum of the squared differences between the observed and predicted values, and the variance of the estimated model (Hayat & Higgins, 2014).

Overdispersion in the data can be tested using a likelihood ratio test. The likelihood ratio test estimates whether or not the negative binomial overdispersion term α is equal to zero (Shaaban et al., 2021). The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) are used to compare the performance of non-nested models. The AIC is constructed as a function of the likelihood of the estimated model and a function of the number of parameters being estimated, while the BIC is a function of the likelihood of the estimated model and a function of the number of parameters and the sample size (Coxe et al., 2009). For both AIC and BIC, the smaller value indicates a better fit.

6.4. The model

Three regression models are used in this analysis: an OLS, a Poisson, and finally a negative binomial. The use of three models allows for validation and robustness checks of direction. The OLS model is presented below:

$$C_{meat} = \beta_0 + \beta_{1N} Nutrition_{1N} + \beta_{2E} Environment_{2E} + \beta_{3M} Culture_{3M} + \beta_{4I} Individual_{4I} + \varepsilon \quad (11)$$

The Poisson model and the negative binomial model follow the same form. The total demand for meat consumed per week is estimated using the following model:

$$\ln(C_{meat}) = \beta_0 + \beta_{1N} Nutrition_{1N} + \beta_{2E} Environment_{2E} + \beta_{3M} Culture_{3M} + \beta_{4I} Individual_{4I} \quad (12)$$

In both equations above, C_{meat} is the total amount of meat consumed per week measured in grams, α is a constant, and ε is an error term. $Nutrition_{1N}$ is a vector of N variables about the nutritional beliefs of an individual. $Environment_{2E}$is a vector of E variables capturing an individual's beliefs about the environment and animal welfare. $Culture_{3M}$ is a vector of M variables on an individual's cultural beliefs. Finally, $Individual_{4I}$ is a vector of I variables, capturing an individual's demographic and socioeconomic characteristics. Nutritional variables include an individual's opinion about the taste of meat, the importance of meat as part of a meal, and an individual's belief about their consciousness regarding health. The variables in the environmental matrix were restricting the consumption of meat for the sake of the climate, the level of importance a person places on sustainable living, and animal welfare. Finally, culture covers whether meat formed part of an individual's cultural ceremonies. Demographic variables include income, education level, gender and race. The age of an individual is included, as well as the square of age, to account for any non-linearity associated with age.

7. Empirical Results

7.1. Descriptive statistics

Descriptive summary statistics were run for both the sample as a whole and the sample segregated by consumption levels. The descriptive statistics for the whole sample are presented in Table 1 below:

Table 1: Descriptive statistics of selected variables

Variables	(1) Mean	(2) Std. Dev.	(3) Min	(4) Median	(5) Max
Total meat (g/week)	1 371.00	813.90	200	1 200	4 700
Beef (g/week)	378.80	431.90	0	200	3 000
Chicken (g/week)	498.40	364.10	0	400	2 100
Lamb (g/week)	183.20	254.50	0	100	1 600
Pork (g/week)	107.80	203.30	0	0	2 100
Fish (g/week)	171.00	241.40	0	100	2 400
Goat (g/week)	24.65	93.01	0	0	600
Other meat (g/week)	6.68	42.73	0	0	400
Main meal planner	0.56	0.50	0	1	1
Main grocery shopper	0.67	0.47	0	1	1
Female	0.45	0.50	0	0	1
Household size	3.78	2.15	1	4	20
Children <5 years	0.68	1.00	0	0	7
Age in 2015	35.92	11.66	14	34	75
Employment status	0.74	0.44	0	1	1
Marital status	0.52	0.50	0	1	1
Race:					
Black	0.59	0.49	0	1	1
White	0.30	0.46	0	0	1
Coloured	0.03	0.18	0	0	1
Indian	0.05	0.22	0	0	1
Asian	0.0046	0.07	0	0	1
Other race	0.02	0.13	0	0	1
Annual Income:					
<R100 000	0.32	0.47	0	0	1
R100 000 - R300 000	0.29	0.45	0	0	1
R300 000 - R500 000	0.14	0.35	0	0	1
R500 000 - R700 000	0.08	0.28	0	0	1
R700 000 - R900 000	0.08	0.27	0	0	1
R900 000 +	0.09	0.29	0	0	1
Level of education:					
High school	0.36	0.48	0	0	1
Some tertiary	0.11	0.31	0	0	1
Diploma	0.22	0.42	0	0	1
Bachelor's	0.16	0.37	0	0	1
Postgraduate	0.14	0.35	0	0	1

The average amount of meat eaten by respondents was 1 371g per week. Chicken consumption had the highest mean and median, of 498.4g and 400g per week respectively, followed by beef with a mean of 378.8g per week. The maximum amount eaten of any meat type was 3 000g of beef. The types of meat least eaten by the respondents in a week were goat meat and 'other' meat.

The mean respondent age was 35.92 – similar to both the sample median age of 34, and to provincial trends in 2016. Female respondents accounted for 44.9% of the sample, which followed provincial demographics (StatsSA, 2018). With respect to the racial make-up of the sample, 59% of the sample were black, 29% were white, 3% of respondents were coloured, 5% were Indian, 0.46% were Asian, and 2% identified as another race. Compared to provincial-level statistics, which showed that 80.4% of the province were black and 13.6% were white, there was an underrepresentation of black individuals and an overrepresentation of white individuals in this sample.

Just over a third of the sample had attended high school, at 36.41% of respondents. Approximately 10.60% of respondents had completed some tertiary education, 22.35% had obtained a diploma, 16.36% a bachelor's degree, and 14.29% had achieved further postgraduate education. There was thus an overrepresentation of educated individuals in the sample, compared to the provincial statistics, which showed that only 21.7% of people had schooling beyond the secondary level (StatsSA, 2018). Within the sample, 32.26% of respondents earned less than R100 000 per year, and 52% of the sample were either married or living together with another as partners. The average household size was 3.78 individuals living together, with as many as 20 people living in a household.

