Drivers of Consumers’ Willingness to Pay for Green Electricity and Remarks on Information Policies

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This thesis studies the consumers’ willingness to pay for renewable electricity. Green electricity consumption induced by improved information on electricity sources appears as an additional alternative to renewable energy support policies in practice today. It is believed that a shift of the demand towards green sources can stimulate renewable generation and have a positive impact on the environment. However, this voluntary initiative will only work if it is perceived worth paying a premium for green electricity. This work aims to examine the drivers of consumers’ behaviour towards green electricity and to develop economic models that embrace these findings. The analysis also elucidates how the demand for renewable electricity is affected by market prices and by consumers’ income and how information and advertising campaigns can stimulate the behaviour towards green electricity so that the voluntary demand system can fully achieve its goals.
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### List of Variables

- $c$: Conventional electricity;
- $g$: Green, renewable electricity;
- $p_g$: Price of green electricity;
- $p_c$: Price of carbon based electricity;
- $\pi$: Price premium;
- $m$: Consumer’s income;
- $w$: Full income;
- $Y$: Public good, environmental quality that arises from consuming electricity from renewable sources;
- $y$: Individual contribution to the public good;
- $\bar{Y}$: Exogenous level of public good;
- $X$: Physical electricity, private good;
- $S$: Self-image;
- $d$: Share of the population that chooses the green alternative over the conventional one;
- $\dot{d}$: Velocity of change of the strategy;
- $n$: Number of individuals in the society, $n = 1, \ldots, N$;
- $h$: Net private cost of the green electricity ($\pi - y$);
- $t$: Time.
List of Abbreviations

AIB: The Association of Issuing Bodies is the leading enabler of international energy certificates systems. It aims to provide the infrastructure and information to support electricity source disclosure in all Europe (AIB, 2014d).

EU: European Union. It is an economic and political partnership between 28 European States (EUROPA, n.d.).

FiT: Feed-in Tariffs aim to create an incentive to the generation of renewable energy, through subsiding it. In most common cases, authorities set a predefined tariff for the energy and producers are secure to sell their renewable energy at a stable price (Menanteau et al., 2003). FiTs are the most widely support policies in use today in Europe, present in 24 member states (REN21, 2013).

GHG: Greenhouse Gases. According to the Kyoto Protocol, Greenhouse gases are six different gases (carbon dioxide, methane, nitrous oxide, hydro fluorocarbons, per-fluorocarbons and sulphur hexafluoride) that trap long-wave infrared radiation in the atmosphere and consequently warm up the earth. Although this is a natural phenomenon, excessive concentration of these gases in the atmosphere due to human activities becomes a severe environmental problem (Hanley et al., 2007).

GO: Guarantees of Origin are an online document that proves that 1 MWh (megawatt hour) of electricity was generated from renewable sources. The document specifies not only the source, but also the dates when the electricity was produced; the identity, location, type and capacity of the production facility; whether the GO relates to electricity or heating or cooling; whether and to what extent the installation has benefited from support; the date when the installation became operational; the date and country of issue; and has a unique identification number (AIB, 2014c). GOs and are the main tracking mechanism used in Europe (AIB, 2014b).

IEA: The International Energy Agency is an autonomous organization that works to ensure reliable, affordable and clean energy. The agency’s work focus on energy security, economic development, environmental awareness and engagement worldwide (IEA, 2014)
PEB: Pro-Environmental Behaviour refers to a way of conduct that consciously seeks to minimize the negative impacts of one’s actions to the environment (Kollumuss & Agyeman, 2010). Examples of pro-environmental behaviours are recycling, reduced consumption of energy, consumption of dolphin-safe tuna (Teisl et al., 2002) and organic products (Moon et al., 2002 in Nyborg et al., 2006), etc.

RES: Renewable Energy Sources refer to energy derived from natural processes that are restocked at a faster rate than they are consumed. Solar, wind, geothermal, hydro, and some forms of biomass are common sources of renewable energy (IEA. 2013b).

VBN: The Value-Belief-Norm theory refers to a model of behaviour that assumes that pro-environmental behaviour is caused by a combination of “egoistic” orientation, social orientation and biospheric orientation. This model was developed by Stern et al. in the work entitled Value orientations, gender, and environmental concern (1993).

WTP: Willingness to Pay represents a general measure of economic value (Hanley et al., 2007). In this thesis, it refers to measure of value for environmental and private benefits. Proper understanding and estimation of willingness to pay is important so it can be included in environmental policy decisions.
1. Introduction

There is no doubt that the negative effects of power generation to the environment and to the society have been a topic of interest in today's economic debate. Environmental economists have widely covered this topic and discussed the problem of externalities of energy production and the possible policies to internalize them, i.e. policies that support the generation of energy from renewable energy sources (RES) and policies that penalize the greenhouse gas (GHG) emissions (European Commission, 2013). It wasn't until recently that end consumers also gained some importance in this debate: with the liberalization of power markets in Europe and the possibility to track energy sources from production to consumption, environmental responsibilities are closer to consumers. Green electricity consumption induced by improved information on electricity sources appears as an additional option to target externalities. It is believed that a shift in electricity demand towards green sources can stimulate renewable generation and have a positive impact on the environment. However, in spite of a high prospective, the evidence shows that the share of adopters of green electricity remains low.

