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Nudge and Tax in a Virtual Supermarket:

Exploring factors affecting decision of purchase and the price elasticity of demand for meat

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Abstract

The IPCC and the Dutch government recognize that a protein consumption shift is a desirable target regarding climate change mitigation efforts. This is an ongoing debate, and policymakers have several instruments at hand to achieve this. Previous research has found that combining an information nudge with a fiscal measure enhances the effect of reducing meat demand. However, little is known if the reaction to the nudge depends on other proximal determinants of individual food choice, namely price meat attachment, price consciousness, and environmental consciousness. Using data from an RCT, this study set out to fill in this gap. Additionally, the responsiveness of the consumers to a 30% price increase on meat was estimated, as this could provide a single estimate for the behavioral response to an environmental tax. Moreover, the effect of the behavioral treatment on consumers' price sensitivity was investigated. No empirical support was found for the chosen proximal determinants. Price elasticity was found to be inelastic, yet no evidence was found that a nudge increased consumers' sensitivity. Although little evidence was found here, it nonetheless provides insights into the dimensions of the effects of nudging and creates the potential for future research and debate.

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1 Introduction

1.1 General introduction

Among the world community, there is a general agreement on the fact that greenhouse gases (GHG) as the main determinant of climate change and environmental degradation needs to be reduced. In order to do so, 193 parties have joined the Paris Agreement, with the commitment to hold the increase in the global average temperate to below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels (UNFCCC, 2021). In Europe alone, food consumption is responsible for approximately 30% of the total greenhouse gas emissions (GHG). This is particularly true for beef due to the emissions of methane (CH4) from enteric fermentation in ruminants (Petrovic et al., 2015). Besides the environmental implications, the consumption of red meat and processed meat has been associated with increased risk of obesity, higher body mass index (BMI) and waist circumference (WC) (Rouhani et al., 2014). Based on epidemiological and mechanistic evidence, the World Health Organization (WHO) has declared processed meat carcinogenic and unprocessed red meat likely carcinogenic to humans (Bouvard et al., 2015). There is also evidence that red and processed meat increases the risks for coronary heart disease, stroke, and type-2 diabetes (Bechthold et al., 2019; Schwingshackl et al., 2017). Special importance is therefore crucial to alleviate the sustainability and health challenges caused by the consumption of meat.

However, the mitigation of agriculture emissions is still constrained by cost and the complexity of agricultural products (IPCC, 2019a). Also, the current global consumption levels of red and processed meat exceed the recommendations (Micha et al., 2015). A more worrying fact is that the demand for livestock products is increasing. Between now and 2050, there will be a sharp increase in the demand for agriculture products, in which global food production will need to grow by 40% to keep up with population growth (Verschuuren, 2016). In the Netherlands, we have seen that the sales of meat were affected by the corona pandemic in 2020. The total consumption of meat and meat products per capita in the Netherlands was 75,9kg in 2020, which is the lowest number observed since 2005 (Dagevos et al., 2021). We also see that the 28% of the Dutch population wants to see a future without meat and the percentage of individuals who identify as flexitarians is

growing (Proveg, 2022). Furthermore, people's openness to plant-based foods demonstrates that there is potential for a protein transition here.

Even though there has been progress, only a few Dutch people meet the Dutch Guidelines for a healthy diet (van Rossum et al., 2020). With this in mind, the change of demand patterns relying on reduced meat intakes have been focalized. The reduction of the consumption of meat could reduce the effects of food consumption on the environment, improve human health and lead to a net social societal benefit (Broeks et al., 2020). In order to do so, *consumption-sided policies* to limit food-related GHG releases and offset the resulting burden on health and the environment are needed. This thesis aims to provide insights on the effectiveness of interventions that target the context in which food choices are made. In this General introduction, I first present the consumption-sided policy interventions that can be implemented to steer consumers' dietary choices. Lastly, I will describe the research aims and the outline of this thesis.

1.2 Consumption-sided policy conceptualization

As society bears the negative externalities arising from individuals consumption, governments are incentivized to take respective steps to minimize arising costs in order to come closer to the social optimum. In regard to the consumption of meat, authorities have the possibility to reduce food-related GHG emission by shifting dietary choices.

There are three (3) main categories of consumption-sided policy instruments that could steer consumption choices (Röös et al., 2021):

I. Changes in relative prices (Pricing strategies)
II. Knowledge and support (e.g., Nudging strategies)
III. Regulation and requirements[1]

[1] These tools (Category III) find finds high usage within the production side of the sector, as is noticed in the Netherlands and the EU where the food production is subject to many environmental laws and regulations. However, from the consumption side, there are currently no laws or regulations which aim to steer the public towards more environmentally sustainable food consumption. There are currently rules for how alcohol and tobacco are sold and marketed, however banning, or regulating what is consumed is subject to high criticism. Thus, although these tools could be promising, they face high implementation challenges and the risk of not being accepted by the overall society. This topic of discussion falls out of the scope of this thesis.

Price-based measures (Category I) rely mainly on the effect that relative prices changes between different commodities have on consumptions decisions. Taxes and subsidies find political interest with regards to the regulation of public food demand on a large scale. Prices are still confirmed to be one of the major driver of food demand structures, and this gives governments latitude in the implementation of the measures to increase their approval (Reisch et al., 2013). When it comes to food, financial disincentives for consumers to buy unhealthy foods or nutrients are created, which makes products with low associated damage costs relatively more attractive (Röös et al., 2021). When it comes meat, some studies have demonstrated the benefits that could be reaped by lowering meat consumption through higher meat prices (Broeks et al., 2020; Springmann et al., 2018). By increasing the price of meat by 30%, the average meat consumption could decrease by 16% over a percent over a period of 30 years in the Netherlands (Broeks et al., 2020).

The tools in category of knowledge and support (Category II) aim to alter people's attitudes and behavior. Increasing individuals knowledge through the provision of information can contribute to a change in attitude and it is one of the oldest and most frequently used method for behavior change (Kollmuss & Agyeman, 2002). in recent years There has been a growing popularity for the implementation of nudges. The nudging approach alter people's decisions by presenting choices and framing information differently or at different times, and can therefore help with the shift towards a more environment-and-health-friendly sustainable food consumption (Garnett et al., 2015). There is various evidence showing how nudges can reduce animal-product consumption (Bianchi et al., 2018; Harguess et al., 2020; Taufik et al., 2019).

It is important to note that the combination of pricing and nudging strategies has been shown to have the largest impact on healthier purchase behaviors in comparison to only using one instrument (Hoenink et al., 2020). This last point is explored in Chapter 3.1.

1.3 Aim and thesis outline

Given the outlined background, this thesis contributes to deeper the understanding of mitigation potential of economic consumption-targeted policies and, more importantly, includes the calculation of price elasticity of demand. For this thesis I will be using the data gathered in a Randomized Controlled Trial (RCT) study conducted by Vellinga et al. (2022). Their aim was to

examine the effect of higher meat prices (Category I), an information nudge (Category II) and the combination of both on meat purchases in a virtual supermarket setting. The results showed that the combination of both tools led to a (stronger) decrease in total gram meat purchased in virtual supermarket (the RCT is explained in more detail in Chapter 4). However, the RCT left several open questions.

My thesis aims to add to this study in two ways. First, I will assess the effects of the interventions with three factors that have been found in the literature that could have an additional influence on meat purchase decisions. This is done because previous research (Godfray et al., 2018) has shown that a set of personally held ideas may influence the decision about food choices, and therefore the overall effect. The indicators studied were *meat attachment*, *price consciousness* and *environmental consciousness*. From a scientific perspective, this analysis would be the next step in understanding whether individuals' reaction to nudges depend on other proximal determinants of food choice. From a public policy point of view, the results obtained could be crucial when it comes to the implementation of a nudge. If the results indicate that that the reaction of a nudge depends directly/or strongly on one of the factors, then regulators will have to first target the individuals.

Second, the focus is shifted to the price elasticity of demand. As shown in the study by Vellinga et al. (2022), the implementation of a meat tax (or a price increase) and a nudge can reduce the purchase of meat, which shows that there is potential to decrease the related GHG emission. However, in real-life, the size of the reduction will depend on the selected tax level and on the precise level of the price elasticities. The success of a tax could proof to be effective provided that the demand is sufficiently elastic or cross-price elastic. If this is not taken in consideration when designing such tax, it could have even more damaging impact and result in a reallocation of spending in cheaper meat cuts, which promotes even less sustainable production practices (Rapoula, 2021). Thus, first I aim to assess the effects of price changes on the demand for meat and meat products category as a whole (as a homogenous good). There has been substantial attention invested to consumer demand for meat, with many finding that the demand is price inelastic and negative (Andreyeva et al., 2010; Gallet, 2010; Wirsenius et al., 2011). This means that the demand for meat does not change as much as its change in price, and therefore most of the tax is passed onto consumers, and governments will likely see a significant increase in their tax revenue.

Furthermore, examining the effects of the information nudge intervention on the price sensitivity is also of importance. Much of the literature focuses on the effects of nudges and strategies independently, without further examining the effects they can have on other variables; in this case the price sensitivity of consumers. Previous research has found that the provision of information could result in less sensitive reactions to increases in prices when it comes to purchasing a sustainable product (Hahnel et al., 2014). Knowing this, I aim explore whether the nudge implemented in the experiment affected the price sensitivity of consumers. Put differently, I aim to assess whether there is an economically meaningful relationship between prices and nudging tools. In order to do this, the demand equations will be estimated, and I will observe whether the randomized behavioral treatment (nudge) significantly alters the estimate of the price elasticity. Since the taxation of meat is currently a topic of discussion in the Netherlands, the estimations could be relevant for policy makers who are trying to achieve social benefits by influencing consumption patterns and improving dietary quality.

In order to achieve these two aims, the following guiding research question was formulated:
What are the combined effects of price and nudge interventions on consumers' demand for meat and meat products?

In Chapter 2, an extensive literature review is provided about the strategies used in the RCT, the economic theory behind the price elasticity of demand and previous estimates. In the third section, the focus is on the first aim of this thesis which is to focus on the three factors mentioned above that could have had an additional influence on meat purchase decisions. The corresponding hypotheses are also presented here. In the fourth section, the experiment and statistical analyses conducted are explained. In section 5, the results from the regressions and the elasticity estimations are presented. Lastly, the conclusion and discussions are included in Chapter 6.

2 Literature review

In this section, previous studies on the use of nudges, pricing strategies and the economic theory of price elasticity of demand is reviewed. Furthermore, prior evidence on the estimation of price elasticity for food and meat is presented.

2.1 Nudging strategies

Definition. The notion of nudging refers to a number of distinct behavioral interventions such as defaults, feedback, and social norms (Croson & Treich, 2014; Sunstein, 2014), many of which have been known and studied before the term was introduced by Thaler and Sunstein (2009). Nevertheless, it fulfills a useful function in summarizing interventions that rely on similar principles especially since Hansen (2016) presented the following refined definition:

> A nudge is a function of (I) any attempt at influencing people's judgment, choice or behavior in a predictable way (1) that is made possible because of cognitive boundaries, biases, routines and habits in individual and social decision-making posing barriers for people to perform rationally in their own declared self-interests and which (2) works by making use of those boundaries, biases, routines, and habits as integral parts of such attempts.
>
> A nudge implies that people's behavior is influenced in ways that work independently of:
> i. Forbidding or adding any rationally relevant choice options
> ii. Changing incentives, whether regarded in terms of time, trouble, social sanctions, economic incentives and so forth, or
> iii. The provision of factual information and rational argumentation.