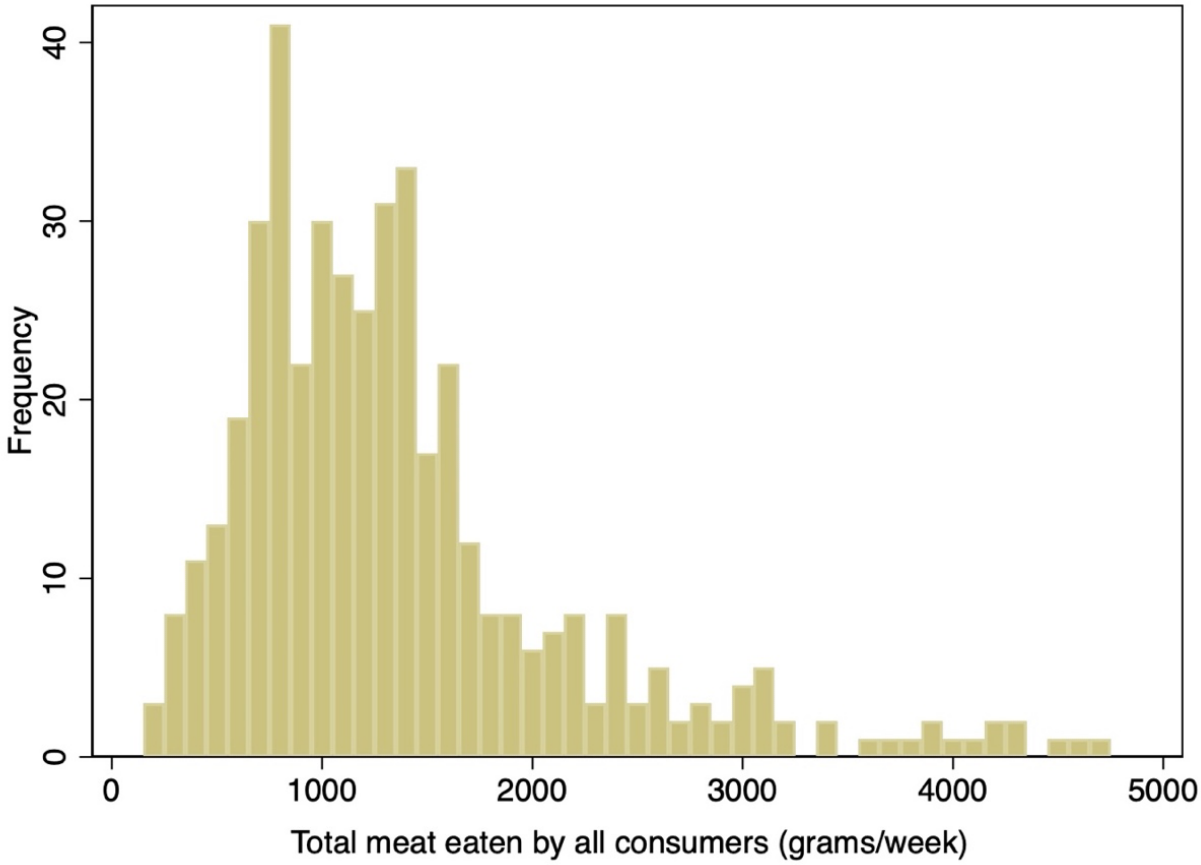


Figure 3: Levels of weekly meat consumption

Figure 3 shows the frequency of responses regarding levels of weekly meat consumption. The distribution of meat consumption does not follow a normal distribution; consumption is positively skewed, with a tail to the right. The modal amount of meat consumption was 800g per week. There are multiple outliers who ate in excess of 3 000g of meat per week. Most responses fell below 2 000g of meat consumption per week; however, over half of the respondents ate more than the guideline recommendation of 900g per week.

Table 2 below presents descriptive statistics, disaggregated by consumer group. On average, low consumers ate 468.5g meat per week, average consumers ate 842.3g, and heavy consumers ate 1 813g meat per week. The standard deviation of meat consumption for heavy consumers was 780.4g, indicating that the level of meat consumption for heavy consumers was far more varied than those of the low or average consumers, who had standard deviations of 125.6g and 110.9g respectively. The wider spread of consumption for heavy meat consumers was also reflected in the high standard deviation values for the various meat types.

Low consumers ate an average of 468.5g total meat per week, and nearly half of this came from chicken, with a mean of 222.2g. Lamb and pork were seldom eaten by low consumers, and goat was not eaten at all. Some low consumers ate as much as 600g of chicken in a week, suggesting that for some, chicken was the only meat type eaten in a week. Average meat consumption was also dominated by the consumption of chicken, with a mean of 351.2g. Heavy meat consumers ate 1 626.8g of chicken per week, on average, and ate more varied types of meat in comparison to low and average consumers. For example, low consumers did not eat goat meat, while heavy consumers ate a mean of 35.80g of goat meat per week.

The ages and marital statuses of the consumers were similar across all three sample groups. Of the heavy consumers, 64% were black and 14.98% were white. Employment rates were 59.3%, 69.1% and 79.4% respectively for low, average and high consumers. Women were represented higher in the low consumer group, and in the main meal planners and main grocery shoppers groups. 78% of low consumers were women, falling to 37% in the high consumer group. This is probably because women are more likely than men to carry the burden of meal preparation and planning. The overrepresentation of heavy meat consumers was expected, due to the urban and wealthy nature of Gauteng province

Table 2: Descriptive statistics of selected variables disaggregated by consumer group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Low meat consumers N = 54					Average meat consumers N=123					Heavy meat consumers N=257				
Variables	Mean	Std Dev	Min	Med	Max	Mean	Std Dev	Min	Med	Max	Mean	Std Dev	Min	Med	Max
Total meat (g/week)	468.50	125.60	200	500	600	842.30	110.90	700	800	1000	1813	780.40	1100	1500	4700
Beef (g/week)	109.30	115.40	0	100	400	192.70	147.80	0	200	600	524.5	499.10	0	400	3000
Chicken (g/week)	222.20	111.00	0	200	600	351.20	164.60	0	300	800	626.8	407.10	0	600	2100
Lamb (g/week)	33.33	58.28	0	0	200	121.10	133.8	0	100	600	244.4	300.00	0	200	1600
Pork (g/week)	27.78	56.36	0	0	200	53.66	93.47	0	0	600	150.6	245.90	0	100	2100
Fish (g/week)	74.07	64.97	0	100	200	108.90	109.40	0	100	400	221.0	292.70	0	100	2400
Goat (g/week)	0	0	0	0	0	12.20	37.52	0	0	200	35.80	116.80	0	0	600
Other meat (g/week)	1.85	13.61	0	0	100	2.44	20.10	0	0	200	9.728	53.24	0	0	400
Main meal planner	0.69	0.47	0	1	1	0.55	0.50	0	1	1	0.53	0.50	0	1	1
Main grocery shopper	0.70	0.46	0	1	1	0.65	0.48	0	1	1	0.67	0.47	0	1	1
Female	0.78	0.42	0	1	1	0.48	0.50	0	0	1	0.37	0.48	0	0	1
Household size	3.94	3.11	1	3	20	3.59	2.07	1	3	16	3.84	1.94	1	4	11
Children <5 years	0.69	1.18	0	0	7	0.51	0.80	0	0	3	0.75	1.05	0	0	7
Age in 2015	35.52	10.86	14	33	75	38.85	12.90	17	37	75	34.61	10.98	16	32	71