Understanding consumer behaviour is key to success of demand-sided programs. Consumers are in the centre of this approach, and only if they are willing to pay a premium for green electricity, the goal of this voluntary initiative can be fully achieved. Proposing to study the role of consumers as drivers of a green energy economy, renowned scholars and organizations have paid considerable attention to consumers’ behaviour and what leads them to select green electricity over the conventional one. Behavioural economics sheds light on this direction and highlights that pro-environmental actions depend not only on economic factors but also, and in a greater extent, on psychological ones. As it will be seen below, empirical studies show that consumers are ready to pay a premium for green electricity and that price is no longer the main element to influence their decisions (see Aasen et al., 2010; Winther & Ericson, 2013; Roe et al., 2001; Timpe & Seabach, 2009; etc.). Instead, the studies find out that the willingness to pay is dependent on consumers’ beliefs on environmental impacts of the green electricity product, on the individuals’ self-image and on
availability and credibility of the information displayed; these seem to be the main drivers of consumers’ decisions.

At the same time, not much has been done to construct economic models that correspond to these findings. The traditional approach of the “Consumer Problem” is weak to explain this new reality. Despite its great importance, models must embrace the fact that consumers base their decisions not only on goods’ prices and that they are ready to contribute to the provision of a clean environment.

The objectives of this thesis are different. It is set out to accomplish the following: (1) identify and understand the main drivers of consumers’ willingness to pay for green electricity; (2) build economic models that embrace these factors; (3) based on the models, comprehend how the demand for green electricity is affected by external parameters; and finally (4) discuss how policies might affect the behaviour towards green electricity.

In order to understand how consumers can have a voice in the environmental scenery, the discussion starts explaining what is known as demand-based program. It will be shown that this voluntary approach empowers consumers to be the driving factor behind a green economy and perhaps ease the burden of environmental policies ruling today.

Then, the work focuses on understanding what determines a pro-environmental behaviour and the willingness to pay (WTP) for green electricity. The main determinants of such behaviour will be studied based on behavioural economic theory. The behavioural theory is wide and embraces different types of pro-environmental behaviours, from recycling to consumption of dolphin-safe tuna. To focus on green electricity consumption alone, the thesis provides a review of the empirical literature available on the topic, exposing the main variables to affect consumers’ decision in this specific behaviour. The findings allow the thesis to build its own understanding of how green electricity behaviour is constructed and how the different drivers of consumers’ WTP interact.

The subsequent section concentrates in developing economic models that take into consideration the drivers of WTP exposed and add them into the “Consumer Problem”. The work will discuss how the theoretical economic literature has been modified to give space to this new reality where consumer is ready to take an environmental action. Different economic models will be constructed, showing that when other factors that influence consumers’ decisions are added to the utility function,
the gap between theory and reality seems to get smaller. Using the models, the thesis then turns to comparative statics and studies how exogenous parameters, as income and prices, affect the demand for green electricity.

The work closes with a discussion on how to promote behaviour change and increase the demand for green electricity through information and advertising campaigns. Finally, the conclusions and the remarks for future research are presented.

2. Targeting at Power Generation’s Externalities and Bringing Environmental Responsibilities Closer to Consumers

According to the International Energy Agency (IEA), the power sector is the largest responsible for carbon dioxide (CO₂) emissions released to the atmosphere (38% of total energy-related emissions) (IEA, 2013a). Carbon dioxide, together with other greenhouse gases (GHG), is causing an unprecedented stress on the environment and a significant cost for the society. Decrease in life expectation, increase respiratory diseases and intensification of global warming are some of the negative effects often related to power production from non-renewable sources (Hanley et al., 2007).

In this context, power generation from renewable sources (RES) gains strength and the European Union’s target for 2020 is to achieve 20% of energy generated by renewable sources (European Commission, 2013). As highlighted by the IEA, benefits of renewable energy generation include improvement on energy security and on access to energy services; decrease of dependence on energy-exporting countries; environmental protection; climate-change mitigation; provision of employment; and consolidation of the competitive edge of countries’ domestic industry (Philibert, 2011, IEA publication).

When these costs or benefits are not fully accounted by the producer, they are known as externalities, a famous type of market failure. Market failure is a key concept in economics. It does not only simply refer to bad market outcomes, but to a situation where the market, if left alone, does not allocate the scarce resources in the most efficient way (Hanley et al., 2007). Menanteau et al. (2003) explain that, clean air and climate

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1 According to the IEA, renewable energy refers to energy derived from natural processes that are restocked at a faster rate than they are consumed. Namely, solar, wind, geothermal, hydro, and some forms of biomass are common sources of renewable energy (IEA, 2013b).
sustainability are public goods, and, because of their non-excludable and non-rivalrous aspects, the private market cannot be let alone to assure the socially optimum. It seems that actors are not ready to roll their sleeves and invest on renewables while the benefits can be acquired by everyone. Instead, to achieve the socially optimum equilibrium there is a need for incentives.