Nudging by governments. Many of the efforts of the government is focused on changing behavior, whether it is by encouraging physical activity, saving for retirement or finding work. As discussed in the previous chapter, the government has a variety of tools, yet nudging is becoming one of the key tools to do so. Although the definition of nudging does illustrate how it differs from traditional government levers for change such as "shoves", it is important to highlight the reason why governments are increasingly opting for this tool. In short, they are simple, costless and non-

coercive actions designed to correct individuals' behavior (but have small effects). On the other hand, shoves tend to be complicated, expensive and have bigger potential effects but also carry greater risks of failure (Barnard, 2019). Calculations of ratios of impact to cost (or cost-benefit analysis) for nudge interventions and for traditional policy show that nudge interventions can compare favorably (Benartzi et al., 2017). Based on this result, one should be careful to not jump to the conclusion that nudges should replace traditional policy tools. There are various negative externalities which nudges cannot fully address. Furthermore, nudging intervention have had generally disappointing results. They also perverse unintended consequences, such as individuals reducing support for policies solutions that are well known to be effective, and leading to individuals blaming themselves for problems with systematic origins (Chater & Loewenstein, 2022a). Thus, traditional regulations and incentives still hold a place in governments' toolbox (Chapter 2.2).

Nudging food choice & promising tool for sustainable consumption. Nudges have been used in the domains of: savings and financial decisions (Madrian & Shea, 2001; Richard & Benartzi, 2004), tax compliance (Hasseldine et al., 2007; Torgler, 2004), energy efficiency (Costa & Kahn, 2013; Pichert & Katsikopoulos, 2008; Schultz et al., 2007), education (Castleman & Page, 2015), and so forth. Most recently, nudges have been used to educate citizens about COVID-19 testing and vaccination (Krawiec et al., 2021). Next to these domains, nudges have been used to encourage health & wellbeing and eating behavior. Since food and drink (together with housing and transport) sums up to 75-80% of the life cycle environmental impacts in industrial countries, nudges has been more frequently promoted as a promising tool for advancing sustainable consumption (Lehner et al., 2016).

Firstly, food consumption is to a large degree a habitual and in many cases relatively unreflective process (Gronow & Warde, 2001), which makes it prone to nudging (Lehner et al., 2016). In many instances, nudges in the area of food choice have focused on the promotion of healthier choices in order to cope with increasingly problematic health problems. Despite increasing efforts, results in the area of food are moderate. This is due to marketing and individuals' complex reactions (Lehner et al., 2016). There are many laboratory experiments and interventions that show considerable potential of nudging in food consumption, however real-life success of nudging interventions are

limited. Evidence include for example combined salience and priming nudges, that showed a positive influence on healthier food and beverage choices (Wilson et al., 2016). Bucher et al. (2016) focused on the effect of changes to the product order and found that this can influence the choice of consumers. Hanks et al. (2012) looked at encouraging healthier eating in school lunchrooms through strategic placement of certain foods. The results showed that the sales of healthier food increased by 18% and grams of less healthy food consumed decreased by 28%. Kallbekken and Sælen (2013) looked at the effects of reducing plate size and providing social cues on food consumption on food waste in hotel restaurants in Norway. Both treatments proved to be effective at changing eating behavior, and reduced food waste by 20%.

Thus, nudging have been frequently in the food choice domain. Evidence shows that they are able to help policymakers in different countries and sector to integrate behavioral insights into policy design and implementation. From a nudging perspective, many behavioral changes can be encouraged in a non-obtrusive way by altering the complex food environment in which consumers are operating. Nonetheless, devising more successful nudges in the food domain will be necessary. It is not always the case that a nudge can be implemented in a controlled environment, hence further research on nudging and sustainable consumption will be a forthcoming topic in upcoming years. In the following section, an explanation of "informational nudges" is brought forward, as this is included in the study conducted by Vellinga et al. (2022) and is part of the topic of this thesis.

2.1.1 Information nudges to reduce meat consumption

Definition. According to Harbers et al. (2020), information nudges alter consumer behavior from a freedom-of-choice perspective to a more healthy choice and may contribute to improve population dietary behaviors.

Information nudges work by providing customers with relevant information about their choices. Information is provided appealingly (Morren et al., 2021), both visually and verbally, and the aim is to educate people while also activating certain heuristics and behavioral biases. The effectiveness of informational nudges is often debated, as it is argued that they rely on cognitive processing and this deviates from the definition of nudging (Harbers et al., 2020). Whether the provision of information should qualify as a nudge has been controversial and debated by for example Hansen

(2016), Schubert (2017) and Sunstein (2015). Furthermore, there is mixed results if the provision of information has the potential to be a promising low-cost strategy to encourage sustainable diets (see for example: Hartmann-Boyce et al. (2018)). This is to an extent caused by the complex nature of sustainable food choices and contradicting information on the footprint, which makes it difficult for consumers to learn about and act upon the information available (Grunert, 2011). Environmental impact is diverse and how to provide information of sustainability and nutrition is unclear. To what extent consumers are able to process such information and translate it into behavior change also lacks clarity (Bernard et al., 2019; Campbell-Arvai et al., 2014; Ikonen et al., 2020). In the best-case scenario, information leads to the creation of knowledge which then overcomes misconceptions, and positively influences individual decision-making. However, it can lead to an overload of information which can result in cognitive overload and suboptimal choices (Gourville & Soman, 2005) and can potentially through text and images encourage unconscious cravings (Klöckner & Ofstad, 2017).

Recognizing all nuances in definitions, going forward, I stick to the definition that the provision or reframing of information does not forbid any option and it does not change the economic incentives either (Mongin & Cozic, 2018). Previous studies have shown that if people were provided with prior information on the effect of meat on the environment, people become more willing to eat less meat (Cordts et al., 2014). Similarly, it has been observed that consumers with lower levels of meat attachments are more open to information about negative consequences of meat-eating and advances of altering eating habits (Graça et al., 2015). Reminding consumers that meat has negative effects for animals or providing information about animal suffering can activate emotional response that could weaken consumers' meat attachment (Kunst & Hohle, 2016; Rothgerber, 2020). In other studies, the provision of information did not change the number of participants willing to choose meals with less or no meat (Campbell-Arvai, 2015; De Groeve & Bleys, 2017), which highlights that only providing information about the climate impact of meat may not be enough to have an effect on the overall support. The provision of information and its effectiveness also depends on variables such personality traits, socio-demographic and socio-cultural variables. For example, individuals who were already aware of the negative impacts of meat consumption before the experiment, tended to be more supportive of meat curtailment strategies (De Groeve & Bleys, 2017). Contrary, a study found that pro-environmental beliefs had

no significant predictive value (Campbell-Arvai, 2015). Furthermore, informational interventions seem to be more successful among women (Graça et al., 2015). Based on these mixed evidence, it is crucial for informational interventions to consider addressing other variables that are related to meat consumption (the roles of these factors will be explored in Chapter 3).

2.2 Pricing strategies

The taxation of unhealthy products can address the negative externalities that arise due to the consumption of a product which does not include the external costs on third parties. However, for such a pricing policy to be effective, the price must influence the purchasing behavior of consumers.

Price matters. There are various studies which show that pricing is a determinant in food choice, next to taste and quality (Cassady et al., 2007; Glanz et al., 1989). Europeans prioritize cost, food safety, and taste over sustainability concerns when purchasing foods (Eurobarometer, 2019). The affordability of food plays a major role in the quantity and composition of that a person can purchase (European Commission, 2014). However, prices are now historically lower than ever due to competition among supermarkets (RIVM, 2017). In the current climate issues and the movement towards a more sustainable consumption pattern, price remains the main barrier for consumers to buy food with an environmental or animal welfare characteristic (RIVM, 2017).

The government's role and evidence of food taxes on consumption. Pricing policies are a tool that government can utilize in order to improve dietary patterns in terms of sustainability and health. Since evidence confirms the role of prices, increases or decreases in prices can directly influence consumer choices. In order to do this, governments can use either taxes or subsidies on foods and nutrients to promote healthier diets. Since the topic of this thesis is regarding the role of taxes, the next section will elaborate more on the mechanisms and present evidence from previous studies which have estimated the possible effects of foods taxes on food consumption and on related environmental influence.

First, governments and opinion formers want people to improve their habits (change diets) based on reasoning that it's in people's own interest and they will appreciate this ex post (Markandya et al., 2016). Secondly, practices such as smoking and bad diets have external costs and can increase the burden on national health services. Thirdly, consumers themselves may not be aware of how unhealthy their diet really is. These 3 points can be argued to support public intervention. The taxation of unhealthy products can address the negative externalities that arise due to the consumption of a product which does not include the external costs on third parties. These are commonly called "corrective taxes", and have been used for decades for alcohol, cigarettes, petrol and other fuels. Fiscal measures as taxation have the potential to be a powerful measure targeting meat reduction as higher prices discourage consumers from purchasing the foods that are taxed (Thow et al., 2014). Health-related food taxes and subsidies are being recognized as an important tool to decrease the externalities of food consumption, with regard to public health outcomes and climate change (Hoenink & Waterlander, 2022). Especially taxes on sugar sweetened beverages (SSBs) are becoming a popular strategy to precent and reduce overweight and obesity around the world.

Taxes are also an attractive option for governments, as taxes revenue could be used for costs arising from negative externalities, but also to subsidize healthy foods. Multiple studies attribute great potential to the proposed policies, though the assessed effects vary widely, and context-dependent consideration is crucial (Martos et al., 2015; Nordström & Thunström, 2011; Smed et al., 2007). Evidence also shows that besides generating income, taxes can also effectively discourage the consumption of unhealthy products (Hoenink, 2021). A review by Thow et al. (2010) showed that food taxes (and subsidies) can affect consumption in high-income countries and that enforcing substantial taxes on flattering foods may lead to an improvement in health outcomes (such as body weight and chronic disease risk). As already mentioned, the price of food is an important driver of food choice (Glanz et al., 1989) and many studies have investigated the effectiveness of pricing strategies on healthier food purchases (Liberato et al., 2014) and consumption (Andreyeva et al., 2010; Hartmann-Boyce et al., 2018; Hawkes, 2012; Thow et al., 2014).

In a supermarket environment, several strategies have been used to promote healthy food purchasing, which generally include environmental (e.g., nudging) and economic (e.g., pricing) interventions (Hartmann-Boyce et al., 2018). Additional evidence from virtual supermarkets and real-world retail setting verifies the effectiveness of pricing strategies' ability to influence the purchase and consumption of targeted foods in the intended direction (Afshin et al., 2017; Epstein et al., 2012; Gittelsohn et al., 2017). For example, Afshins et al. (2017) study found that a 10% decrease in price (i.e. subsidy) increased consumption of healthy foods by 12% whereas a 10% price increase (i.e. tax) decreased consumption of unhealthful foods by 6%. A large RCT conducted in a virtual supermarket found the proportion of healthy foods purchased increases when a tax for saturated tax, sugar tax and salt tax was introduced (Waterlander et al., 2019). In that same study, a SSB tax and a subsidy for fruit and vegetable did not result in significant changes of food purchases. SSB taxes are becoming increasingly popular, which has led to it being implemented in over 40 countries are SSB taxes (Bridge et al., 2020). This type of tax (10%) has been found to lead to a decrease of 10% in the purchases of beverages (Teng et al., 2019). For example in Denmark, excise duties on chocolate, ice cream, sugary drinks and confectionary were increase by 2010. Additionally, in 2011 a tax was introduced on foods such as meats, cheese, butter, edible oils, margarine and snacks containing more than 2.3% saturated fat. This is expected to raise revenue to over €200 million per year, and saturated fat consumption is expected to fall by 4% (WHO, n.d.).