Employment status	0.59	0.50	0	1	1	0.69	0.46	0	1	1	0.79	0.41	0	1	1
Marital status	0.56	0.50	0	1	1	0.50	0.50	0	0	1	0.53	0.50	0	1	1
Race:															
Black	0.59	0.50	0	1	1	0.50	0.50	0	1	1	0.64	0.48	0	1	1
White	0.35	0.48	0	0	1	0.37	0.49	0	0	1	0.25	0.44	0	0	1
Coloured	0	0	0	0	0	0.04	0.20	0	0	1	0.04	0.18	0	0	1
Indian	0.02	0.14	0	0	1	0.07	0.26	0	0	1	0.05	0.21	0	0	1
Asian	0	0	0	0	0	0.01	0.09	0	0	1	0.00	0.06	0	0	1
Other race	0.04	0.19	0	0	1	0	0	0	0	0	0.02	0.15	0	0	1
Annual income:															
<R100 000	0.33	0.48	0	0	1	0.37	0.48	0	0	1	0.30	0.46	0	0	1
R100 000 - R300 000	0.33	0.47	0	0	1	0.20	0.40	0	0	1	0.32	0.47	0	0	1
R300 000 - R500 000	0.19	0.39	0	0	1	0.13	0.34	0	0	1	0.14	0.35	0	0	1
R500 000 - R700 000	0.09	0.29	0	0	1	0.13	0.34	0	0	1	0.06	0.24	0	0	1
R700 000 - R900 000	0.04	0.19	0	0	1	0.07	0.26	0	0	1	0.09	0.28	0	0	1
R900 000 +	0.04	0.19	0	0	1	0.11	0.31	0	0	1	0.09	0.29	0	0	1
Level of education:															
High school	0.44	0.50	0	0	1	0.30	0.46	0	0	1	0.38	0.49	0	0	1
Some tertiary	0.04	0.19	0	0	1	0.11	0.31	0	0	1	0.12	0.33	0	0	1
Diploma	0.24	0.43	0	0	1	0.25	0.44	0	0	1	0.21	0.41	0	0	1
Bachelor's	0.15	0.36	0	0	1	0.20	0.40	0	0	1	0.15	0.36	0	0	1
Postgraduate	0.13	0.34	0	0	1	0.14	0.35	0	0	1	0.15	0.36	0	0	1

A further disaggregation of meat consumption by level of consumption shows how the mean level of meat consumption varies according to the groups of consumers. These results are presented in Figure 4 below. The dominance of chicken is clear for all consumers. Since chicken is the cheapest meat option in South Africa, it is not surprising that chicken ranks top of all meat types consumed. Low consumers predominantly ate chicken, followed by beef, with low variation in/amounts of other meat types in their diet.

Both goat meat and other types of meat were more prominent in the diet of heavy consumers. Beef consumption more than doubled from average consumers to heavy consumers. Fish is the third-most consumed meat type for low consumers, but the fourth-most consumed meat type for average and heavy consumers. Consumption levels between low and average consumers increased gradually for each meat type, except for chicken, which doubled. However, there was a far more substantial increase in consumption between the average and the heavy consumers.

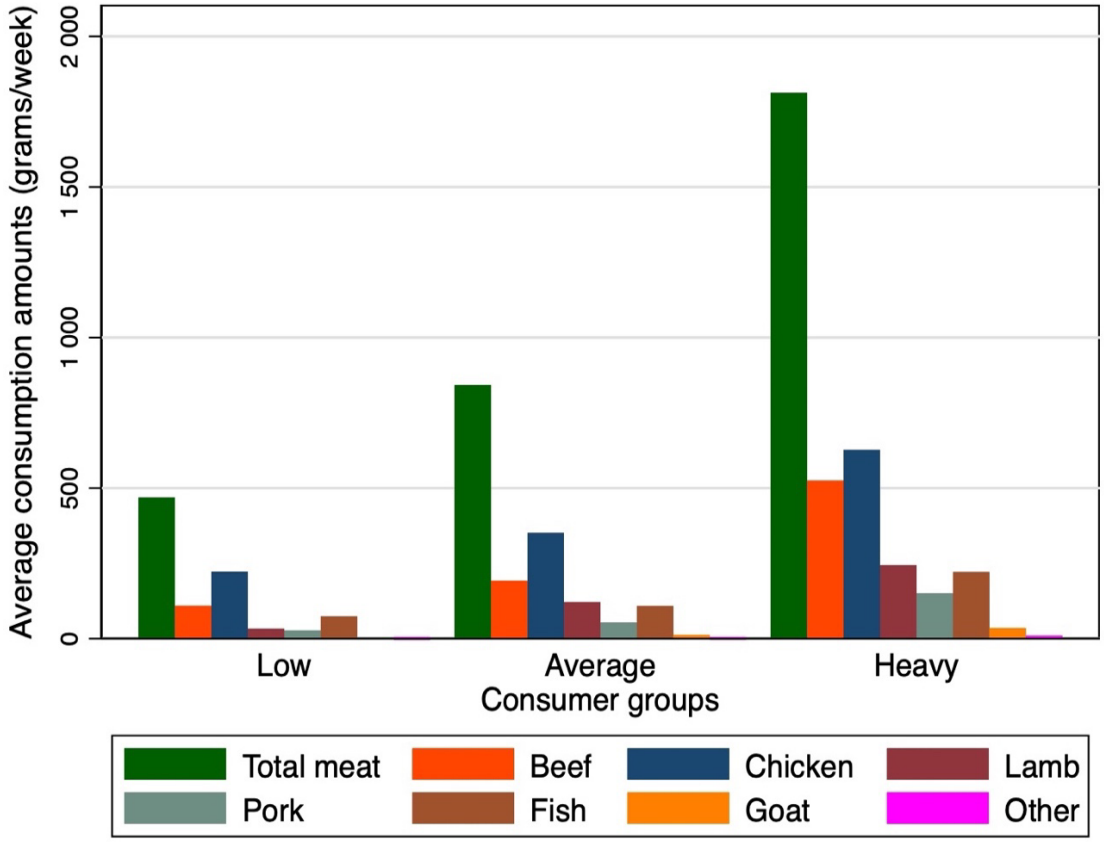


Figure 4: Mean consumption levels by types of meat and consumer groups

7.2.ANOVA analysis

In this research, ANOVA analysis is performed, followed by Tukey-Kramer post-hoc estimation in order to test the pairwise comparison of meat consumption means for each consumer group. The ANOVA analysis validates the need to split the sample by consumption level. The theory behind ANOVA and Tukey-Kramer is outlined in section 6.1. The models chosen for the regression analysis are OLS, Poisson, and negative binomial. Their assumptions and probability distributions are discussed in section 6.2. In order to test for goodness of fit and accuracy of model choice, post-estimation tests will be conducted, as outlined in section 6.3.

A one-way ANOVA was performed, in order to determine if the differences in the mean values of weekly meat consumption were statistically significant. As shown in Table 1 above, the mean values were 468.5g, 842.3g and 1 813g for low, average and heavy meat consumers respectively. The results from this procedure are reported in Table 3 below. The F-statistic F(2, 431) = 175.02 and the corresponding P value of 0.000 show that there is a statistical significance among the mean weekly meat consumption of the three groups.

Table 3: One-way ANOVA on total meat consumption (g/week)

Source	Sum of Squares	Degrees of freedom	Mean Squares	F	Prob>F
Between groups	128538218	2	64269109	175.02	0.0000
Within groups	158264271	431	367202.484		
Total	286802488	433	662361.405		
Bartlett's equal-variances test: chi2(2) = 449.4802 Prob>chi2 = 0.000					

A Tukey-Kramer post-hoc test was conducted to identify the individual statistical differences between the three groups of consumers. These results are presented in Table 4 below, and show that the difference between the means of the average and low consumers, the heavy and low consumers, and the heavy and average consumers are all statistically significant at the highest level, with P = 0.00. Since there are significant differences between the means of all three groups, it is worth performing an empirical analysis on the disaggregated sample in order to obtain nuanced determinants of meat consumption.