Aiming to internalize these externalities, the European community has taken substantial actions to penalize carbon emissions and offer support to renewable energy. Policies focussed at renewable energy generation are not a new mechanism. Faber et al. (2000) show that concerns over green electricity generation in Europe date back to the early 1980s when it was already possible to find incentives for wind turbines in Germany and Denmark. Over the years, support programs became more popular in various European countries and a wide range of policies to increase the dissemination of renewable sources has been put into practice. Feed-in tariffs (FiT), for example, are the most widely support policies in use today in Europe, present in 24 member states (REN21, 2013). It aims to create an incentive to the generation of renewable energy, through subsiding it. In simple words, authorities set a predefined tariff for the energy, and producers are secure to sell their renewable energy at a stable price (Menanteau et al., 2003). The establishment of quotas for renewable energy generation or consumption is another mechanism that is gaining space today. In this case, market actors receive their own share of the quota and have an obligation to buy energy certificates (green certificates)\(^2\) equal to their ratio or pay a penalty fee (Menanteau et al., 2003).\(^3\)

Such policies have been for long appraised by scholars and renewable energy production has increased substantially in recently years (Philibert, 2011, IEA publication). However, in times of economic downturn critics raise against support policies. Some authors argue that, while certificate systems are more sustainable in the long term, they might scare investors once there is a price volatility risk. At the same time, critics of FiT often stress that, while it reduce investors’ uncertainty, it offers too generous subsidies to producers posing a high cost for the society (Menanteau et al., 2003). The safety that feed-in tariffs might bring to investors is also questionable since at a time of economic downfall, some countries, e.g. Italy, Portugal and Spain, had to abandon subsides to renewables, leaving investors empty handed (Roca, 2013).

\(^2\) Green certificates are also commonly known as Renewable Energy Certificates, Elcertificates, or Renewable Obligation Certificates. (Grexl, 2014)

\(^3\) It is not the intent of this thesis to explain in details support or penalty policies. Instead, it gives a brief look into them so later the reader can better understand the demand-sided programs.
Germany, a long-time supporter and leader of feed-in tariffs implementation in Europe, is facing continuously increasing prices of electricity bills. According to Spiegel magazine’s article, Germany's Energy Poverty: How Electricity Became a Luxury Good, German consumers are loaded with taxes which are used to support a reckless expansion of wind and solar power energy in the country; and the government is considering shifting the policies towards a system of quotas with tradable green certificates (Dohmen et al., 2013).

While policy makers focus on the generation side of the production chain and intent to support the generation of renewable energy, a newer mechanism that proposes to stimulate the demand side is also gaining space among European states. Differently than the support policies mentioned, the demand-based program is a newer approach that aims to target externalities by focussing at the consumption side of the energy production chain and it appears as a viable option to the heavy support policies in practice today. Such initiative is central in the present discussion and will be explained next.

2.1. Demand-Based Program and Electricity Disclosure

While FiT and renewable quotas focus on the generation side of the production chain, the demand-based program, also known as voluntary approach, bases itself on the consumers’ willingness to pay for renewable energy and aims to stimulate the consumption side. This mechanism suggests that environmental problems can be alleviated through “buying green” that is, if a sufficient number of consumers is willing to pay a premium to have their electricity generated from renewable sources, they can themselves induce renewable energy generation and perhaps reduce the burden of the support policies mentioned before (Brennan, 2006).

This voluntary approach only became a real option with the liberalization of power markets and disclosure legislation. The liberalization of the electricity market forced suppliers into competition and to look for a way differentiate their products in order to attract customers who, in turn, can freely migrate from one electricity supplier to another. At the same time, the EU Directive 2009/72/EC mandates that electricity suppliers within the EU disclose to their customers information about how their electricity has been generated and also details on their electricity’s environmental
impact as CO$_2$ emissions and radioactive waste (Boardman & Palmer, 2007, RECS International, 2013 and Aasen et al., 2010). As Aasen et al. (2010) emphasize, the disclosure scheme intents to “increase market transparency”, to “comply with the consumers right to information regarding purchased products”, to “enable consumers to make informed choices” and finally to “educate consumers and stimulate electricity generation that contributes to a secure and sustainable electricity system” (Aasen et al., 2010 p. 7921).

Furthermore, EU mandates that the electricity disclosure is done by the means of Guarantees of Origin (GOs) certificates, an online document that proves that 1 MWh is produced during a specific time period from a certain production unit, from renewable non-fossil sources such as wind, solar, hydropower, biomass, etc. (EU Renewable Energy Directive 2009/28/EC.). The physical electricity that arrives at the end-consumer is a mix of several electricity sources but GOs facilitate electricity tracking by de-linking the physical electricity from its attributes. And when a certain amount of MWh from a given source is consumed, the necessary volume of GOs certificates are cancelled/used proving the source of the electricity sold to consumers.

The birth of a system of electricity de-linked tracking by the use of Guarantees of Origin made it possible to define an electricity product, i.e., to separate the consumed electricity by its sources (renewable, fossil, nuclear) and present the consumer with a choice. Thus, a GO is no different from a label in a bottle that informs about generation attributes of the consumed electricity$^4$.

Winther and Ericson (2013) explain that the fundamental presumption of this “labelling regime” by the use of Guarantees of Origin certificates is that environmentally aware consumers are able to choose their electricity based on factors other than price. Now, their decision also reflects their environmental values (Boardman and Palmer, 2007; as cited in Winther & Ericson, 2013). In Winther’s and Ericson’s words, “the combination of an open electricity market, the disclosure information and environmentally conscious consumers are expected to produce a shift over time towards less polluting electricity sources” (Winther & Ericson, 2013, p. 369).