Although the social costs from livestock-related environmental damages and health effects are significant, they have remained largely unaddressed in fiscal policy. If it is to be addressed, the tax should be optimal, and it will depend on which externalities and regulatory objectives are to be tackled. For example, optimal consumption taxes generally contain a 'Ramsey taxation element', which states that highest tax rates should be levied on goods which have inelastic demands (Sandmo, 1975) for the general purpose of revenue-raising. However, the introduction of policies with the aim of a reduced meat consumption is a delicate matter and approval might not be easily obtained. In summary, there is various evidence that pricing strategies can lead to positive effects on consumer-level behavior, with the majority of the studies reporting an increase in purchasing and consumption of healthy foods or beverages or decreased purchasing and consumption of unhealthy foods and beverages. Thus, taxation could be an effective measure to target meat reduction, as higher prices discourage consumers from purchasing the foods that are taxed.

Nevertheless, some gaps in the literature remain which call for further investigation. This includes evidence on price-elasticities, cross-price elasticities, and what the effect is of utilizing a combination of strategies on meat-consumption behaviors, some of which is to be addressed in this thesis.

2.3 The price elasticity of demand

In this section the economic theory that explains the effects of price changes on the demand for meat products is explained. The aim of this section is to elaborate on the consumer demand theory that is the foundation for the calculation of the price elasticity of demand. Therefore, this section presents the relevant aspects of the theoretical framework to reflect on consumer behavior regarding price changes on the demand for meat. First, the law of demand and the relationship with the price elasticity of demand is discussed. Secondly, an elaboration on the price elasticity of food and meat is provided.

2.3.1 Economic theory

Law of demand and the price elasticity of demand. This law explains that demand for a product increases when the price of a product decreases, holding constant taste, household income, prices of substitute or complements and other factors that could influence consumption (Perloff, 2012). This law is strongly related to the price elasticity of demand, or price sensitivity[2]. This is the (percentage) change in the quantity demanded for a product in response to a change in the (percentage) price of a product. In mathematical form this is:

$$\in_{ij} = \frac{\frac{\Delta Q_i}{Q_i}}{\frac{\Delta p_j}{p_j}} = \frac{\Delta Q_i}{\Delta p_j}\frac{p_j}{Q_i} \quad (1)$$

This formula (1) shows that the price elasticity of demand ($\in_{ij}$) is the percentage change in the quantity demanded for product *i* ($\frac{\Delta Q_i}{Q_i}$) and the percentage change in price of product *j* ($\frac{\Delta p_j}{p_j}$). In other words, the amount of a good consumers will purchase varies inversely with price, other factors

[2] In general "price sensitivity is often used as a synonym for "price elasticity" (Link, 1997), and therefore both terms are used synonymously in this research.

being held constant (*ceteris paribus*) (Leuthold & Nwagbo, 1977). The price elasticity of demand is illustrated in the form of a negative sign, which illustrates that when a price increases, the quantity decreases (Perloff, 2012). At a price elasticity of 0, demand will not respond to a price change. When the relative change in purchased quantity is below the relative change in price, demand is said to be "inelastic" (the absolute value of price elasticity <1.0). If the change in demand exceeds the relative price change, then demand is said to be "elastic" (the absolute value of price elasticity >1.0). Values equal to -1 are "unit elastic", which indicates that there is equal (in absolute value) percentage changes in the quantity demanded and price. Put in another way, when there is a specific change in price, inelasticity implies that consumers will alter their consumption very little, while elasticity implies a relatively major change in the amount consumed.

The price elasticity of demand depends on the availability of substitutes. When there are relatively more substitutes available, the magnitude of the price elasticity will increase. To understand the mechanism behind this it is important to define own-price and cross-price elasticity, since it defines in which rate the quantity demanded of a product will change relative to price fluctuations of that same product or another product. The own-price elasticity of demand is defined as the percentage change in the price of that same product (Pindyck & Rubinfeld, 1998). This is in most cases negative, with the exception of products termed "Giffen goods". The cross-price elasticity is the percentage change in the quantity of one good demanded in response to a 1% change in the price for another good. A positive value would indicate that the two goods are substitutes, and a negative value would imply that these goods are complementary. When there is no effect observed on the quantity demanded due to a price change, the products are considered independent (Pindyck & Rubinfeld, 1998). Furthermore, the price change of a product has two additional effects on demand, namely: a substitution and an income effect. The substitution effect is the change in consumption pattern due to a relative change in the price of a product compared to a substitute, holding the level of utility constant. The income effect is the change in consumption in relation to the change in purchasing power because of a price change of a product. When both effects are included in the cross-price elasticity, the products are called gross substitutes or gross complements. If only the substitution effect is included, the products are called net substitutes or net complements (Huq & Arshad, 2010).

2.3.2 Price elasticity for food and meat

The price elasticity is generally inelastic since it is a basic necessity (Barkley, 2016). If prices of basic necessities increase, e.g. food or electricity, the quantity demanded decreases relatively little (Eaton & Lipsey, 1989). Although food in general might be price inelastic, the magnitude of the price elasticity varies amongst food categories. There are various reasons why this is the case. Firstly, some food categories are substitutes to each other, e.g. chicken and beef, which increase the magnitude of the price elasticity. Secondly, products in various food categories are more competitively distinctive in substitutes and quality, which increases the likelihood of being more elastic (Bèrges et al., 2013).

In order to analyze the demand for food products, the Almost Ideal Demand System (AIDS) has been commonly used. In the AIDS framework the budget share of the good examined is linearly related to the log of the total expenditure and relative prices (Deaton & Muellbauer, 1980). In their analysis, the results showed that the demand elasticities are in line with economic theory and previous studies. In here, the price elasticities of demand for necessities, such as food or housing, are inelastic and for more luxury goods, such as transport and communication, the price elasticities of demand appear to be more elastic, ranging from -0.01 for food to -1.21 for transport and communication. Besides the AIDS model, the Rotterdam model is also used estimate demand elasticities. In a study conducted by Barten (1993), both models were used. Here food was inelastic in both models, ranging from -0.321 to -0.748 in the Rotterdam model and -0.360 to -0.105 in the AIDS model. Furthermore, meta-analysis is also used to estimate price elasticities. To summarize the AIDS framework, it i) the model examines the influences of expenditure and prices on the consumers' purchasing behavior and ii) it makes use of a price index that relies on prices of the different product groups that are also included in the calculations of the budget shares. Although this a widely used model to estimate the price elasticity of demand, it is not used in this study due to insufficient amount of data. Furthermore, the most consumed meat products in the Netherlands fall under the categories of, i.e., beef, pork, and poultry (Terluin et al., 2017). If all the information was available, the AIDS framework could have been useful to also estimate the cross-price elasticities between these different meat products, however for this thesis the entire food group is examined, and cross-price elasticities are beyond the scope of this research.

Going back to evidence, considerable data can be found on price elasticities of demand for certain foods. Previous systematic review of modelling studies found a mean price elasticity ranging from -0.27 to -0.81 (absolute values), with the highest price elasticities for food away from home, soft drinks, juice, meats, and fruit and the most inelastic demand for eggs (Andreyeva et al., 2010). However, contrary to the evidence from experimental studies, modelling studies evidence suggest that the percentage change in demand is smaller than the percentage change in price as most price elasticities on food groups are below 1.0 (Andreyeva et al., 2010; Hoenink, 2021).

When the food category for meat product is zoomed in, it can be noticed that research has put substantially greater attention to consumer demand for meat, particularly beef and pork, than demand for any other food. Out of the 160 studies included in Andreyeva et al. (2010) systematic review, 31% provided price elasticity estimates for beef; 29% for pork; 14% for poultry; and 10% for fish. In the U.S. the price elasticity with values range from -0.68 to -0.75. In a meta-analysis conducted by Gallet (2010) the price elasticity is for West Europe equals -1.191, and taking homogeneous effects into account, this is -0.851 across the globe. In another study by Wirsenius et al. (2011), the price elasticities of food demand in EU27 were approximately -1.30 for beef, -0.80 for pork and -1.00 for poultry demand. In Appendix 1 an overview can be found of the previous research conducted on the price elasticity of meat. These results are important for the comparison between the results obtained in this thesis.

3 Hypotheses development

Although the attention of this thesis is majority focused on price, it is important to recognize that people make decisions about purchasing meat not solely based on this, but also on factors such as availability, convenience, and its social cultural value. The meat consumption pattern is also shaped by force of habit and social norms (Godfray et al., 2018). Thus, a set of personally held ideas may also influence decision about food choices, and therefore the overall effect. With this logic, I aimed to investigate the variances between the combined effects of the price intervention and the information nudge on consumer demand by also taking three drivers and inhibitors, namely: meat attachment, price consciousness and environmental consciousness, into account. The four hypotheses developed and tested are briefly discussed in this chapter.

3.1 Mixed-policy strategy

The results the study conducted by Vellinga et al. (2022) shows that in the combination condition less meat was purchased compared with the control condition. In line with the available literature, singular or informative measures are often less effective in achieving dietary change compared with more robust measures such as fiscal measures or mixed policies with more pronounced effects (Garnett et al., 2015; Latka et al., 2021). This result is also in line with the results found by Anderson and Simester (2003), in which it was concluded that combining pricing strategies with communication about price changes (salience) may further enhance their overall effectiveness. Similar results are expected to be seen in the analysis of this hypothesis. In the study of Vellinga et al. (2022) the primary outcome was the difference in the total amount of meat purchases (in g) per household per week. For this hypothesis we will conduct similar analysis as was used in the study in question, but the primary outcome will focus on the quantity of meat (in *N*). We expect the same results as obtained in the study by Vellinga et al. (2022).

H1. *The combination of a Tax & Nudge will lead to a stronger reduction in the demand for meat in comparison to the Nudge on its's own.*

3.2 Meat attachment

Many individuals still display a highly positive attitude to eating meat, they enjoy and derive pleasure from consuming it (Piazza et al., 2015). Consumers who display an affective connection with meat, or meat attachment, can play a role in their willing to change consumption habits (Graça et al., 2015). It is argued that that the affection towards meat represent a continuum in which one refers to disgust, while the other shows a pattern of attachment that may hinder consumption habits change (Graça et al., 2015). Furthermore, information campaigns aimed at raising awareness of the negative impacts of meat consumption on the environment, animal welfare and human health can trigger psychological defense mechanisms and fail to reduce meat consumption levels in the general population (Modlinska & Pisula, 2018). These types of campaigns have been shown to yield better results among people characterized by lower emotional attachment to eating meat products in comparison to individuals who are strongly attached to meat (Graça et al., 2015). Based on the available evidence, it is expected that a price increase and the information nudge will have less of a strong effect on consumers with a strong attachment to meat in comparison to less frequent meat-eaters. The following hypothesis is developed.

H2. *In their purchasing behavior, consumers with strong meat attachment respond less strong to the combination of a Tax & Nudge than consumers with lower meat attachment.*

3.3 Price consciousness

The standard definition of price consciousness in economic refers to the change of consumers demand due to price changes, equivalent to “price elasticity”. One of the limitations of price elasticity” research is that it focuses primarily on the aggregate level and cannot account for sensitivity to price changes at an individual level (Rihn et al., 2018). Other methods have been developed in order to address this limitation. For this hypothesis we assume that consumers’ level of price consciousness influences their decision-making processes and purchasing behaviors (Hafstrom et al., 1992; Kim et al., 1999). Since price is an important attribute in the decision-making process, it can encourage (Chandon et al., 2000) or discourage consumption (Aschemann-Witzel & Zielke, 2017; Magnusson et al., 2001). Additionally, price becomes consumers’ primary information cue when information overload occurs (Grebitus & Seitz, 2014), and a greater visual attention to price information leads to lesser purchase likelihood (Rihn et al., 2018). It is therefore

expected that a price increase will discourage consumption and this effect is expected to be stronger for consumers with higher levels of price consciousness. Thus, the following hypothesis is developed.