Table 4: Pairwise comparisons of marginal linear prediction

			Tukey-Kramer test	
	Diff. between means	Std error	T	P>|t|
Average vs Low	373.7579	98.92134	3.78	0.001
Heavy vs Low	1344.322	90.71301	14.82	0.000
Heavy vs Average	970.564	66.43937	14.61	0.000

7.3.Regression analysis

Three types of regression were run on all four sample groups (i.e. the sample as a whole, and the three consumer groups). The first was the linear OLS model, the second was the Poisson model, and the third was the negative binomial model. Initially, the sample was treated as a whole. The results from these regressions are presented below, in Table 5.

Table 5: Regression results of total meat eaten by all consumers (g/week)

Variables	(1) OLS	(2) Poisson	(3) Negative binomial
Meat tastes good	207.5	0.159	0.154
	(135.1)	(0.108)	(0.110)
I am health conscious	3.405	0.00759	-0.00761
	(84.33)	(0.0589)	(0.0561)
Meat forms the centre of my meals	239.2***	0.177***	0.193***
	(78.97)	(0.0579)	(0.0536)
I restrict meat consumption for the climate	-210.1**	-0.157**	-0.174***
	(81.50)	(0.0617)	(0.0612)
Living sustainably is important to me	-19.34	-0.0198	-0.0467
	(124.3)	(0.0832)	(0.0810)
I don't think much about animal welfare	21.05	0.0150	0.0327
	(80.69)	(0.0565)	(0.0535)
I avoid meat because animals are killed	-15.61	-0.00694	-0.0467
	(125.4)	(0.0916)	(0.0840)
Meat is part of my cultural ceremonies	64.03	0.0476	0.0379
	(86.68)	(0.0624)	(0.0584)
I am the main meal planner	-3.089	-0.00148	-0.00939
	(111.5)	(0.0750)	(0.0676)
I am the main grocery shopper	140.0	0.0889	0.0917
	(111.9)	(0.0757)	(0.0664)
Age in 2015	-28.06	-0.0191	-0.0217
	(20.20)	(0.0144)	(0.0139)
Age in 2015, squared	0.235	0.000151	0.000192
	(0.220)	(0.000161)	(0.000156)
Female	-401.6***	-0.291***	-0.303***
	(90.56)	(0.0621)	(0.0572)
Employment status	79.67	0.0584	0.0689
	(101.4)	(0.0728)	(0.0676)
Marital status	18.97	0.00258	0.0207
	(87.50)	(0.0619)	(0.0589)
Household size	-13.37	-0.00828	0.000220
	(27.91)	(0.0189)	(0.0206)
Children <5 years	47.26	0.0318	0.0267
	(45.78)	(0.0304)	(0.0304)
Race (Base: Black)			
White	-156.0	-0.123*	-0.151**
	(96.54)	(0.0709)	(0.0709)
Coloured	452.1	0.283*	0.242*
	(281.7)	(0.149)	(0.133)
Indian	110.4	0.0641	0.0365
	(213.0)	(0.134)	(0.122)
Asian	-447.5***	-0.360***	-0.316***
	(167.8)	(0.109)	(0.115)
Other race	112.5	0.0559	0.127

	(262.9)	(0.182)	(0.207)
Annual income (Base: <R100 000)			
R100 000 - R300 000	25.97	0.0166	0.00873
	(101.8)	(0.0702)	(0.0657)
R300 000 - R500 000	35.66	0.0235	0.0402
	(113.2)	(0.0821)	(0.0821)
R500 000 - R700 000	-8.101	-0.0233	-0.0258
	(140.8)	(0.106)	(0.103)
R700 000 - R900 000	365.0*	0.249**	0.236**
	(196.7)	(0.121)	(0.117)
R900 000 +	161.9	0.110	0.116
	(141.1)	(0.0945)	(0.0932)
Education (Base: High school)			
Some tertiary	-18.26	0.000259	0.0396
	(130.9)	(0.0875)	(0.0799)
Diploma	-214.2**	-0.154**	-0.103
	(102.2)	(0.0721)	(0.0680)
Bachelor's	-206.0*	-0.151*	-0.118
	(113.0)	(0.0792)	(0.0775)
Postgraduate	-158.5	-0.109	-0.0949
	(124.9)	(0.0886)	(0.0855)
Ln(α)			-1.455***
			(0.0621)
Constant	1844***	7.523***	7.541***
	(469.8)	(0.335)	(0.328)
Observations	434	434	434
R-squared	0.192	-	-

Robust standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1*

The results above are robust in direction, but the coefficient values between the OLS model, and the Poisson and negative binomial models cannot be directly compared as the Poisson and negative binomial values are in log-count form. In the OLS model, those who restrict their meat consumption in the interests of slowing climate change eat on average 210.1g less than people who don't restrict their meat consumption for the climate, ceteris paribus. In the Poisson and negative binomial models respectively, restriction of meat consumption for the environment results in an expected log 0.159 decrease and a log 0.174 decrease in weekly meat consumption, holding all else constant. These results indicate that beliefs regarding climate are important factors in meat consumption, as are demographic factors. Across all three models, respondents who agreed that meat forms the centre of their meals ate more meat on average than those who disagreed. This can be seen as affirmation that for some, meat is an essential component of a meal.

As expected, women eat less meat than men, holding all other variables constant. The OLS estimates show that women eat 401.6g less meat than men. White people ate log counts of 0.123 and 0.151 less meat than black people, estimated by the Poisson and negative binomial models respectively. Individuals with more education ate less meat than those with a high-school level of education. The Poisson model estimates that individuals with either a diploma or a bachelor's degree ate log counts of 0.154 and 0.151 less meat respectively than individuals with a high-school education, ceteris paribus. In comparison to individuals who earned less than R100 000 per year, meat consumption tended to increase with an increase in annual income, except for those who earned between R500 000 and R700 000 per year.

Post-estimation Pearson and deviance tests of goodness of fit were run on the Poisson model for all four sample groups, in order to determine the suitability of the model choice. The results from these tests may be found in Table A.1 of the appendix. These results were significant, highlighting the unsuitability of the Poisson model due to the overdispersion of the data. As these results were significant at all levels, the negative binomial model is preferable. The choice of the negative binomial model was also confirmed through the AIC and BIC selection processes. The results from testing with the AIC and BIC criteria are presented in Table A.2 of the appendix.

The suitability of the negative binomial model for all four sample groups was confirmed yet again through testing for overdispersion, using the overdispersion parameter α. The parameter α was found to be significantly above zero in all cases, showing that the data suffers from overdispersion. Thus a negative binomial model is more appropriate, given the data available. But although the negative binomial model is more appropriate, throughout the analysis the results were compared to the OLS and Poisson models, to check for robustness.

The results from the negative binomial regressions on the three consumer groups are presented in Table 6 below. The OLS and Poisson models – used for robustness checks of the negative binomial estimates – can also be found in the appendix, in Tables A.3 and A.4. The respective coefficients of all the models are identical in direction, and the magnitudes of the Poisson and negative binomial model estimates are similar to each other, which supports the robustness of the negative binomial model.