$^4$ However, GOs shouldn’t be mistaken by electricity labels as EkoEnergy, or TÜV SÜD Generation EE. Those labels go further than GOs and require that the electricity generation comply with other pre-requisites as, for example, additionality in case of EkoEnergy. Besides that, these are private efforts while GOs are required by EU regulation. Nevertheless, the private labels can benefit from the GO system once it already certifies the source of electricity (AIB, 2014a).
Not only the GOs enables the creation of an electricity product but also the renewable energy producer can have a small income from selling his certificates to the market. Although the sole purpose of Guarantees of Origin is to inform consumers, it can’t be ignored that they consequently also generate an extra source of revenue to investors. In Raadal’s paper “The potential role of GO (Guarantees of Origin) in creating a consumer-based demand for renewable energy” (2010), the author explains:

“When a GO is sold, the producer gets an extra income of approx. 2 – 5 percent of the power price. The extra income increases the general profitability of renewable energy and might influence on decisions to invest in new renewable production capacity. The GO system uses the market mechanisms to put a value on the environmental performance of different energy sources. It is natural to assume that increased profitability increases the willingness to increase investment in new renewable energy production.” (Raadal, 2010, p. 6)

It also should be noted that, not giving space for the consumer to be part of the decision process does not fit the modern reality. Menges (2003) says that it is surprising that normally “consumer sovereignty” and household’s preferences are seen as opponents to policy. Illogically, policy most often gives little space for private decision towards green electricity, as it would be counter-productive from political point of view. The author clarifies that “due to the liberalization process, green electricity is not solely an object of political support but it becomes an object of private market participants’ decisions too” (Menges, 2003, p. 584).

Today a number of European countries have realized that is important to give to the consumer the power of choice and the instruments to possibly influence the energy panorama. GOs are the main mechanism in practice for electricity tracking in Europe; currently 18 countries have implemented the system according to the directive and others are in the process of doing so (AIB, 2014b). Hence, the electricity market is under great ongoing modifications. The emergence of the tracking mechanism by use of GOs means that the consumers can make a more informed decision about their supplier and their source of electricity. It is believed that in this new scenery, consumers can provoke a shift of the electricity supply towards green energy and green preferences
can, thus positively affect renewable energy production. In this sense, demand-based policies can be seen as a powerful alternative to costly generation based options.

Obviously, the consumers are in the centre of this voluntary approach. It is their willingness to pay that will determine how the supply can be affected. Such system will only work if it is perceived worth paying a premium for electricity generated from green sources. However, it is a well accepted truth in economics, and already mentioned before in this thesis, that actors are not ready to roll their sleeves and invest on renewables while the benefits can be acquired by everyone. Individuals have a great incentive to “free ride”, i.e., consumers might have no motivation to purchase a green product with a higher price once they can get a “free ride” on the clean air provided by others (Wiser, 1998). The next question that this thesis will focus on is, therefore, what are the main drivers of consumers’ willingness to pay for green electricity? What makes consumers take such altruistic action?

3. Pro-Environmental Behaviour and Consumers’ perception of green electricity

One may doubt that consumers are willing to pay a premium for renewable energy sources. The traditional way that Economics looks at the consumer behaviour would easily lead to such preliminary conclusions. The standard economic approach sees the consumer decision problem as a simple rationalization of cost versus benefit. In this simplistic ‘homo economicum’ framework, only four elements seem to matter: the consumer’s income, the market prices, the individual’s preferences and the quest to maximize his utility (Darnton, 2008 and Clark et al.2003). This outline abstracts from human behaviour other cultural dimensions such as moral, ethical, religious, political, etc. and beliefs that the consumer seeks only to attain his consumption goals with the least possible cost. In such formalization, there is no space for altruistic actions and provision of a public benefit from purchasing green electricity.

However, it is not difficult to find evidence that proves this framework wrong. Despite its powerful insights, recent studies reveal that the consumers demonstrate, what would be considered by standard economics, an irrational behaviour. Examples are
plenty: individuals are concerned over elephant ivory and this might influence their consumption patterns (Heltberg, 2001 in Nyborg et al., 2006); they show positive attitude towards dolphin-safe tuna (Teisl et al., 2002) and organic products (Moon et al., 2002 in Nyborg et al., 2006); they look for socially responsible investments (Cullis et al., 1992 in Nyborg et al., 2006) and, finally, consumers also demonstrate concerns over their electricity consumption and its impact to the environment.

Intrigued by what determines such behaviours, the economic theory has reached towards other disciplines such as psychology to construct a complete understanding of the consumer’s decision-making process. Behaviour Economics is the field of economics that provides this bridge. Models of behaviour were built on many principles of the “older” theory but also provided newer insights and allowed economists to understand the greater complexity that involves choice.

Behavioural models are numerous and cover a wide range of fields. This chapter will present charters of behaviour that are used to explain a pro-environmental behaviour and that, in this thesis’s opinion, fit best the case of green electricity. These models will serve as base to identify and understand different factors that affect consumer decision towards green electricity.

Two of the most coherent and accepted approaches to explain a pro-environmental behaviour are Schwartz’s (1977) Norm Activation theory and the Value–Belief-Norms model developed by Stern et al. (1993).