H3. *In their purchasing behavior, price conscious consumers respond stronger to the combination of a Tax & Nudge than consumers with lower price consciousness.*

3.4 Environmental consciousness

Environmental consciousness is the degree to which individuals are aware of problems regarding the environment and they support the efforts to solve them or indicate willingness to contribute personally to their solution (Dunlap & Jones, 2002). Environmental motives may therefore effect consumers' attitude toward green products (Chekima et al., 2019). Modlinska and Pisula (2018) proposed that individuals with pro-environmental and pro-animal attitudes are more likely to adapt their diets in order to decrease the negative impacts. Another study found that these types of consumers are also willing to pay a higher price and purchase more organic wines (D'Amico et al., 2016). Although the majority of the studies conducted focus primarily on organic food/green products, it provides basis to argue that a similar influence can be seen for the purchase of meat. It is expected that consumers who hold high levels of environmental consciousness care more about environmental protection and its impact on human health and society. Thus, a higher emphasis will be placed on environmental protection rather than price in the purchase decision process. The following hypothesis is developed.

H4. *In their purchasing behavior, environmental consciousness consumers respond less stronger to the combination of a Tax & Nudge than consumers with lower environmental consciousness.*

4 Methodology

In this thesis, meat is considered as a homogenous good. This choice was based on the notion that consumers choose more often for meat products rather than for meat from a certain type of animal (Mangen & Burrell, 2000). All meat and meat products (see Appendix 2 for list) available and sold in the virtual supermarket were considered as one good, after which the price elasticity for the entire food group was estimated. In this section, the experiment, the data and the statistical analysis is explained.

4.1 The experiment

The study was conducted in a Dutch virtual supermarket, and ran between 22 June 2020 through 28 August 2020. More of the study design can be read elsewhere (Vellinga et al., 2022). The purpose of this section is to briefly elaborate the treatments that the participants were exposed to in order to have clarification of the analysis of this thesis.

Treatments. In the RCT conducted there were four treatments (we will refer to these as conditions going forwards in this report). However, the first treatment is considered a control. In the Price condition prices of meat and meat products were increased by 30% at the consumer food purchase level. Participants were notified of this price change before entering the supermarket with the following statement: “The government has increased the tax on meat in the virtual supermarket, leading to a price increase of 30% for meat”. In the Information nudge condition participants were exposed to an information nudge that aimed to create awareness regarding the environmental impact associated with meat production and to influence the consumer’s role in that regard (Vellinga et al., 2022). The information nudge was exposed to participants before entering the virtual supermarket and stated the following: “The government wants to reduce the consumption of meat in the Netherlands because meat production damages the environment. You can help to reduce the environmental damage caused by meat production by purchasing less meat”. In the third condition (combination), participants were exposed to both higher prices (30% price increase of meat) and the information nudge, both (notification) were exposed before entering the virtual supermarket.

TABLE 1. RCT CONDITIONS

Conditions	Intervention
Price condition	30% price increase on meat (and meat products)
Information nudge	Nudge (regular food prices were used)
Combination condition	30% price increase + nudge

The supermarket. The study was conducted in a Dutch Virtual supermarket. Virtual supermarkets are becoming increasingly popular to study the effects of pricing strategies of pricing on food purchases given the ease of implementing RCTs within this setting (Hoenink, 2021). The available foods available amounted to 580, and was based on the stock of the leading supermarket chain and supplemented with the most frequently consumed foods within the most recent Dutch National Food Consumption Survey 2012-2016 (van Rossum et al., 2020).

Participants and setting. Eligible participants were adults (≥ 18 years) with an adequate command of the Dutch language, largely or totally responsible for grocery shopping for the household and with access to a laptop or computer (Vellinga et al., 2022). Participants were recruited via an online research panel in the Netherlands (Panel Inzicht) and were rewarded with virtual points which could be redeemed for cash. In short, after participants were recruited and completed the screening questionnaire, they were invited via email to participant in the study. Once they logged into the software, they were asked about their household size and composition to determine their weekly shopping budget. The full procedure of this study is described in the studies conducted by Vellinga et al. (2022) and Eykelenboom et al. (2022).

4.2 Data collection and variables

The data consisted out of 533 participants that completed the virtual shopping, and included socio-demographic characteristics such as age, gender, income etcetera., but also total household expenditure. The inclusion criteria is described in detail elsewhere (Vellinga et al., 2022). The socio-demographic characteristics of respondents are derived from background data, which were measured by using the screening and final questionnaire responses of the study in question.

4.2.1 Dependent variable

The total amount of meat products purchased in the virtual supermarket is used to measure the total meat demand per household per week (in *N*). A new variable is created for the Log transformation of the quantity values for normalization purposes and was used for modeling as the dependent variable for the calculation of the price elasticity of demand (Chapter 5.2). The Log transformation is a common specification used in a large number of previous studies measuring price elasticity of demand (Gallet, 2010). It is used here as it provides a good fit to the data and makes it possible to make a direct comparison with previous results from the literature.

4.2.2 Explanatory variables

The experimental conditions 'Price condition', 'Information nudge condition' and 'Combination condition' were used as the explanatory variable to test the first hypothesis[3]. In order to do so, dummy variables were necessary. Thus, three variables were created for each condition, with the value of 1 indicating the participant received the corresponding treatment, and with 0 otherwise.

In order to test the hypotheses, multiple measurement had to be created. In order to do, several questions of the study questionnaire were selected. The questions selected can be seen in Table 2.

[3] These experimental manipulations are referred to as "*Tax*", "*Nudge*" and "*Tax & Nudge*" in the regression results in Chapter 5.

TABLE 2. ITEM/INCLUSION SPECIFICATION PER CONSTRUCT/EXPLANATORY VARIABLE

Construct	Items/inclusion	Measurement
Attachment to meat	1. I enjoy eating meat (ARG 1) 2. I eat meat because it is a habit (ARG2) 3. I eat meat because it is healthy (ARG3)	ARG1 and ARG2 measured in 5-point Likert scale. The remaining was measured in 6-point Likert-scale.
Price consciousness	1. It is important to me that what I eat and drink a normal day is not expensive (KEUZE3) 2. I will buy less meat if it is 30% more expensive than normal (MEAT4) 3. To what extent did you pay attention to prices in the virtual supermarket? (VIRT4) 4. To what extend did you let prices determine your choice in the virtual supermarket? (VIRT5)	KEUZE3 measured in 5-point. MEAT4 measured in 6-point scale, with point 6 meaning no consumption. VIRT4 and VIRT5 are measured in 7-point Likert scale: 1 “not at all” to 7 “extremely”.
Environmental consciousness	1. It is important to me that what I eat and drink in a normal day causes the least possible harm to the environment (KEUZE5) 2. I think that the cost of meat damages to the environment should be included in the price (MEAT2) 3. I have sufficient knowledge about the damage to the environment (MEAT1)	All measured in 5-point Likert scale

The attachment to meat selection is based on the study conducted by Joy (2011). Meat consumers commonly justify their consumption by the following points; they believe that eating meat is natural, normal and necessary (Three Ns of Justification). This theory was further supplemented by (Piazza et al., 2015) with an additional “N” for “nice” which together create the 4N scale. The post questionnaire allows us to focus on three of the N’s, with 1 items per N. Secondly, price consciousness was measured using four items. These items were chosen based on the Price Perceptions questionnaire designed by Lichtenstein et al. (1993), which allows to assess different ways how consumers react to price and price promotions. Furthermore, the degree to which a customer’s buying decision are based on price-related aspects is also consider as a measure of price consciousness (Low et al., 2013; Stock, 2005). Lastly, there are several measurement items that have been used to measure consumers’ level of environmental consciousness. Wang et al. (2020) adopts Prakash measurement scale, which indicates consumers’ perceptions and their willingness

to solve environmental problems regarding their purchase behaviors when it comes to purchasing organic food products in physical retailers (Prakash et al., 2018). Other studies which have used this scale include those (but not limited) by Kriwy and Mecking (2012), (Zepeda & Deal, 2009) and (Hamm & Gronefeld, 2004).

4.3 Statistical analysis

The data obtained for the analysis was already inspected for normality using Q,Q-plots and Kolmogorov-Smirnov tests. Further visual inspection was conducted was conducted in this study to further ensure normality (Appendix 3 & 4).

To evaluate the effect of the conditions on the quantity of meat demanded, I started by creating a hierarchical multiple regression model. The experimental condition and all control variables were included (i.e., gender, age, household size, BMI[4], education and household monthly income) to evaluate the effect of the conditions on the quantity of meat demanded. Before the analysis was conducted, a likelihood ratio was estimated between two models in order to ensure which covariates to include in the model. Model 1 consisted out of the variable household size, gender (male, female, other), BMI (continuous), and education (low, moderate, high). These variables were argued to be strong predictors for the total amount of meat purchases by Vellinga et al. (2022). Model 2 included a variable for household monthly income (gross in €) (low, moderate, high) and age. Gross income was included as previous studies have shown that preferences for meat demand differ by income (Lusk & Tonsor, 2016). The latter was added as previous studies have found that meat appreciation was a possible predictor of meat eating among people 18 to 32 years (Worsley & Skryzpiec, 1998). The test statistic was 12.38 and the associated p-value was relatively low (0.002). This result indicated that adding both gross income and age as predictor variables resulted in a statistically significant improvement in the model fit.

In order to test the hypotheses, 3 indicators were chosen (as explained in section 4.2.2). To create these variables, the aggregation method was chosen. This is the compilation of many values to create one aggregate value based on survey data (The World Bank, n.d.). Careful inspection was

[4] BMI had 12 missing values and were replaced using the replacement by mean method.

done in order to check if any missing values were created, which was not the case. In order to ensure whether the items selected (to aggregate) were reliable (or for internal consistency), a Cronbach's alpha (α) test was run. The standards for what makes a good α coefficient are arbitrary, however many methodologist recommend a minimum α coefficient between 0.65 and 0.8 (or higher in many cases) (Goforth, 2015). For *Meat attachment*, this was found to be acceptable, with ($\alpha = 0.77$). For *Price consciousness* this was $\alpha = 0.65$, which is also acceptable. Lastly, the score for environmental consciousness was $\alpha = 0.57$, which is relatively low and might not be representative of the domain of behavior. In order to improve the reliability of the coefficient, more items of the questionnaire can be added. However, the questionnaire had limited questions that addressed the environment, thus this was not possible. It is also possible to remove an item if they highly correlate with each other, which was also not the case here. The decision was made to carry on with the analysis with the 3 items, however the results should be interpreted carefully.

Next to developing the 3 measurement instruments, I aimed to demonstrate the overall multidimensionality of the variables and how its effect differ depending on the type or level of the attachment. This is necessary since a simple measure does not always predict attitudes or willingness to support/oppose interventions, and that within the place dimension, the type and level of the attachment should be considered (Scannell & Gifford, 2010). In order to differentiate the difference, dummy variables were created. This method is line with the study conducted by Boun My and Ouvrard (2019) where they used several questionnaires to determine the environmental sensitivity of subjects and how this in this interacts with a nudge to contribute to a public good. For *Meat attachment*, the variable takes the value 1 (consumer has high meat attachment) if the participants score was above 8.113, the mean of the aggregated variable. The same procedure is conducted for the other two measurements (see Appendix 6 for mean statistics). In the social sciences it is also common to treat ordinal variables as continuous, and this has no harm to the analysis (Johnson & Creech, 1983; Norman, 2010; Sullivan & Artino Jr., 2013). Since this is the case, additional estimations were conducted. However, the supplementary analysis did not alter the qualitative interpretation of the results (Appendix 9).