Table 6: Negative binomial results of total meat consumption (g/week), by consumer group

Variables	(1) Low Consumers	(2) Average Consumers	(3) Heavy Consumers
Meat tastes good	0.0566	0.0416	0.174**
	(0.0856)	(0.0617)	(0.0830)
I am health conscious	0.0128	-0.0673**	0.0570
	(0.100)	(0.0287)	(0.0514)
Meat forms the centre of my meals	-0.0992**	0.0178	0.123**
	(0.0482)	(0.0231)	(0.0479)
I restrict meat consumption for the climate	-0.374***	0.0314	-0.0720
	(0.0776)	(0.0276)	(0.0559)
Living sustainably is important to me	-0.690***	0.101***	0.0245
	(0.172)	(0.0388)	(0.0716)
I don't think much about animal welfare	0.205***	-0.00225	-0.00511
	(0.0633)	(0.0231)	(0.0473)
I avoid meat because animals are killed	-0.0190	-0.0149	0.143*
	(0.0933)	(0.0327)	(0.0830)
Meat is part of my cultural ceremonies	0.301***	0.00313	0.00540
	(0.0539)	(0.0251)	(0.0527)
I am the main meal planner	-0.0384	0.0152	-0.0184
	(0.0713)	(0.0326)	(0.0655)
I am the main grocery shopper	0.00198	0.0161	0.0346
	(0.0655)	(0.0326)	(0.0614)
Age in 2015	-0.0165	-0.00505	-0.00283
	(0.0148)	(0.00532)	(0.0131)
Age in 2015, squared	0.000120	6.05e-05	-1.42e-05
	(0.000174)	(5.79e-05)	(0.000142)
Female	-0.113	-0.0580**	-0.155***
	(0.0915)	(0.0274)	(0.0517)
Employment status	-0.434***	0.00575	-0.0741
	(0.0747)	(0.0269)	(0.0644)
Marital status	-0.147	-0.0262	0.0354
	(0.0900)	(0.0255)	(0.0547)
Household size	-0.00164	-0.00271	0.00613
	(0.0105)	(0.00681)	(0.0156)
Children <5 years	-0.0512**	0.0127	-0.00433
	(0.0227)	(0.0159)	(0.0249)
Race (Base: Black)			
White	0.0671	-0.0608**	-0.0980
	(0.0792)	(0.0275)	(0.0658)

Coloured		0.0442	0.195
		(0.0609)	(0.163)
Indian	0.469*	-0.0888*	0.128
	(0.241)	(0.0476)	(0.119)
Asian		0.0978*	-0.582***
		(0.0545)	(0.118)
Other race	-0.194		0.0817
	(0.147)		(0.153)
Annual income (Base: <R100 000)			
R100 000 - R300 000	0.259***	0.0256	-0.0877
	(0.0984)	(0.0382)	(0.0605)
R300 000 - R500 000	0.147*	0.0144	-0.0120
	(0.0887)	(0.0414)	(0.0731)
R500 000 - R700 000	0.0768	0.0601	0.0152
	(0.136)	(0.0479)	(0.104)
R700 000 - R900 000	0.442*	-0.0452	0.123
	(0.246)	(0.0494)	(0.112)
R900 000 +	0.768***	0.0536	0.0499
	(0.182)	(0.0411)	(0.0920)
Education (Base: High school)			
Some tertiary	-0.414**	0.0774*	-0.0778
	(0.184)	(0.0452)	(0.0729)
Diploma	0.225***	0.0397	-0.0969
	(0.0777)	(0.0348)	(0.0650)
Bachelor's	-0.0218	0.0251	-0.0525
	(0.142)	(0.0372)	(0.0719)
Postgraduate	-0.221	-0.00561	-0.0971
	(0.187)	(0.0422)	(0.0792)
Ln(α)	-3.642***	-4.433***	-2.203***
	(0.341)	(0.125)	(0.0824)
Constant	7.393***	6.743***	7.434***
	(0.374)	(0.144)	(0.291)
Observations	54	123	257

Robust standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1*

It is evident that splitting the sample by consumption levels provides more clarity on the determinants of meat consumption for each kind of consumer. More variables become statistically significant when divided by consumption levels, and the direction and magnitude of certain variables changes. The differences in beliefs among the consumer groups become evident. For instance, low meat consumers who value living sustainably have a 0.690 log count

lower level of meat consumption than those who do not value living sustainably, on average, ceteris paribus. However, average consumers who value living sustainably consume a 0.101 log count *higher* amount of meat than average meat consumers who do not value sustainable living, holding all other variables constant.

Not only are there differences in direction among the consumer groups; there are also differences in the magnitudes of the coefficient values. Women who are average consumers eat a log count of 0.058 less meat than men who are average consumers. Contrastingly, women who are heavy consumers eat a log count of 0.155 less meat than men who are heavy consumers, i.e. 0.86 times what men eat.

However, the analysis of the results from the negative binomial model is limited in its usefulness for interpretation. There is no direct interpretation of variables in log-count form. Rather than analysing the log counts of meat consumption, it is simpler instead to look at the average marginal effects of the negative binomial model which yields directly interpretable results in gram form, presented in Table 7 below.

Table 7: Average marginal effects of a negative binomial model of total meat consumption (g/week)

	(1)	(2)	(3)	(4)
	All	Low	Average	Heavy
Variables	consumers	Consumers	Consumers	Consumers
Meat tastes good	197.6	25.90	34.40	292.0**
	(131.8)	(38.21)	(49.99)	(129.5)
I am health conscious	-10.46	5.995	-57.74**	101.8
	(77.22)	(46.80)	(25.06)	(91.16)
Meat forms the centre of my meals	258.5***	-46.40**	15.00	217.8***
	(71.20)	(22.45)	(19.44)	(84.43)
I restrict meat consumption for the climate	-227.9***	-172.8***	26.67	-127.7
	(77.44)	(34.96)	(23.57)	(97.77)
Living sustainably is important to me	-65.29	-455.5***	81.84***	44.06
	(115.2)	(157.8)	(30.29)	(127.4)
I don't think much about animal welfare	44.83	96.31***	-1.897	-9.261
	(73.47)	(29.57)	(19.50)	(85.66)
I avoid meat because animals are killed	-63.04	-8.842	-12.47	274.2
	(111.1)	(43.30)	(27.29)	(169.3)
Meat is part of my cultural ceremonies	51.90	140.8***	2.637	9.771