Schwartz’s Norm Activation theory focuses on norms as one of the factors to influence behaviour. For him, the activation of personal norms explains the possibility of an altruistic or “helping” behaviour (Darnton, 2008 and Turaga et al., 2010). The individual studied by Schwartz is aware of his actions consequences to others and feels a personal responsibility to help (Turaga et al., 2010). Thus, the interaction of awareness of consequences (AC) to others and ascription of responsibility (AR) to himself launches the individual’s personal norms and leads to his pro-environmental behaviour (PEB) as sketched in the figure that follows.
The first step in this structure is the awareness that there is a circumstance of need in the society and that certain pro-environmental actions could help to mitigate such need. This is the activation step and it is completed once the individual trust that he can take such actions. Next, the individual ascribes a level of responsibility to himself and this process creates personal feelings of obligation triggering what Schwartz called personal norms (Turaga et al., 2010). According to this framework, the individuals focus beyond themselves and care for society as a whole, presenting a strong pure altruistic motivation.

Kollumuss & Agyeman (2010) note, however, that such caring conduct can only in fact happen if the individual also shows a need for self-esteem, belonging, personal control or self-efficacy. This means that the pure altruistic motivation is not enough. For Menges (2003), the consumer’s willingness to pay for green goods is more likely driven by impure altruism than pure altruism. Berkke et al. (2003) also affirm that, “assuming that people truly care about each other’s welfare is not enough to explain the large contributions to public goods that can be observed” (Berkke et al., 2003, p.1968). Schwartz himself recognizes that personal norms are built in specific situations and actually reflect expectations that the actors hold for themselves. This means that the individual is not only focussing on the good that he can promote to the whole society, but also gain some positive private utility from his actions (Turaga et al., 2010).

Following this lead, Stern et al. (1993) argue that in additional to Schwartz altruism conduct there are norms based on self-interest (“egoism”). This is seen in the Value-Belief-Norm (VBN) theory. The VBN is centred on 3 values orientations that determine an individual’s pro-environmental behaviour. First, an “egoistic” orientation,
which is the positive effects that the individual behaviour can have for himself. Second, a social orientation, which is concerned with the positive impacts of one’s actions to others, and finally, a “biospheric orientation”, related to the beneficial outcomes to the environment (Turaga et al., 2010 and Kollumuss & Agyeman, 2010). Menges (2010) explains that such egoistic orientation is a form of impure altruism, i.e. when the consumer receives a private benefit, a ‘warm-glow’ when contributing to the common good.

Stern et al. (1993)’s VBN theory is built on top of their predecessor’s theory. The illustration of the VBN theory that follows leaves clear such influence. From Figure 2 it is possible to see that the VBN framework takes a broad view of the Schwartz’s norm activation ideas and incorporates biospheric and egoistic values besides altruistic value into motivations of PEB. The 3 values evolve to a more stable set of beliefs, i.e. to a generalized worldview. This will then shape the individual’s awareness of consequences and his personal responsibility to act and, as in Schwartz’s theory, activate the individual’s personal norms. The resulting actions from this process aim to mitigate possible negative consequences to the individual himself, to others and to the environment.

**Figure 2 – VBN framework**

<table>
<thead>
<tr>
<th>Values</th>
<th>Beliefs</th>
<th>Personal Norms</th>
<th>Behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biospheric (environmental benefits)</td>
<td>Environmental WorldView</td>
<td>Perceived ability to act (acquisition of responsibility - AR)</td>
<td>Sense of obligation to take pro-environmental actions</td>
</tr>
<tr>
<td>+ Altruistic (benefits to other)</td>
<td>Awareness of Consequences (AC)</td>
<td>Sense of responsibility - AR</td>
<td>Sense of obligation to take pro-environmental actions</td>
</tr>
<tr>
<td>+ Egoistic (own benefits)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Based on Kollumuss & Agyeman, (2010)

Stern et al. (1993) found evidence that the auto-enhancing (“egoistic”) orientation is the strongest factor determining PEB; the second is the social concern followed by the biospheric concerns (Kollumuss & Agyeman, 2010). Studies about
recycling behaviour exemplify the importance of this “egoistic” orientation. In this case, the individual increases his self-image as a result of acting as a morally responsible person. Bruvoll et al. (2002) found that 41% of the respondents of their research agreed with the statement “I recycle partly because I want others to think of me as a responsible person,” 73% said that “I recycle partly because I want to think of myself as a responsible person” and 88% claimed to recycle because they felt that “I should do what I want others to do.” (Bruvoll et al, 2002, as cited in Nyborg et al., 2006, p. 352). Clearly, the fact that individuals derive a private benefit, as an increase in their self-image, has a considerable weight in determining PEBs.

Another important aspect concerning pro-environmental behaviour is the possibility of a gap between intended behaviour and actual behaviour. Many studies have concluded that while consumers state a positive willingness to pay for environmental goods, it does not mean that they actually do so. This indicates that, even though some consumers see the importance of behaving in a certain why, not all will indeed transform their willingness into action. Turaga et al. (2010) explain that “this difference may partly reflect the influence of “external factors” that place limits on personal norm-behavior relationship. For example, it is perhaps less costly to sign a petition to support an environmental cause than it is to pay a price premium on a green product, and thus, activated personal norms are less constrained in the former case” (Turaga et al., 2010, p. 215).