Lastly, cross-variables were created to capture the effect of having high attachment/levels, while being treated with the *Nudge* and *Tax & Nudge*. All the statistical analyses was performed using

STATA software version 17.0, and a two-sided p-value of <0.05 was considered statistically significant.

5 Results

5.1 Results for hypotheses testing

RCT conditions

In order to test the hypothesis whether the combination of the tax and nudge had a stronger effect on the demand for meat in comparison to the interventions independently, a linear regression was conducted. The dependent variables here was the quantity of meat demanded. This analysis also included the experimental conditions as independent variables, age, household size, sex, BMI, education and income as control variables[5].

TABLE 4. EFFECTS OF THE RCT CONDITIONS ON MEAT DEMAND

	(1)
VARIABLES	
Experimental manipulation	
Tax	-0.509*
	(0.289)
Nudge	-0.294
	(0.294)
Tax & Nudge	-1.155***
	(0.299)
Observations	533
Adjusted R-squared	0.238

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

All experimental conditions had a negative coefficient. For *Tax* and *Nudge* independently, a relative less negative effect was observed in comparison to the combination of both. Although negative results were observed for the independent conditions, these were not statistically significant (at the 5% level). Based on this analysis, the expectations are confirmed, this is also reflected in the significant results (β = -1.155, 95%CI -1.744; 0.566). This is the same outcome that was observed in the study conducted by Vellinga et al. (2022), the difference here is that meat purchased is measured in *N* (contrary to in *g*).

[5] Since the main interest was the experimental conditions, the regression output is shortened. The full regression table, including the covariates, are included in Appendix 7 & 8. This will also be the case for the remaining hypotheses.

For the following hypotheses, the same dependent variable was used. This is also the case for the experimental conditions and the covariates. In addition, the interaction between the experimental conditions and the measurement variables are incorporated to answer the specific questions that were formulated.

Meat attachment

It was hypothesized that consumers with strong meat attachment respond less strong to the combination of a tax and nudge. In order to investigate this, two models were estimated. First, in model 1 the variable *Meat attachment* had a positive and significant effect (β = 1.401, 95%CI -0.938; 1.865), this is the difference between those with high attachment to meat in contrast to those with lower levels (reference group). The experimental manipulations with *Tax* and *Tax & Nudge* had a negative and significant effect (at the 5% level) on the quantity of meat demanded, which means that both remain relevant when even when controlling for meat attachment. The *Nudge* manipulation did not have a significant effect in this model.

TABLE 5. EFFECTS OF MEAT ATTACHMENT ON MEAT DEMAND

VARIABLES	(1)	(2)
Experimental manipulation		
Tax	-0.648***	-0.675**
	(0.282)	(0.282)
Nudge	-0.503*	0.198
	(0.286)	(0.563)
Tax & Nudge	-1.133***	-0.689
	(0.290)	(0.456)
Interactions		
Meat attachment	1.401***	1.755***
	(0.236)	(0.317)
Nudge x Meat attachment		-0.679
		(0.545)
Tax & Nudge x Meat attachment		-0.931
		(0.625)
Constant	-1.047	-1.400*
	(0.759)	(0.786)
Observations	533	533
Adjusted R-squared	0.285	0.286

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

Since there is evidence that those with strong attachment to meat may be more difficult to shift through a nudge (Graça et al., 2015), I estimated a second model in which two cross-variable were added to capture the effect of being attached to meat while being treated with a nudge (*Nudge x Meat attachment*) and the combination of tax and nudge (*Tax & Nudge x Meat attachment*).

In the second model, again a positive and significant effect is observed for *Meat attachment*. Here, only the *Tax* had a significant effect on meat demanded (β = -0.675, 95%CI -1.123; -0.121). Compared to model 1, the experimental manipulation *Tax & Nudge* has turned out to be insignificant, which shows that controlling for meat attachment and treatment renders this manipulation ineffective in changing people's behavior. The same cannot be said for the *Nudge* on its own, since in both models the coefficients were insignificant. In order to see whether *Meat attachment* was a moderator, two interactions were added. However, neither of the interaction terms were significant, which meant that there was not a significant difference on the effectiveness of the manipulations whether the person was highly attached to meat or less attached. Although insightful, these results did not allow to confirm the hypothesis formulated.

Price consciousness

To test whether price conscious consumer respond stronger to the combination of a tax and nudge two models were estimated here as well. In the first model, the *Price consciousness* variable is negative and significant (β = -0.593, 95%CI -1.012; -0.172). The treatment with the *Tax* had a negative and significant effect on the quantity of meat demanded, whatever (or controlling for) the participants' price consciousness (at the 5% level). This is also the case for the manipulation *Tax & Nudge*. Similar to the previous analysis, the *Nudge* manipulation did not have an effect on the quantity of meat demanded.

TABLE 6. EFFECTS OF PRICE CONSCIOUSNESS ON MEAT DEMAND

VARIABLES	(1)	(2)
Experimental manipulation		
Tax	-0.572**	-0.544*

	(0.289)	(0.290)
Nudge	-0.309	-0.190
	(0.292)	(0.405)
Tax & Nudge	-1.169***	-0.688**
	(0.298)	(0.405)
Interactions		
Price consciousness	-0.593***	-0.332
	(0.214)	(0.289)
Nudge x Price consciousness		-0.219
		(0.522)
Tax & Nudge x Price consciousness		-0.918*
		(0.525)
Constant	-0.063	-0.181
	(0.761)	(0.770)
Observations	533	533
Adjusted R-squared	0.247	0.249

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

Given that price can become the primary information cue when information overload occurs (Grebitus & Seitz, 2014), and nudges can increase the virtual attention to price information (Rihn et al., 2018), an additional model was estimated. Here two cross-variable were added to capture the effect of having high a high price consciousness while being treated with a nudge (*Nudge x Price consciousness*) and the combination of tax and nudge (*Tax & Nudge x Price consciousness*). The results can be seen in Table 5.

In the second model, unlike the first, *Price consciousness* was not significant. Here, the experimental manipulation *Tax & Nudge* remained effective in reducing the quantity of meat demanded, which was not the case for the *Tax*, which has now turned ineffective. Here again, the *Nudge* treatment did not have a significant effect. In order to investigate whether *Price consciousness* was a moderator, the interactions were added. The interaction *Tax and Nude x Price consciouses* approached significance (p<0.10), which would have meant that there is a significant difference of the manipulation effect (on the dependent variable) when an individual has higher price consciousness than those with lower levels. Nevertheless, this cannot be concluded because it is not in accordance with the chosen significance level (p<0.05). The remaining interaction

(*Nudge x price consciousness*) was also not significant. To conclude, these results did not allow to confirm the hypothesis formulated.

Environmental consciousness

TABLE 7. EFFECTS OF ENVIRONMENTAL CONSCIOUSNESS ON MEAT DEMAND

VARIABLES	(1)	(2)
Experimental manipulation		
Tax	-0.550*	-0.553**
	(0.282)	(0.282)
Nudge	-0.232	-0.174
	(0.285)	(0.374)
Tax & Nudge	-1.096***	-1.376***
	(0.291)	(0.387)
Interactions		
Environmental consciousness	-1.189***	-1.294***
	(0.210)	(0.288)
Nudge x Environmental cons.		-0.109
		(0.507)
Tax & Nudge x Environmental cons.		0.559
		(0.288)
Constant	0.726	0.806
	(0.758)	(0.768)
Observations	533	533
Adjusted R-squared	0.280	0.280

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

Lastly, it was hypothesized that environmental conscious consumers respond less stronger to the combination of a tax and nudge. Just like the first two hypotheses, two models were estimated. In the first model, the variable *Environmental consciousness* had a negative and significant effect (β = -1.189, 95%CI -1.601; -0.776). The experimental manipulation *Tax & Nudge* had a negative and significant effect (at the 5% level) on the quantity of meat demanded, which means that this remained relevant even when controlling for environmental consciousness. Both the *Tax* and *Nudge* manipulation independently did not have a significant effect.

The literature suggests that individuals with pro-environmental and pro-animal attitudes are more likely to adapt their diets in order to decrease the negative impacts, and are willing to pay a higher price (Chekima et al., 2019; Modlinska & Pisula, 2018). In other words, these type of consumes place a higher emphasis on environmental protection rather than price in their purchasing decision. In order to see if this played a role in the experiment, two cross-variable were added to capture the effect of having high environmental consciousness while being treated with a nudge (*Nudge x Environmental consciousness*) and the combination of tax and nudge (*Tax & Nudge x Environmental consciousness*).

In the second model, the variable for *Environmental consciousness* remained negative and significant. Both the *Tax* and *Tax & Nudge* manipulations had a negative effect on the quantity of meat demanded. The former was not significant in the first model, which indicates controlling for environmental consciousness and treatment renders this effective.

Seeing these other results here, the conclusion is that *Nudge* alone does not perform better, also this is not significant. A stronger negative effect is observed for the combination of strategies, which was expected and tested. To explore the role of the moderator, two interaction terms were added. Nevertheless, none of the interactions were significant, which caused that the hypothesis could not be confirmed.

5.2 Price elasticity (PE) estimates

In this section the focus is on the calculation of price elasticity of demand for meat. First a short theoretical argumentation is presented in order to specify the estimation of the PE. Second, the PE estimates are presented step-wise with the method specification.

In order to estimate PE using an OLS regression, it is necessary that the OLS assumptions are not violated (Stock & Watson, 2015). Since Marshallian demand equals supply in equilibrium, it makes price of meat an endogenous factor (Rickertsen, 1996). A possible solution to this is the use of Two Stage Least Squares (TSLS) regressions. Since the experiment took place in a controlled environment, which means that the jump in price was not endogenous, running a TSLS was not required for this analysis.

Thus, in order to derive to the PE (for the entire meat group[6]) a linear regression was used. To do this, the sales information (quantity of meat and meat products purchased) and the prices of the virtual supermarket were used. The dataset contained 533 observations. For this calculation there was no consideration of competition, no in-store alternative, no promotional activities and no seasonal-effects. Finally, as mentioned in the literature review, the double-log form, sometimes called the log-log form is often used because a researcher has specified that the elasticities of the model constant, and the sloped are not (Studenmund, 2016). The practical advantage of the log-log is that the interpretation of the regression coefficients is straightforward. It also ensures that demand cannot sink below zero as the price increases and on the other side demand exponentially grows as the price decreases (Lüttgau, 2018). Furthermore, it is important to note that the data used concerns (representative) shopping for one week. Thus, the estimated price elasticities are interpreted as short-term elasticities rather than long-term[7].

The elasticity is estimated as follows (endogeneity is ignored since it is not an issue here and no control variables are used):

$$\ln Q_i = \beta_0 + \beta_1 \ln P_i + e_i \tag{2}$$

[6] The calculation of individual price elasticity was not conducted since the goal was not to answer which meat product was more elastic/inelastic. The analysis also proved to be difficult since the data contained multiple zeros.

[7] Short-run elasticities are for a time span of less than one year (Pindyck, 2009).