	(79.48)	(26.38)	(21.19)	(95.33)
I am the main meal planner	-12.89	-18.01	12.81	-33.26
	(92.81)	(33.39)	(27.51)	(118.7)
I am the main grocery shopper	125.9	0.930	13.58	62.74
	(91.26)	(30.70)	(27.42)	(111.2)
Age in 2015	-29.75	-7.712	-4.252	-5.123
	(19.07)	(6.905)	(4.490)	(23.79)
Age in 2015, squared	0.264	0.0563	0.0509	-0.0257
	(0.214)	(0.0814)	(0.0489)	(0.257)
Female	-405.0***	-54.53	-48.78**	-274.7***
	(76.87)	(45.90)	(23.11)	(90.85)
Employment status	92.98	-217.0***	4.838	-137.2
	(89.55)	(42.16)	(22.65)	(121.9)
Marital status	28.40	-69.25	-22.08	64.06
	(80.92)	(42.54)	(21.52)	(99.14)
Household size	0.302	-0.770	-2.279	11.12
	(28.21)	(4.927)	(5.738)	(28.24)
Children <5 years	36.67	-23.99**	10.69	-7.855
	(41.71)	(10.61)	(13.38)	(45.07)
Race (Base: Black)				
White	-198.2**	31.78	-51.03**	-170.8
	(91.31)	(38.00)	(23.06)	(112.7)
Coloured	386.5		39.04	393.8
	(235.7)		(54.97)	(361.2)
Indian	52.51	273.8	-73.49*	250.2
	(177.8)	(171.3)	(38.30)	(244.3)
Asian	-382.7***		88.86*	-807.1***
	(122.9)		(51.58)	(129.1)
Other race	190.8	-80.59		155.7
	(331.1)	(56.58)		(303.0)
Annual income (Base: <R100 000)				
R100 000 - R300 000	11.61	119.5***	21.44	-154.0
	(87.43)	(45.73)	(32.11)	(106.9)
R300 000 - R500 000	54.36	64.07*	12.04	-21.81
	(111.8)	(38.93)	(34.58)	(133.1)
R500 000 - R700 000	-33.77	32.32	51.26	28.14
	(133.4)	(58.00)	(41.46)	(193.5)
R700 000 - R900 000	353.5*	225.3	-36.55	240.3
	(188.3)	(147.8)	(39.64)	(228.7)
R900 000 +	163.6	468.0***	45.58	93.77
	(134.9)	(137.7)	(35.38)	(175.4)
Education (Base: High school)				
Some tertiary	58.35	-158.5**	66.27*	-142.6

	(118.4)	(61.81)	(39.57)	(131.9)
Diploma	-141.5	117.7***	33.38	-175.9
	(92.99)	(42.88)	(29.31)	(117.4)
Bachelors	-160.7	-10.07	20.91	-97.42
	(104.3)	(65.50)	(31.04)	(132.6)
Postgraduate	-130.6	-92.49	-4.609	-176.3
	(116.1)	(74.53)	(34.59)	(141.9)
Observations	434	54	123	257

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

The interpretation of results is now more clear, with an average marginal effects model. For instance, in Table 6, heavy meat consumers who believed that meat tastes good ate 0.174 log count more meat per week than those who disagreed with the statement, holding all else constant. However, in Table 7, heavy meat consumers who believed that meat tastes good ate 292 grams per week than heavy meat consumers who disagreed that meat tastes good, ceteris paribus.

The value of disaggregating the sample based on consumption levels is evident when examining the variable 'Meat forms the centre of my meals'. When the sample is treated as a whole, individuals who agree with this statement eat on average 258.5g more than those who disagree, as expected. However, for low consumers, those who agree that meat forms the centre of their meals eat 46.40g less than those who disagree, ceteris paribus. Health-conscious individuals eat less meat if they are average or low consumers, but eat more meat if they are heavy consumers on average. As mentioned previously, consumers who agree that living sustainably is important to them eat 461.2g less meat if they are low consumers, but contrastingly, eat 76.87g more meat if they are average consumers. Average meat consumers who believe that they are health conscious eat an average of 49.92g less meat than those who don't believe they are health conscious, ceteris paribus, which is indicative of the belief that meat is damaging to an individual's health.

Annual income has no statistically significant impact on meat consumption for either heavy or average consumers; however, there is a positive trend between increased income and increased meat consumption for low consumers. For low consumers, those who have an annual income of between R100 000 and R300 000 eat on average 119.5g more than those who earn less than

R100 000 per year, holding all other variables constant. This result is statistically significant at all levels. Employed low meat consumers eat 217g less meat than unemployed meat consumers, contrary to expectation. As expected, for all three consumer categories, women eat persistently less meat than men on average. Although the direction is constant, the gendered effect of meat consumption varies depending on the consumer group. Women who are heavy consumers eat 277.9g less meat than men who are heavy consumers on average, ceteris paribus. This gendered difference is far less obvious in the average and low consumer groups, where women eat 37.08g and 58.76g less meat respectively than men.

The effect of education on meat consumption changes based on the consumer category – those who have a diploma and are low meat consumers eat 140g more meat than those who have a high-school education. However, for the same level of education, heavy meat consumers eat 223.1g less meat in a week on average, compared to those with a high-school education. Neither marital status nor household size have statistically significant effects on the amount of meat eaten in a week, for all three consumer groups.

The conflicting direction of meat consumption in average and low consumers who place importance on sustainable living suggests that low meat consumers link eating less meat to sustainable practices, while average consumers do not make this connection. There is further evidence of incongruent beliefs among the consumer groups, in the direction of the estimates for climate meat-consumption restrictors for low, average, and heavy consumers. Distinctions between consumer groups are also evident in the direction of the health consciousness of the three groups. Being health conscious increased meat consumption for low and heavy consumers, but decreased meat consumption for average meat consumers relative to not being health conscious.

The intrinsic nature of meat and meat products is an important factor in meat consumption, especially for heavy meat consumers – both taste and meat as the centre of a meal correspond to eating more meat. In the results above, it is evident that the different groups of consumers have differing motivations for consuming meat. These nuances are lost in the aggregation of the sample and by treating consumers as homogenous. Individuals who eat more than 1 000g of meat in a week – heavy meat consumers – eat more meat if they enjoy its taste, and if they place meat at the centre of their meals than heavy meat consumers who disagree with these statements. Low meat consumers eat less meat based on their beliefs about the environment

and living sustainably. However, this is not the case with heavy consumers. In order to change consumers from heavy meat consumers to average or low consumers, there must be more education on the connection between meat production and consumption, and the effects of both on the environment.

8. Conclusion

As South Africa's economy has developed since 1994, and per capita income has increased, diet patterns have changed. Given the potential purchasing power embedded in it, meat consumption has become a crucial issue both in South Africa and around the world, as emerging economies continue to rapidly increase their levels of meat consumption. Since the demand situation and influential factors vary over time, this study has attempted to provide the most recent information on drivers of meat consumption in South Africa by splitting the sample used according to various categories of meat intake.

Interventions should be multifaceted in their approach and should try target the heterogeneity of consumers. In order to promote a reduction of meat consumption for heavy meat eaters, interventions should be aimed at switching the default meal option from meat-centred to vegetarian. These nudges, based in behavioural economic theory, have been proven successful in Sweden and could be replicated locally (Kurz, 2018). Campaigns to remove the feminised reputation of vegetarianism could induce men of all consumer groups to eat less meat. Informative labelling and similar informational and behavioural interventions could help average and heavy consumers establish the link between meat production and consumption, and various environmental and health ailments.