Many behavioural theorists explored the importance of external factors and the possibility of a gap between intentions and actual behaviour. Kollmuss & Agyemen (2002), for example, develop a model of pro-environmental where they highlight factors already mentioned in the VBN theory and other internal factors as emotional commitment, feelings and fear. But, what is interesting in their study is the attention to barriers that might mitigate a pro-environmental behaviour. As it can be understood from the illustration below, there are barriers that can influence the individual internally and externally. In the first case, barriers such as lack of knowledge and emotional blockings prevent the individual to build his values and knowledge over the environmental issue and have a proper environmental consciousness. External to the individual there are also obstacles such as lack of appropriate institutions that provide incentive to pro-environmental behaviour, negative or insufficient feedback about others behaviours and old patterns of behaviour that are difficult to change.
The importance of external factors was already a focus on Stern’s work as well. Stern (1999) explains that the contextual domain where the individual is inserted is also very important in determining his actions. These structural variables are highly diverse; they include aspects that the individual carries from birth (as cultural background, economic conditions, etc.), the capabilities acquired through life (as education), the individual immediate situation, constrains coming from public policies (e.g. energy taxes and incentive programs), economic variables (prices, income, availability of goods) and many more (Stern, 1999).

He argues that there is an important interaction between the values (the “personal domain”, as the author says) and the contextual domain where he is inserted. For him, “the weaker the contextual forces, the more personal domain variables are likely to matter” (Stern, 1999, p.466). This means that, when the external barriers seem to have a heavy weight in the individuals’ behaviour, their own values must be even stronger so that individuals indeed have a willingness to pay for green goods. Stern also emphasize that policies that aim to influence behaviour must keep in mind the interaction between the contextual domain and the personal domain: “policy interventions in the personal domain have interactive effects with policies aimed at
context.” (Stern, 1999, p.466). He analyses the effects of incentives to ease the negative implications of external barriers. The thesis will come back to the discussion of possible interventions to positively affect a pro-environmental behaviour latter on.

The charters of behaviour seen here illustrate how pro-environmental behaviour is formed. Each framework brings powerful insights for this thesis. It was seen that the individual has altruistic concerns over the society and the environment but these alone are not enough to determine a pro-environmental behaviour. The VBN theory let clear that auto-enhancing factors as self-image that derives from acting as a socially responsible person are a much more important influence in consumers’ behaviour. Besides that, it is clear that there are barriers or control factors that might keep the individual from acting as his will. The external context where the individual is inserted is equally important to determine any kind of pro-environmental behaviour.

Next, the thesis will focus on green electricity choice, one specific type of pro-environmental behaviour. The most prominent empirical evidence on the field will be studied so it can be connected to the frameworks of behaviour just seen.

### 3.1. Green Electricity Case

There are plenty of empirical studies in green electricity willingness to pay and adoption. These studies often carry out a survey of a selected number of consumers so they can derive some conclusions about their behaviour. The studies highlight important variables that influence consumers’ decisions, namely: information and credibility on product offered, environmental concerns and self-image. Each of these will be discussed below. Other factors will be briefly mentioned. Besides that, the literature is also concerned with the existing gap between stated preferences and actual behaviour when deciding for green electricity; thus, attention will be given to it as well.

#### 3.1.1. Information and Credibility

If randomly asked to anyone what her or his discernment of green electricity is, most doesn’t even know that there is a possibility of choosing the source of their electricity, or doesn’t understand how it is possible that the electricity they buy is green. Those who do know about the possibility of electricity tracking by the use of
Guarantees of Origin in Europe seem sceptical about it. Availability of information and reliability on the electric product seem to be the first factors to determine consumer’s choice towards green electricity.

Obviously, the lack of knowledge of the possibility to choose the source will immediately prevent any consumer to have an influence in the electricity market. The report *Consumer Attitudes to Electricity Disclosure in Europe* by Arvidson et al. (2003) finds out that most of its survey participants agree that accessible and comparable information would help them to become more active consumers and help to educate the society about the relationship between electricity and environment. The report shows that the consumers want to know a series of details form percentage of different fuels, to country of origin of the electricity and to straightforward presentation of environmental impacts.

The availability of electricity disclosure information has been broadly studied. Many results suggest that the information is not easily available. Aasen et al. (2001) show that in Norway consumers must search their electricity information online while the address is given on their bill; none of the surveyed consumers would look it up. Even more surprising is that, for the participants who received their bill electronically, no address was provided. Their study also highlights that the consumer does not understand how it is possible to select his electricity source or trust that the product is actually green. A question by one of the survey’s participant exemplifies well the problem: “how is it possible to know where the electricity I use comes from? All the electricity goes into a common grid!” (Aasen et al., 2001, p.7925). The survey indicates that consumers must spend a fair amount of time to obtain credible information.

Samela & Varho (2005) studied consumers in the Finnish market and also found out that it is difficult to find proper information on electricity sources choices. Their study showed that it is hard for the consumer to understand the mechanisms of electricity supply and contracts in a liberalised market. Many of the consumers interviewed in their study were unaware that if ones buy green electricity, he actually receives a mix of sources and buying a green electricity product is only directing consumer money to a renewable production but not delivering it at one’s home.

Ozaki (2011) also conclude that:

“People are uncertain about the quality of green electricity (e.g. ‘is it really generated from renewable sources?’ and ‘is it reliable?’).
The nature of the contract and costs can cause some anxiety, which in turn leads to rejection. Potential adopters, especially those who have high green values and awareness, need accurate information to evaluate and make a decision. Currently, information is fragmented and inaccurate” (Ozaki, 2011, p.13).

Roe et al. (2001) analysed US consumers’ demand for green electricity and found out that while the consumer is willing to pay a premium to obtain an electricity with certain environmental characteristics it is not well understood how this is even possible. Their results suggest that green demand is dependent on consumers’ credibility on the information provided.