This means that the natural logarithm of meat demand Q_i depends on a constant β_0 and the log of the price of meat P_i. In this model, β_1 represents the price elasticity. Using this equation the following results are obtained (Table 7). In column (1) the estimation does not include any control variables. The assumption that there is a single price elasticity for the entire population is quite a simplification, since the level of price sensitivity differs per individual (U.S. Committee of Finance, 1985). However, this can be justified if the I) price elasticity to describe everyone's behavior is appropriate if the differences are distributed randomly in the population and II) the experiment was done with a representative sample (at 5% Margin of Error, 95%CI). To see whether the price elasticity differs substantially among for example income classes, it is appropriate to include the control variables. The same control variables included in the analysis for the hypotheses were used here. Furthermore, this step is also required to control for the possible effect induced by the treatments. This estimation is shown in column (2).

TABLE 8. PRICE ELASTICITY OF DEMAND

VARIABLES	(1)	(2)
ln (Average Price)	-0.637***	-0.603***
	(0.221)	(0.202)
Observations	533	533
Sample	Full	Full
Adjusted R-squared	0.013	0.186

Note: Dependent variable is the natural log of the quantity of meat demanded. Average price was estimated based on the 44 meat products available in the virtual supermarket. For model (2) estimations are controlled for sex, age, household size, education, and income, although these are not reported. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

As can be seen, in the first model, the result is significant and negative, which is in accordance with theory. The own-demand elasticities is 0.64 (in absolute values), which is inelastic, i.e., the total quantity of meat purchased was only partly dependent on the price of meat. This result is within the range of price elasticity for food, which was estimated to be in the range of 0.27 to 0.81 by Andreyeva et al. (2010). However, compared to the previous price elasticity of meat estimates (Appendix 1), the results presented here are relatively less inelastic. However, if a comparison is made with the own-price elasticity for the whole meat category calculated by Boer et al. (2006),

the results are the same. For model (2), the estimate is slightly lower, yet in the same food elasticity range.

Second, a dummy variable was included in the model to indicate whether the *Nudge* treatment was received (the value of 1 if the participant was exposed to the Nudge condition and 0 otherwise). This was done in order to determine whether elasticities vary when consumers were exposed to a nudge and to determine if these elasticities are statistically different from each other.

This was estimated as follows:

$$\ln Q_i = \beta_0 + \beta_1 \ln P_i + \beta_2 \, Nudge_i + e_i \quad (3)$$

TABLE 9. PRICE ELASTICITY OF DEMAND WITH NUDGE

VARIABLES	(1)	(2)
ln (Average Price)	-0.681***	-0.715***
	(0.262)	(0.238)
Nudge	-0.025	-0.065
	(0.081)	(0.738)
Observations	533	533
Sample	Full	Full
Adjusted R-squared	0.012	0.185

Note: Dependent variable is the natural log of the quantity of meat demanded. Average price was estimated based on the 44 meat products available in the virtual supermarket. For model (2) estimations are controlled for sex, age, household size, education, and income, although these are not reported. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Here, the coefficient is also negative and significant in both models. By adding the dummy, the own-price elasticity has gone up and is estimated to be 0.68 in absolute value in model (1). This should be interpreted as follows: including the nudge makes the estimate more precise, since it removes noise from the random variable. In the model not (Table 8) accounting for the nudge, the nudge acts as a disruption in the experiment that is not being accounted for, and therefore obfuscated the magnitude of the estimate.

Thus, here the purchased amount decreased by 0.68% when there was a 1% increase in price. For model (2), the change in own-price elasticity the purchased amount decreased by 0.71% when price went up by 1%. The latter estimate is in the range of the estimates found for beef, poultry and pork (Andreyeva et al., 2010). The interpretation of the dummy coefficient is not the same here. Since the dummy is not continuous, it is not possible to differentiate Quantity (logged) with respect to the dummy (Giles, 2011). The method to estimate an almost-unbiased estimator of the percentage impact of the Nudge dummy variable on the Quantity is to use the formula suggested by Kennedy (1981), which is as follow:

If *Nudge* goes from 0 to 1, the % impact of *Nudge* on Quantity is:

$$100[Exp\left(c^* - \frac{1}{2}\, v^*(c^*)\right) - 1] \tag{4}$$

Where $v^*(c^*)$ = estimated variance of c^*, i.e. it is the square of the standard error for c^*.
When the *Nudge* goes from 1 to 0, or the Nudge is removed, the formula is:

$$100[Exp\left(-c^* - \frac{1}{2}\, v^*(c^*)\right) - 1] \tag{5}$$

By plugging in the coefficients obtained from the regression show in Table 8 in Equation 4 and 5, the approximate effect on sales is[8]:

- $100[Exp(-0.71472) - 1] = -51.1\%$
- $100[Exp(0.71472) - 1] = 90.9\%$

In this case, the effect is not symmetric, since removing the Nudge does not lead to the same effect. This interpretation was brought forward as an illustration, but as can be seen in Table 9, the Nudge did not have a statistically significant effect in Model 1 (β = -0.025, 95%CI -1.19; -0.167) nor Model 2 (β = -0.065, 95%CI -0.210; -0.080).

Lastly, the aim was to also investigate whether the nudge made participants more responsive to price changes. This is referred to as price-sensitivity effect (PSE), which is defined as the degree

[8] The same calculation holds for Model 2.

to which the nudge increased consumer's price-sensitivity. The identification of this effect is as follows: the price elasticity is estimated using Equation 6, then the price variable was interacted with the randomized Nudge treatment. The resulting coefficient on this interaction is the PSE. The demand regression takes the following form:

$$\ln Q_i = \beta_0 + \beta_1 \ln P_i + \beta_2 Nudge_i + \beta_3 (\ln P_i \; x \; Nudge_i) + e_i \quad (6)$$

TABLE 10. PRICE ELASTICITY OF DEMAND WITH NUDGE INTERACTION

VARIABLES	(1)	(2)
ln (Average Price)	-0.681***	-0.715***
	(0.262)	(0.238)
ln (Average price) x Nudge	-0.024	-0.062
	(0.077)	(0.070)
Observations	533	533
Sample	Full	Full
Adjusted R-squared	0.012	0.185

Note: Dependent variable is the natural log of the quantity of meat demanded. Average price was estimated based on the 44 meat products available in the virtual supermarket. For model (2) estimations are controlled for sex, age, household size, education, and income, although these are not reported. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

The PSE coefficient in column (1) and (2) is -0.024 and -0.062 suggests that there was no PSE in both models. Thus, no consistent evidence was found that the Nudge had a meaningful interaction with prices (economic incentive).

6 Conclusion and discussion

In this research I set out to explore the combined effects of price and nudge interventions on consumers' demand for meat and meat products. In order to do so, data from an experiment was used to make a direct comparison of the effects of a Tax, Nudge, and the combination of both on the purchase of meat in a virtual supermarket.

First, similar results were found as those included in the study by Vellinga et al. (2022). The combination of a price increase (Tax) and an information nudge decreased the amount of meat purchased relatively more in comparison to both these interventions independently. This result is line with what was expected and also with previous evidence which suggests that singular or informative interventions are less effective in achieving shifts in consumption in comparison to fiscal measures or mixed policies (Garnett et al., 2015; Latka et al., 2021). A stronger relative effect is observed for the combination strategy in the remaining hypotheses (H2 – H4) as well.

I then asked the question if individuals' meat attachment, price consciousness and their environmental consciousness would be of influence in the effect of the experimental conditions on the demand for meat. Although little empirical evidence was found to support the expectations formulated for hypotheses 2 through 4, it did provide several interesting insights which can have implications for the implementation of future (information) nudges.

For meat attachment, what stood out was that the experimental manipulation *Tax & Nudge* turned out to be infective in changing people's behavior when a model was estimated to capture the effect of being meat attached while also being treated. Nevertheless, no evidence was found that meat attachment was a moderator, which can interpreted as there being no difference on the effectiveness of both interventions whether the person was highly attached to meat or less so. For price consciousness, *Tax* did not significantly affect people's decision to purchase meat in the model created to capture having price consciousness while being treated[9]. Moreover, no evidence was found to support the notion that the effectiveness of the Nudge and Tax & Nudge differs when an individual has higher price consciousness than lower price consciousness. Lastly, I looked into the role of environmental consciousness. In the second model estimated, Tax turned out to be

[9] This means that taxing does not significantly affect people's decision to purchase if we take into account how conscious they are of prices.

effective[10]. Additionally, no evidence was found that there was a significant difference of the effectiveness of the Nudge and Tax & Nudge interventions whether the person was more environmental conscious or less so. The overall model seems to show that Tax & Nudge is the way to go for accounting for environmental consciousness since individual effects cannot be relied on to have a reliable effect on consumers.

These results seem to indicate a trend that consumers are more affected by their own preconceptions and preferences than by any individual effects, save perhaps price consciousness.

Additionally, the price elasticity of demand was estimated based on the sales information of the virtual supermarket experiment. The aim was to estimate the responsiveness of the consumers to the 30% price increase on meat and meat products, as this could provide a single estimate for the behavioral response to an environmental tax on meat consumption. For this research, the log-log specification of demand was used to estimate the own-price elasticity. The estimate equaled -0.60 for the model where covariates were included. Since previous studies suggest that the provision of information could nudge consumers into consuming food which are less polluting and increase price sensitivity, I set out to investigate whether this was the case in the experiment. By doing this, the own-price elasticity equaled -0.72 when covariates were included. Which gives an indication that the information nudge implemented during this study explained some of the variance. For both estimations the signs were negative which was in accordance with theory. These results indicate that meat is an inelastic good, which implies that if an environmental tax is to be introduced, meat consumption would somewhat decrease, but the increase in price is required to increase more than the desired proportional decrease in consumption. Moreover, I set out to explore the degree to which the nudge affected price sensitivity. Although there is (limited) evidence in the literature on how the provision of information could interact with price incentives, I found little empirical evidence to support that this interaction is meaningful.

[10] The significance of the variable does go below the 5% threshold, however it does so barely. One should be cautious in believing this result if it is right within the margin of tolerance.

In the following section, the interpretation and policy implications arising from these results are discussed, after which a discussion is provided on the limitations that were faced during this research.

6.1 Interpretation and policy implications

First, it is necessary to address the role of individuals preferences and preconceptions and how they might interfere with the implementation of nudges that aim to change consumer behavior towards decarbonization.

As was presented in the literature review of this thesis, there are countless of evidence of how nudges can be effective in shifting behavior towards more sustainable choices. Furthermore, nudges are rapidly becoming part of the policy maker's tool kit. We've seen a rise of "green nudges", which aim to influence people's behavior to reduce negative externalities (Carlsson et al., 2021). However, there is still a lack of knowledge which individuals are more prone to accept nudges than other. It has been suggested by previous research that more focus is required on individual traits in order to predict nudge effectiveness and acceptability (Van Gestel et al., 2021). This insight would benefit policy makers in knowing when and for whom nudges would be an acceptable tool to stimulate the desired behavior. To an extent, this research also aimed to gather more information on the individual factors and whether the reaction to the nudge depended on this, and hoped to inform policymakers to first target individuals if this was the case. For example, accounting for the treatment and individual meat attachment, made it clear that it rendered the combination strategy ineffective. Thus, it is recommended that future research or governments consider tailoring interventions by first targeting individuals first. A similar conclusion can be made for environmental consciousness. However, what stands out about previous recommendations and the one just provided, is the tendency to focus on the so called "i-Frame". The i-Frame focuses on individuals, and the neural and cognitive machinery that underpins their thoughts and behaviors (Chater & Loewenstein, 2022) . This is in contrast to "s-Frame", which is the system of rules, norms and institutions in which we live in (Chater & Loewenstein, 2022). The result of this thesis could help in designing evidence-based policy, as RCT is widely considered the gold-standard method for evaluation and improving policy. However, this recommendation does not take the s-Frame into

consideration. This has become an ongoing debate whether climate change mitigation depends on behavior change or the system (Grover, 2021)

The IPCC reported that behavioral change has the potential to reduce global emissions by 40-70% by 2050 (IPCC, 2022). It also stated that motivation to behavior change needs to be raised under the specific contexts of socio-economics, awareness, perceived risk, etcetera. In order for changes in lifestyle to happen, it must happen on all systematic level across all aspects of the society. Thus, it is important to separate the idea that pursuing behavior change should always mean appealing to individuals to changing their behavior. There are much more larger savings that can be made from demand-side solutions. This will require an increased focus on s-level policies, as this can help understand the origin of the problem and provide the best method to address it.