Environmental concerns were not a statistically significant reason for Belgium consumers adopting meat alternatives, but were a motivation for South Africans to purchase plant-based proteins (Szejda et al., 2021; Moons et al., 2018). The results above support using environmental concerns to frame a meat reduction message, especially for low meat consumers. Low meat consumers in this study are sensitive to climate, and environmental and animal welfare concerns. This suggests they make the connection between sustainable living and meat consumption. Heavy meat consumers, however, are significantly influenced by the taste of meat and the centrality of meat in their meals. This finding echoes similar motivations found in other studies in both developing and developed countries. The taste of meat was a reason for Ghanian university students consuming meat (Mensah et al., 2022). Similar

motivations were also present in Belgium and for Dutch heavy meat eaters (Moons et al., 2018; De Boer et al., 2017). The contrasting impact of health is in line with global and national literature in which health is both a reason for eating meat and not eating meat, or eating plant based proteins (Perino & Schwirplies, 2022; Szejda et al., 2021; De Boer et al., 2017).

Gauteng consumers are representative of a wealthy, urban, and globalised population; they are therefore more likely to be excessive consumers of meat. The in-depth questions in this dataset open up opportunities for further research – for instance, running an ordered probit model on the three consumer groups, to determine the probability that consumers will move from one group to another. Other additions could include using price data from the OECD (2023) database to control for the economic determinants of meat consumption, and comparing South African determinants of meat consumption to determinants in other countries. Choice and field experiments to explore meat reduction strategies are a way of improving upon the results in this study. Further, the sample area can – and should – be expanded to explore the determinants of meat demand in other areas of South Africa, such as other provinces and rural areas. There are determinants of consumption which are distinctive to urbanised areas, and may not be as significant for those living in rural areas.

There are several notable challenges to using a consumer survey as a data source. Consumers are subject to recall bias when remembering their usual consumption patterns, and may as a result provide incorrect information about their behaviour (Parkasca & Qaim, 2022). Furthermore, although the size of a meat portion was demonstrated in this survey, errors are possible in the measurement of the consumer's usual serving (Parkasca & Qaim, 2022). Notably, surveys and questionnaires on consumption almost always suffer from the same issue – there can be no one consistent eating pattern, as consumption behaviours change from day to day, and from week to weekend.

This study is a step towards creating behavioural policies to reduce meat consumption in order to mitigate the damage that overconsumption of meat can wreak on the health of individuals and the environment, while simultaneously not restricting individuals at risk of food and nutritional insecurity. South Africa faces a double burden of malnutrition, and the differentiated results in this paper show the value of analysing consumers at either end of the consumption scale. This study has shown that in Gauteng, the meat consumption of low consumers is shaped by the value they place on the environment, the climate, and animal welfare. The over-

consumers of meat are predominantly men, and the determinants of meat consumption for heavy consumers are notably the taste of meat and the importance of meat in a meal. In order to shift heavy consumers towards reducing their consumption, policies could focus on shifting the culture of meat away from meat as intrinsic to masculinity and meals, to meat as an infrequent – but nevertheless important – source of nutrition to be consumed alongside vegetarian protein sources and other vegetables. The links between meat consumption, meat production and the environment are a reason for low consumers to eat less, and a valuable channel for promoting meat reduction.

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Appendix

Table A. 1: Deviance and Pearson goodness of fit estimates for the Poisson model

Model	Deviance goodness of fit	d.f.	$P > \chi^2$	Pearson goodness of fit	d.f.	$P > \chi^2$
All consumers	143708.2	404	0.0000	156187.5	404	0.0000
Low consumers	640.9855	27	0.0000	591.2033	27	0.0000
Average consumers	1371.079	95	0.0000	1359.787	95	0.0000
Heavy consumers	58850.27	228	0.0000	64239.3	228	0.0000

Table A. 2: Akaike's information criterion (AIC) and Bayesian information criterion (BIC)

Model	N	LL(null)[a]	LL(model)[b]	d.f.	AIC	BIC
OLS C_{Full}	434	-3523.893	-3479.025	30	7018.050	7140.241
OLS C_{Low}	54	-337.118	-306.711	27	667.422	721.124
OLS C_{Avg}	123	-753.177	-737.412	28	1530.824	1609.565
OLS C_{Heavy}	257	-2075.751	-2050.940	29	4159.880	4262.803
Poisson C_{Full}	434	-9.35e+04	-7.38e+04	30	1.48e+05	147755
Poisson C_{Low}	54	-1180.714	-535.007	27	1124.015	1177.717
Poisson C_{Avg}	123	-1413.997	-1212.325	28	2480.650	2559.391
Poisson C_{Heavy}	257	-3.81e+04	-3.06e+04	29	61290.260	61393.180
Neg. binomial C_{Full}	434	-3441.563	-3385.896	31	6833.791	6960.055
Neg. binomial C_{Low}	54	-340.376	-310.987	28	677.974	733.666
Neg. binomial C_{Avg}	123	-752.169	-735.956	29	1529.912	1611.466
Neg. binomial C_{Heavy}	257	-2028.751	-1996.763	30	4053.526	4159.999

Note:

BIC uses N = number of observations

[a]*Log likelihood of a constant-only model*

[b]*Log likelihood of the specified model*

Table A. 3: OLS regression results of total meat eaten, by consumer group (g/week)

Variables	(1) All consumers	(2) Low consumers	(3) Average consumers	(4) Heavy consumers
Meat tastes good	207.5	37.30	36.91	312.2**
	(135.1)	(58.31)	(58.45)	(148.5)
I am health conscious	3.405	9.264	-56.62**	122.3
	(84.33)	(60.25)	(27.87)	(111.0)
Meat forms the centre of my meals	239.2***	-41.67	14.19	208.4**
	(78.97)	(30.26)	(22.48)	(100.6)
I restrict meat consumption for the climate	-210.1**	-147.9***	25.40	-125.8
	(81.50)	(49.75)	(27.27)	(113.2)
Living sustainably is important to me	-19.34	-283.5**	85.11**	87.63
	(124.3)	(124.5)	(37.25)	(147.0)
I don't think much about animal welfare	21.05	83.63*	-2.114	-50.61
	(80.69)	(43.71)	(22.62)	(103.9)
I avoid meat because animals are killed	-15.61	-13.62	-12.46	288.5
	(125.4)	(57.99)	(32.10)	(198.2)
Meat is part of my cultural ceremonies	64.03	118.2***	3.015	-4.760
	(86.68)	(34.26)	(24.20)	(111.7)
Main meal planner	-3.089	-24.08	11.93	-35.06
	(111.5)	(47.30)	(31.48)	(152.0)
Main grocery shopper	140.0	5.496	11.90	86.36
	(111.9)	(44.75)	(32.39)	(136.0)
Age in 2015	-28.06	-6.231	-4.165	-7.634
	(20.20)	(9.789)	(5.107)	(29.06)
Age in 2015, squared	0.235	0.0436	0.0503	0.00549
	(0.220)	(0.115)	(0.0558)	(0.310)
Female	-401.6***	-47.42	-45.86*	-293.4**
	(90.56)	(59.40)	(27.07)	(115.1)
Employment status	79.67	-180.6***	5.048	-114.9
	(101.4)	(44.60)	(26.24)	(142.0)
Marital status	18.97	-63.96	-20.61	78.20
	(87.50)	(58.97)	(25.08)	(115.4)
Household size	-13.37	-0.467	-2.297	9.557
	(27.91)	(6.608)	(6.557)	(37.41)
Children <5 years	47.26	-24.63	10.83	-10.60
	(45.78)	(15.80)	(15.91)	(55.07)
Race (Base: Black)				