Thus, proper knowledge of the possibility of making an active choice regarding the consumed electricity source and credibility on the electric product purchased are basic factors to influence consumer decision. The information presented to the consumer must be easy to find, to understand and to compare between suppliers. In addition, it is vital that such information is reliable and independently verified. Without the information of opportunity to choose green electricity, the whole system is set to fail. As a result, information and trust in green electricity products are the foundation of consumer willingness to pay for green electricity. Absence of knowledge and trust constitute a significant barrier to consumer engagement.

3.1.2. Environmental Concern and Contribution

Once consumers are able to make an active choice and confidently select their electricity source, environmental concerns is one of the main factors to influence their decision.

Arvidson et al. (2003)’s survey shows that only 12% of domestic consumers said not to care about the environmental impacts of their electricity. The large majority of respondents do not want cause any aggravation of climate change by using electricity and are willing to pay for it. Samela & Varho (2005), Ozaki (2011) and Boardman & Palmer (2007) also find high level of environmental concern among the consumers they study.
Moreover, the E-track II project states that consumers have a desire for additionality, that is, additional renewable production that would not occur without incentives (Timpe & Seebach, 2009). For example, consumers want to ensure that the extra money spent in green electricity will in fact contribute to increase generation of renewable sources and not only increase the suppliers’ profits. Here again the consumer seems to be left empty-handed regarding information on how his money is used.

However, Roe et al. (2001) also showed that additionality is not a necessary condition for WTP. They show that people in US are willing to pay a premium for green electricity even if it does not result in alteration in generation, but are willing to pay a higher premium if also emission reductions and increase reliance upon renewable sources are guaranteed. They found out that on average the population is willing to pay $6 dollars more per annum if there is 1% increase in renewable energy production. Their survey states still that this amount changes according to income, location and level of education.

Hence, studies demonstrate that the consumer presents an environmental concern regarding the impacts of his electricity. The consumers show positive willingness to pay for green electricity when it does not intensify the climate change. Besides that, empirical results show that the consumer is willing to pay a higher premium if additionality is also guaranteed. Thus, environmental concern is another important driver of consumer’s demand for green electricity.

### 3.1.3. Moral Satisfaction and Self-Image

While many studies indicating that consumers choose green electricity over the conventional one because they believe that it leads to positive effects to the environment and to the society, studies also state that environment concerns are not a sufficient reason to explain positive willingness to pay. Recent research indicates that, when consuming green electricity, consumers are also interested receiving a subjective personal benefit from their giving, as the VBN theory would expect.

Wüstenhagen & Bilharz (2006)’s empirical findings for German consumers confirm the importance of personal benefits. Their results suggest that, while a massive group of individuals demonstrate positive attitude towards renewable sources and are aware of their positive environmental impact, they only pay a premium price for green
energy in order to feel better about themselves (Wüstenhagen & Bilharz, 2006, as cited in Hartmann & Ibáñez, 2012).

Regarding what these personal benefits are, evidence suggests that it refers to an intrinsic satisfaction (warm-glow) when acting as morally responsible person in accordance with social norms. Ozaki (2011) explains that with social norms it is possible to judge whether adopting a new energy service is expected by others in the society or not; people want to belong to the society by acting as ‘dictated’ by the norm within the group they belong to. “Both personal identity (e.g. ‘I am green and act pro-environmentally’) and social identity (e.g. ‘I am part of the group that is concerned about the environment’) are expressed by the adoption of green tariffs.” (Ozaki, 2011, p.13).

The study of the Swedish electricity market by Ek & Söderholm (2008) discovers that moral motivation pay an important role in consumer decisions. They found out that choosing green electricity is related to the perceived contributions of others in the society. The survey indicates that when it is believed that the society contribute little to the public good, only 8% of the survey participants say that will demand green electricity as well. However, when the scenario changes and the individual believes that others contribute a lot, 75% of the households consider buying green electricity and 40% can also pay a premium for it.

Thus, when the individual behaviour gets closer to the “morally accepted” behaviour, he achieves a higher moral satisfaction or self-image, gaining from choosing green electricity. This personal benefit seems to have a heavier influence in consumer decisions than environmental concerns alone.

However, the evidence also indicates that is very difficult to realize the electricity consumption patterns of others in the society. Ek & Söderholm (2008), for example, asked Swedish consumers about in what extent they believe that others in the same group also purchases green electricity. The results were unsatisfying: from a 1 to 5 scale (where 1 refers to a low perception of others purchasing green electricity and 5 to a high perception of green consumption), the average was only 1.56.

Such result can be understood once discernment of others’ consumption of electricity is a difficult task. Differently from recycling, a behaviour that can be seen in the society, it is difficult to know what source of electricity other consume. For example, one may see his neighbour separating trash for recycling, but without asking it
is difficult to find out about his electricity preferences (and one should not forget what was already discussed in section 3.1.1: it is very likely that the neighbour doesn’t even know what electricity source he uses).

Therefore, self-enhancing benefit that arises when acting as a morally responsible person is one of the main factors to influence consumers’ decisions towards green electricity. Empirical results demonstrate that the consumer wants to be part of the society and act accordingly to his perception of the community behaviour and social norms. The individuals want to be seen as a morally responsible person when purchasing green electricity. However, studies also emphasise that observing the electricity consumption patterns in the society is not an easy task.

3.1.4. Other Factors

The empirical literature also mentions other factors that influence green electricity consumption. Among these factors, there are price, income, household size, old habits, demographic characteristics, etc. Although important, these factors are not as imperative to green electricity behavioural patterns as the ones seen above.