To conclude on this part, nudging strategies can still be effective in reducing meat consumption, but as was noticed it can become infective when individuals preconditions and preferences play a role. Thus, policy makers should consider targeting individuals first. However, there are also other opportunities to encourage and promote behavior change – it is crucial to also reshape the environments which shaped these behavior in the first place.

Next, the impact of an environmental tax will to a large extent depend on the relevant price elasticities. If the response of consumers to the introduction of an environmental tax are known *a priori*, policymakers could set the adequate environmental taxes to realize the given environmental target. Thus, the understanding of behavioral responses to environmental taxes are a necessary precondition to implement correct instruments of environmental policy.

As mentioned in the previous section, the estimated price elasticity of meat demand (accounting for the nudge implemented) of -0.72 indicated that meat is an inelastic good, e.g. if price would change by 1%, the demand would decrease by 0.72%. This implies that an environmental tax on meat and meat products can lead to a protein consumption shift, however the price should increase more than the desired proportional decrease in consumption. Thus taxing meat might be less affected by behavioral responses than goods which are elastic (Fullerton et al., 2010). This result can create a paradox among governments, because although environmental taxes are to internalize environment externalities, it can also be used to generate revenue. This revenue can be used in assisting fiscal consolidation or help in reducing other taxes. The paradox is that meat is a highly

polluting product with inelastic demand, which means that the introduction of the tax will generate relatively high revenue – which is in line with the optimal theory of indirect taxation (Vollebergh, 2012). Thus, using only pricing strategies (fiscal measure) based on the results obtained here, shows that the regulating effect on the internalization of environmental externalities will be limited. Consequently, policymakers should make use of other policy instruments.

First, since the amount of good consumers will purchase varies inversely with price, other factors being held constant (ceteris paribus), it is necessary for all other factors to change as well in order to change behavior towards a more sustainable diet. An important role here is the price of substitutes, especially those of plant-based foods. Plant-based foods present major opportunities for adaptation and mitigation (IPCC, 2019b) while also generating significant co-benefits in terms of keeping the world's growing population healthy. However, prices is still commonly mentioned as the main barrier to consume plant-based food among omnivores (Szejda & Parry, 2020). Yet, the gap between plant-based and conventional meat is shrinking in the Netherlands (Southey, 2022). This is because the price of plant-based alternatives has come down significantly and the price of meat has increased. Thus, depending on the cross-price elasticities, an environmental tax would be more effective in reducing meat demand when the meatless alternatives witness a price decrease, which is expected to happen in the next few years as a result of scaled up production and competition between supermarkets.

Besides the role of substitutes, the provision of information has been suggested to raise awareness of the negative environmental impact associated with meat production. This is exactly what was studied by Vellinga et al. (2022), where they witnessed that higher prices (fiscal measure) combined with an information nudge on the environmental impact of meat production and consumers role in that regards resulted in a decrease of -389 g meat per household per week in a virtual supermarket. In this thesis, similar results were also found.

However, to the best of my knowledge, previous studies did not go further in their analysis to see whether a nudge increased consumers' price sensitivity. Although in this thesis we found no evidence to support that this was the case, it is highly recommended that this additional analysis is incorporated into future studies as it can proof to be an effective tool to either diminish or increase the sensitivity towards prices to overcome problems which cannot be addressed by fiscal measures.

To conclude, according to this thesis, meat consumption is slightly inelastic, and a change in the price will lead to a decrease in consumption that is of a smaller proportion than the price change itself. The implementation of an environmental tax can lead to a decrease in the related greenhouse gas emissions, and the effectiveness can be strengthened when the role of substitutes is taken into consideration. Furthermore, as evidence from the study by Vellinga et al. (2022) and this thesis suggest, the provision of information could enforce the effect of a fiscal measure. However, information should go further the environmental impact of meat production and consumers' role. The provision of information should offer transparency and certainty in order to receive public acceptance and therefore increase the effectiveness of environmental taxation.

6.2 Limitations

The result of this analyses have several limitations. To start, for two out of the 3 measurements (Price and Environmental consciousness), moderately low alphas were observed, which indicates that the items selected might not be suited to measure of the construct they are meant to represent. This might have to do with the fact that the questionnaire was not designed in the first place to analyze these measurements. Only the results were obtained after the experiment was conducted, and based on this, a selection was made on possible indicators of interest. This procedure is not common practice, and could have played a role in the overall results. Furthermore, the decision to form groups to compare levels of attachment/consciousness may have caused that some information/variance were lost. Thus, arguments can be made to conduct this analysis with continuous variable instead. For optimal comparison, the decision was made to conduct an additional analysis, which is included in Appendix 9. Nevertheless, the results did not change. However, as already mentioned, future research should pay closer attention to the scales, as this might lead to improved results.

In regard to the estimation of the price elasticity, several points can be brought forward. First, the assumption in this research was that meat products is homogeneous. However, it can also be considered a heterogenous good. This means that meat products can be substitutes for each other, which will require different estimations for price elasticities. The study by Gallet (2010) provides a good example on how the elasticities differ per meat products, with beef having a higher price elasticity in comparison to poultry. Thus, if a meat tax is introduced on all meat, substitution among

the meat category itself is a possibility. Even worse, it could lead to more damaging impact and result in reallocation of spending in cheaper meat cuts, promoting even less sustainable consumption. In the design of an environmental tax, the substitution effect should be taken into consideration, which can be derived from estimates of cross-price elasticities of meat demand.

According to Mankiw (2009), demand tends to be more elastic in the long-run rather than in the short-run (estimates can differ substantially). This is because when prices change, consumer requires time to respond and change their shopping habit. In this thesis, the price elasticity estimations were considered short-term, and the results indicated that meat demand is inelastic. However, food consumption changes slowly after a price change (Wirsenius et al., 2011), which means that meat demand are consequently considered to be larger for the long-term. In order to appropriately determine the effects of taxes, it is important to use medium-to long-run price elasticities, since governments are unlikely to change taxes repeatedly over a short period of time (Nghiem et al., 2013).

Furthermore, disaggregating the meat product categories to product level may provide a more comprehensive understanding of price changes on demand. Besides this, there are many other factors, such as already discussed; substitutes, promotional activities, competition etcetera, that influence the price elasticity for demand for meat. Including all possible variables require more data points and thorough research at product-level, which is recommended for future research.

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Appendix

APPENDIX 1. PREVIOUS RESEARCH ON THE ELASTICITY OF DEMAND FOR MEAT

Author	Year	Country	Specification of demand	Elasticities of meat
Andreyev a, et al.	2010	United States	Meta-analysis	Beef: -0.75 Poultry: -0.68 Pork: -0.72
Boer, et al.	2006	Netherlands	Cobb-Douglas	-0.64
Burton, et al.	1999	United Kingdom	Dynamic AIDS Framework	Beef: -0.763 Poultry: -0.835 Pork: -1.104
Gallet	2010	West-Europe	Meta-analysis	-1.191
Mangen & burrel	2000	Netherlands	Switching AIDS Framework	Beef: -0.90 Pork: -1.41
Rickertsen	1995	Norway	Dynamic AIDS framework	Beef: -0.87 Poultry: -0.32 Pork: -1.52
Rickertsen, et al.	2003	Denmark; Norway; Sweden	AIDS Framework	-0.75; -0.67 -0.73
Säll & Gren	2015	Sweden	AIDS Framework	Beef: -0.394 Poultry: -0.409 Pork: -0.561
Wirensius, et al.	2011	EU27	Dynamic AIDS Framework	Beef: -1.30 Poultry: -1.00 Pork: -0.80
Zhao, et al.	2022	United States	AIDS Framework	Beef: -0.943 Poultry: -0.920 Pork: -0.927

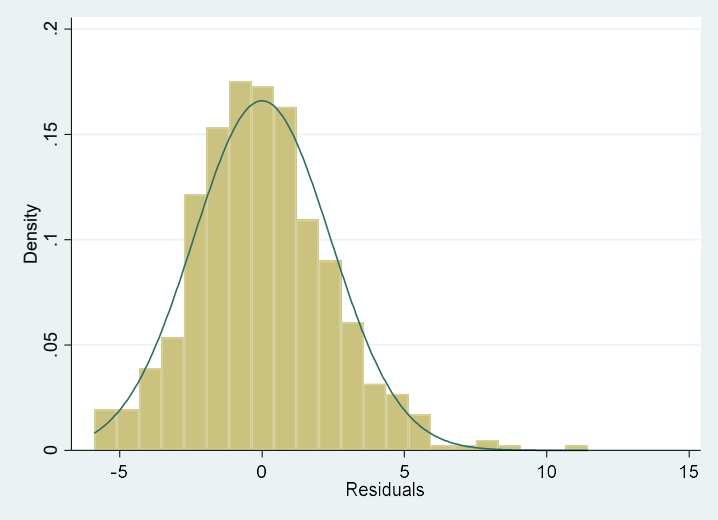
APPENDIX 2. LIST OF MEAT PRODUCTS (WITH OLD AND NEW PRICE)

Product id	Product name	Old price	New price
P1	Back of ham (slices)	€ 3.59	€ 4.67
P2	Steak (fresh)	€ 5.14	€ 6.68
P3	Farmers sausage	€ 3.49	€ 4.54
P4	Buttermilk Wurst (sliced)	€ 1.99	€ 2.59
P5	Bratwurst	€ 2.49	€ 3.24
P6	Carpaccio	€ 2.69	€ 3.50
P7	Cervelles (slices)	€ 2.01	€ 2.61
P8	Chicken wings (frozen)	€ 2.55	€ 3.32
P9	Chorizo	€ 2.53	€ 3.29
P10	American fillet	€ 2.49	€ 3.24
P11	Frikadells (frozen)	€ 1.48	€ 1.92