White	-156.0	30.51	-50.44*	-171.6
	(96.54)	(51.65)	(26.24)	(136.3)
Coloured	452.1		42.71	411.8
	(281.7)		(61.25)	(407.0)
Indian	110.4	221.9	-69.85	318.4
	(213.0)	(147.5)	(45.91)	(279.1)
Asian	-447.5***		81.40	-891.1***
	(167.8)		(53.96)	(241.2)
Other race	112.5	-59.56		85.03
	(262.9)	(91.70)		(290.1)
Annual income (Base: <R100 000)				
R100 000 - R300 000	25.97	98.12	18.73	-161.8
	(101.8)	(61.43)	(37.23)	(126.8)
R300 000 - R500 000	35.66	54.14	10.81	-73.07
	(113.2)	(60.92)	(40.99)	(144.7)
R500 000 - R700 000	-8.101	43.95	47.43	9.559
	(140.8)	(81.82)	(47.18)	(222.0)
R700 000 - R900 000	365.0*	170.2	-37.32	192.7
	(196.7)	(146.3)	(47.17)	(255.6)
R900 000 +	161.9	320.8***	45.89	81.27
	(141.1)	(109.5)	(41.22)	(192.0)
Education (Base: High school)				
Some tertiary	-18.26	-159.5	64.22	-147.8
	(130.9)	(132.5)	(44.76)	(153.9)
Diploma	-214.2**	103.1	32.70	-210.0
	(102.2)	(60.76)	(34.34)	(134.4)
Bachelor's	-206.0*	-8.063	21.16	-82.97
	(113.0)	(88.12)	(36.06)	(150.5)
Postgraduate	-158.5	-72.33	-4.650	-182.3
	(124.9)	(109.8)	(41.04)	(161.7)
Constant	1,844***	970.2***	846.0***	1,737***
	(469.8)	(235.0)	(138.6)	(608.0)
Observations	434	54	123	257
R-squared	0.192	0.678	0.231	0.177

Robust standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1*

Table A. 4: Poisson regression results of total meat eaten, by consumer group (g/week)

Variables	(1) All consumers	(2) Low consumers	(3) Average consumers	(4) Heavy consumers
Meat tastes good	0.159	0.173**	0.0445	0.173**
	(0.108)	(0.0844)	(0.0624)	(0.0844)
I am health conscious	0.00759	0.0691	-0.0665**	0.0691
	(0.0589)	(0.0569)	(0.0283)	(0.0569)
Meat forms the centre of my meals	0.177***	0.117**	0.0163	0.117**
	(0.0579)	(0.0530)	(0.0233)	(0.0530)
I restrict meat consumption for the climate	-0.157**	-0.0669	0.0301	-0.0669
	(0.0617)	(0.0581)	(0.0278)	(0.0581)
Living sustainably is important to me	-0.0198	0.0489	0.101***	0.0489
	(0.0832)	(0.0753)	(0.0392)	(0.0753)
I don't think much about animal welfare	0.0150	-0.0266	-0.00194	-0.0266
	(0.0565)	(0.0530)	(0.0233)	(0.0530)
I avoid meat because animals are killed	-0.00694	0.151*	-0.0144	0.151*
	(0.0916)	(0.0902)	(0.0325)	(0.0902)
Meat is part of my cultural ceremonies	0.0476	0.00497	0.00320	0.00497
	(0.0624)	(0.0570)	(0.0249)	(0.0570)
Main meal planner	-0.00148	-0.0217	0.0146	-0.0217
	(0.0750)	(0.0749)	(0.0320)	(0.0749)
Main grocery shopper	0.0889	0.0485	0.0146	0.0485
	(0.0757)	(0.0680)	(0.0330)	(0.0680)
Age in 2015	-0.0191	-0.00244	-0.00482	-0.00244
	(0.0144)	(0.0149)	(0.00532)	(0.0149)
Age in 2015, squared	0.000151	-2.26e-05	5.86e-05	-2.26e-05
	(0.000161)	(0.000161)	(5.79e-05)	(0.000161)
Female	-0.291***	-0.162***	-0.0546*	-0.162***
	(0.0621)	(0.0588)	(0.0279)	(0.0588)
Employment status	0.0584	-0.0649	0.00611	-0.0649
	(0.0728)	(0.0695)	(0.0270)	(0.0695)
Marital status	0.00258	0.0343	-0.0248	0.0343
	(0.0619)	(0.0596)	(0.0259)	(0.0596)
Household size	-0.00828	0.00631	-0.00240	0.00631
	(0.0189)	(0.0186)	(0.00678)	(0.0186)
Children <5 years	0.0318	-0.00799	0.0124	-0.00799
	(0.0304)	(0.0278)	(0.0160)	(0.0278)
Race (Base: Black)				
White	-0.123*	-0.0944	-0.0602**	-0.0944
	(0.0709)	(0.0718)	(0.0270)	(0.0718)
Coloured	0.283*	0.202	0.0482	0.202
	(0.149)	(0.168)	(0.0602)	(0.168)
Indian	0.0641	0.151	-0.0850*	0.151

	(0.134)	(0.122)	(0.0485)	(0.122)
Asian	-0.360***	-0.593***	0.0954*	-0.593***
	(0.109)	(0.121)	(0.0556)	(0.121)
Other race	0.0559	0.0331		0.0331
	(0.182)	(0.156)		(0.156)
Annual income (Base: <R100 000)				
R100 000 - R300 000	0.0166	-0.0863	0.0223	-0.0863
	(0.0702)	(0.0664)	(0.0380)	(0.0664)
R300 000 - R500 000	0.0235	-0.0400	0.0132	-0.0400
	(0.0821)	(0.0762)	(0.0423)	(0.0762)
R500 000 - R700 000	-0.0233	0.0125	0.0567	0.0125
	(0.106)	(0.113)	(0.0483)	(0.113)
R700 000 - R900 000	0.249**	0.107	-0.0477	0.107
	(0.121)	(0.119)	(0.0497)	(0.119)
R900 000 +	0.110	0.0422	0.0548	0.0422
	(0.0945)	(0.0937)	(0.0417)	(0.0937)
Education (Base: High school)				
Some tertiary	0.000259	-0.0811	0.0758*	-0.0811
	(0.0875)	(0.0793)	(0.0451)	(0.0793)
Diploma	-0.154**	-0.115*	0.0383	-0.115*
	(0.0721)	(0.0698)	(0.0352)	(0.0698)
Bachelor's	-0.151*	-0.0476	0.0258	-0.0476
	(0.0792)	(0.0770)	(0.0376)	(0.0770)
Postgraduate	-0.109	-0.0967	-0.00582	-0.0967
	(0.0886)	(0.0829)	(0.0432)	(0.0829)
Constant	7.523***	7.413***	6.733***	7.413***
	(0.335)	(0.318)	(0.145)	(0.318)
Observations	434	257	123	257

Robust standard errors in parentheses
**** p<0.01, ** p<0.05, * p<0.1*