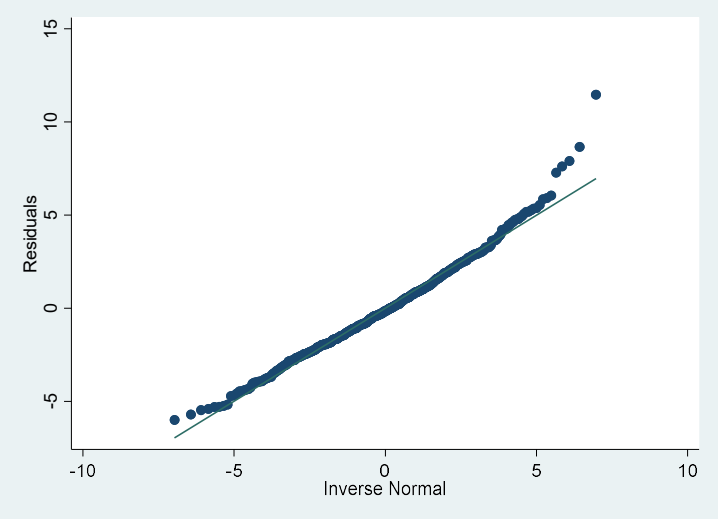
P12	Frikandellen (frozen)	€ 3.59	€ 4.66
P13	Roast chicken breast (slices)	€ 2.80	€ 3.64
P14	Roast beef	€ 3.12	€ 4.06
P15	Gelderland cooked sausage	€ 2.09	€ 2.72
P16	Smoked sausage	€ 2.04	€ 2.65
P17	Gouda salami (slices)	€ 2.49	€ 3.24
P18	Half and half minced meat	€ 1.99	€ 2.59
P19	Hamburger (fresh)	€ 2.99	€ 3.89
P20	Hamburgers (frozen)	€ 2.52	€ 3.28
P21	Deer steak	€ 9.25	€ 12.03
P22	Turkey breast	€ 3.25	€ 4.23
P23	Chicken drumsticks	€ 2.45	€ 3.19
P24	Chicken burger	€ 1.73	€ 2.25
P25	Chicken breast	€ 3.25	€ 4.23
P26	Knackered sausage (tin)	€ 1.62	€ 2.11
P27	Lamb cutlet	€ 7.42	€ 9.65
P28	Canned liver pate	€ 1.29	€ 1.68
P29	Liver sausage	€ 2.83	€ 3.68
P30	Low fat smoked sausage	€ 2.00	€ 2.61
P31	Lean bacon strips	€ 2.69	€ 3.50
P32	Smoked bacon	€ 2.89	€ 3.76
P33	Ox sausage	€ 2.60	€ 3.38
P34	Roompate	€ 2.24	€ 2.91
P35	Minced beef (fresh)	€ 2.29	€ 2.98
P36	Beef tartar (fresh)	€ 2.19	€ 2.85
P37	Salami (sausage)	€ 1.51	€ 1.96
P38	Shoulder ham (sliced)	€ 2.29	€ 2.98
P39	Shoulder chops (pork)	€ 2.78	€ 3.61
P40	Smac (tin)	€ 2.29	€ 2.98
P41	Sliced sausage	€ 2.01	€ 2.61
P42	Spareribs (frozen)	€ 5.79	€ 7.53
P43	Unox Hamburgers	€ 2.39	€ 3.11
P44	Pork fillet steaks	€ 3.04	€ 3.95

Note: new price was an experimentally induced tax of 30%

APPENDIX 3. HISTOGRAM FOR DISTRIBUTION OF QUANTITY OF MEAT DEMANDED



APPENDIX 4. Q-Q PLOTS



APPENDIX 5. CRONBACH'S ALPHA STATISTICS TO TEST RELIABILITY

MEAT ATTACHMENT

Test scale =	Mean (unstandardized items)
Reversed items:	ARG1 ARG2 ARG3
Average interitem covariance:	0.8427424
Number of items in the scale:	3
Scale reliability coefficient:	0.7749

PRICE CONSCIOUSNESS

Test scale =	Mean (unstandardized items)
Reversed items:	VIRT4 VIRT5 MEAT4 KEUZE3
Average interitem covariance:	0.6662364
Number of items in the scale:	4
Scale reliability coefficient:	0.6530

ENVIRONMENTAL CONSCIOUSNESS

Test scale =	Mean (unstandardized items)
Reversed items:	KEUZE5 MEAT1 MEAT2
Average interitem covariance:	0.3185414
Number of items in the scale:	3
Scale reliability coefficient:	0.5692

APPENDIX 6. SUMMARY STATISTICS FOR EXPLANATORY VARIABLES

Variable	Obs.	Mean	Std. Dev.	Min	Max
Meat attachment	533	8.113	3.129	3	19
Price consciousness	533	13.118	1.621	4	21
Environmental cons.	533	7.805	2.244	3	15

APPENDIX 7. RCT EFFECTS FULL REGRESSION OUTPUT

VARIABLES	(1)
Experimental manipulation	
Tax	-0.442
	(0.289)
Nudge	-0.263
	(0.292)
Tax & Nudge	-1.088***
	(0.298)
Covariates	
Age	0.010
	(0.007)
Sex (base: Male)	
Female	0.138
	(0.218)
Male	-0.605
	(1.736)
Household size	0.853***
	(0.098)
BMI	0.069***
	(0.019)
Education (base: Low)	
Moderate	0.419
	(0.326)
High	-0.199
	(0.321)
Income (base: Low)	
Moderate	1.127***
	(0.300)
High	1.176***
	(0.285)
Constant	-1.021
	(0.787)
Observations	533
Adjusted R-squared	0.243

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

APPENDIX 8. FULL REGRESSION OUTPUT FOR HYPOTHESIS 2, 3 AND 4

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Experimental manipulation						
Tax	-0.648**	-0.675**	-0.572**	-0.544*	-0.550*	-0.553*
	(0.282)	(0.282)	(0.289)	(0.290)	(0.282)	(0.282)
Nudge	-0.503*	0.198	-0.309	-0.190	-0.232	-0.174
	(0.286)	(0.563)	(0.292)	(0.405)	(0.285)	(0.374)
Tax & Nudge	-1.133***	-0.689	-1.169***	-0.688*	-1.096***	-1.376***
	(0.290)	(0.456)	(0.298)	(0.405)	(0.291)	(0.387)
Measurements						
Meat attachment	1.401***	1.755***				
	(0.236)	(0.317)				
Price consciousness			-0.593***	-0.332		
			(0.214)	(0.289)		
Environmental consciousness					-1.189***	-1.294***
					(0.210)	(0.288)
Interactions						
Nudge x Meat attachment		-0.679				
		(0.545)				
Tax & Nudge x Meat attachment		-0.931				
		(0.625)				
Nudge x Price consciousness				-0.219		
				(0.522)		
Tax & Nudge x Price consciousness				-0.918*		
				(0.525)		
Nudge x Environmental consciousness						-0.109
						(0.507)
Tax & Nudge x Environmental cons.						0.559
						(0.514)
Covariates						
Age	0.010	0.010	0.008	0.008	0.010	0.010
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Sex (base: Male)						
Female	0.321	0.363*	0.116	0.115	0.069	0.068
	(0.216)	(0.217)	(0.218)	(0.218)	(0.213)	(0.213)
Other	0.457	0.414	-0.716	-0.639	-0.693	-0.658
	(1.701)	(1.708)	(1.732)	(1.735)	(1.693)	(1.699)
Household size	1.992***	1.997***	2.012***	2.037***	1.874***	1.871***
	(0.227)	(0.227)	(0.233)	(0.234)	(0.229)	(0.229)
BMI	0.062***	0.063***	0.074***	0.072***	0.057***	0.055***

	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Education (base: Low)						
Moderate	0.315	0.311	0.433	0.428	0.392	0.379
	(0.318)	(0.319)	(0.326)	(0.326)	(0.318)	(0.319)
High	-0.022	-0.006	-0.098	-0.111	-0.034	-0.031
	(0.313)	(0.315)	(0.321)	(0.321)	(0.314)	(0.314)
Income (base: Low)						
Moderate	0.851***	0.884***	1.056***	1.044***	0.900***	0.904***
	(0.296)	(0.297)	(0.306)	(0.306)	(0.297)	(0.297)
High	0.888***	0.958***	1.088***	1.085***	0.882***	0.885***
	(0.287)	(0.290)	(0.296)	(0.296)	(0.288)	(0.289)
Constant	-1.047	-1.400*	-0.063	-0.181	0.726	0.806
	(0.759)	(0.786)	(0.761)	(0.770)	(0.758)	(0.768)
Observations	533	533	533	533	533	533
Adjusted R-squared	0.285	0.286	0.247	0.249	0.280	0.280

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

APPENDIX 9. FULL REGRESSION OUTPUT FOR SUPPLEMENTARY ANALYSIS OF HYPOTHESIS 2, 3 AND 4

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	H2	H2	H3	H3	H4	H4
Experimental manipulations						
Tax	-0.588**	-0.601**	-0.534*	-0.520*	-0.486*	-0.483*
	(0.274)	(0.274)	(0.289)	(0.290)	(0.276)	(0.277)
Nudge	-0.443	-0.469*	-0.255	-0.250	-0.247	-0.245
	(0.278)	(0.279)	(0.293)	(0.295)	(0.280)	(0.280)
Tax & Nudge	-1.150***	-1.202***	-1.157***	-1.168***	-1.064***	-1.073***
	(0.284)	(0.284)	(0.299)	(0.299)	(0.286)	(0.287)
Measurements						
Meat attachment	-0.264***	-0.311***				
	(0.033)	(0.044)				
Price consciousness			0.067*	0.034		
			(0.034)	(0.047)		
Environmental consciousness					0.337***	0.358***
					(0.046)	(0.062)
Interactions						
Nudge x Meat attachment		0.017				
		(0.089)				
Tax & Nudge x Meat attachment		0.165*				

		(0.075)				
Nudge x Price consciousness				0.045		
				(0.079)		
Tax & Nudge & Price consciousness				0.094		
				(0.086)		
Nudge x Environmental consciousness						-0.020
						(0.109)
Tax & Nudge x Environmental cons.						-0.078
						(0.116)
Covariates						
Age	0.007	0.007	0.008	0.008	0.013*	0.013*
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Sex (base: Male)						
Female	0.384*	0.382*	0.119	0.123	0.074	0.077
	(0.211)	(0.210)	(0.220)	(0.220)	(0.209)	(0.209)
Other	-0.201	-0.100	-0.725	-0.671	-0.369	-0.372
	(1.650)	(1.646)	(1.738)	(1.741)	(1.662)	(1.669)
Household size	1.967***	1.997***	2.002***	2.017***	1.862***	1.872***
	(0.222)	(0.222)	(0.234)	(0.235)	(0.224)	(0.225)
BMI	0.047**	0.045**	0.074***	0.073***	0.050***	0.049***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Education (base: Low)						
Moderate	0.439	0.410	0.436	0.436	0.402	0.392
	(0.310)	(0.309)	(0.328)	(0.328)	(0.312)	(0.313)
High	0.077	0.042	-0.102	-0.103	-0.002	-0.004
	(0.307)	(0.306)	(0.323)	(0.323)	(0.308)	(0.309)
Income (base: Low)						
Moderate	0.698**	0.704**	1.040***	1.039***	0.885***	0.887***
	(0.291)	(0.290)	(0.308)	(0.308)	(0.291)	(0.292)
High	0.775***	0.805***	1.063***	1.068***	0.882***	0.881***
	(0.281)	(0.282)	(0.297)	(0.298)	(0.282)	(0.283)
Constant	0.457	0.505	-0.395	-0.373	0.181	0.181
	(0.727)	(0.726)	(0.779)	(0.782)	(0.731)	(0.732)
Observations	533	533	533	533	533	533
Adjusted R-squared	0.318	0.322	0.242	0.240	0.308	0.306

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

Additional estimations with explanatory variables expresses as continuous variables

Additional estimations were conducted in order to assess the effect of the variables *Meat attachment*, *Price consciousness* and *Environmental consciousness* when they are considered as

continuous variables. Similar to the analysis included in Chapter 5, a linear regression was conducted. This included the quantity of meat demanded as the dependent variable, the experimental conditions as independent variables (as dummies), and age, household size, sex, BMI, education and income as covariates.

Furthermore, unlike the analysis conducted before, here the continuous variables are centered at the mean. This is the act of subtracting a variable's mean from all observations on that variable in the dataset such that the variable's new mean is zero (Iacobucci et al., 2016). This helps with reducing multicollinearity risk in a regression model and also allows for reporting on the significance and contributions of the variables. In the results presented in the table above, two models are presented for each hypothesis. The first model is without the interaction term, and the second model incorporates this.

This analysis studied the general effect of the 3 measurements, however no significant difference was found between this analysis and the one included in Chapter 5.