Clark et al. (2003) found evidence that household’s size and consumers’ income has an impact on their decision: the larger the household size, smaller the chance of joining green electricity programs. In case of income, the higher the income, higher is the chances of green electricity consumption. The same survey found out that age, gender or the fact that a member of the family would directly benefit from a cleaner air (for example if the person has asthma) has no correlation to willingness to pay for green electricity.

Samela & Varho (2005) also discuss the effect of old habits and cultural influences in green electricity purchasing behaviour. Their study brings evidence that, long established habits make difficult for consumers to change from a conventional source to an alternative one, unless the gains from the green option are well understood.

Roe et al. (2001) results lead to understanding that education levels and enrolment on environmental organizations affect green electricity choices. In their survey sample, those individuals with higher education level demonstrated a higher preference for green electricity and agreed to pay higher premiums. This may be explained by the fact that individuals that are more educated have a better understanding
of the environmental problems and thus a higher concern and perceived responsibility over climate problems. Similarly, those enrolled in environmental organizations are also willing to pay more for green electricity. In this case, these individuals already demonstrate a level of environmental concern and involvement on environmental activities and contributing to the environment is part of their values.

Price of electricity, of course, cannot be forgotten as a factor to influence decision. However, most of the studies agree that such factor does not have a strong relevance in determining whether green electricity will be chosen or not (Samela & Varho, 2005; Ozaki, 2011; Arvidson et al., 2003). In addition, more interesting is that individuals agree on an even higher price premium for green electricity when its benefits are clearly perceived (Litvine and Wüstenhagen, 2011).

3.1.5. Gap Between Intention and Actual Behaviour

Although many consumers show a positive willingness to pay for green electricity and the factors present above explain such intentions, this doesn’t mean that they actually do so. Litvine and Wüstenhagen (2011) notice that the share of green electricity adopters is still in single-digit percentage in most countries.

Arkestijn & Oerlemans (2005), for example, studied the Dutch market and state that green electricity has a potential share in the consumer market of 20%, but the reality is much different. Only about 2% of consumers actually demanded green.

Wiser (2007)’s research found out that the difference between intended behaviour and actual behaviour among US residents is quite astonishing. While the willingness to pay is between 40-70%, the actual demand among the studied residential consumers in his survey was only 3%.

Such gap between intention and actual behaviour confirms what was exposed about barriers inhibiting the consumer to act as his intention. Most of the scholars who studied green electricity purchasing behaviour agree that these controls are, mainly, lack of proper information. Litvine & Wüstenhagen (2011) say that, “by providing information targeted at the key factors influencing the intention to purchase green electricity (…) significant increase in green electricity market share can be achieved.” (Litvine & Wüstenhagen, 2011, p. 462). Mewton & Cacho (2011) also have similar opinion:
“The wide variation in market penetration between jurisdictions and between countries for Green Power, and the low awareness of Green Power found by surveys indicate that Green Power sales could be increased by appropriate marketing and government policies. The most cost effective means to increase sales was found to be advertising campaigns (...)” (Mewton & Cacho, 2011, p.377).

Clearly, understanding behaviour towards green electricity is not a simple task. Numerous factors influence such pro-environmental behaviour. From the empirical literature discussed, it is possible to conclude that some of the factors have a bigger role in determining the choice for green electricity than others.

Environmental awareness and concern are without doubt drivers of consumers’ willingness to pay. Studies indicated that individuals show a greater level of knowledge over environmental questions and are willing to take altruistic action in order to contribute to a better environmental quality. Some studies also discuss whether additionality is a key in determining behaviour. It is possible to conclude that consumers are willing to pay a higher premium if such criterion is also met.

The empirical literature also leaves clear that more important than altruistic motives are the self-enhancing ones. Consumers seem to want to maintain a certain level of self-image, and appear to the society as morally responsible people. Through the internalization of social norms, the consumers prescribe some level of responsibility to themselves and are induced to take action. Therefore, actions in accordance with the social norm lead to an intrinsic satisfaction to the individual.

Availability of information and credibility on what is disclosed to consumers were proved extremely important. Proper information is not only a basic criteria to allow the environmental choice to exist and consumers to have an active voice in the electricity market, but also influences all the other factors discussed. As seen, when consumers exhibit a level of environmental concern and want to contribute to it, they are left empty handed regarding the impact of their electricity and how the extra money paid for green sources is actually used (does it lead to additionality or not?). As soon as social norms were discussed, it got clear that the individual needs to comprehend how others in the society are behaving to construct his own level of responsibility over the environmental issue. Finally, the scholars who studied the existence of a gap between
stated WTP and real adoption of green electricity leave apparent that without appropriate information such window cannot be narrowed.

Thus, it is this thesis’ first conclusion that the formation of actual willingness to pay for green electricity is a combination of (1) environmental concerns and additionality, as altruistic values, and (2) self-image and moral satisfaction, as “egoistic” ones. Moreover, the second factor clearly has greater weight is determining green electricity consumption. These variables are part of the individual’s personal domain and shape the individual’s awareness of consequences and his personal responsibility to act as in the VBN theory.

The external context were the consumer is inserted should also receive attention. This institutional domain should provide the individual with necessary information so he can be active in influencing the energy panorama. Without a well establish external context, the personal domain’s factors cannot have their full influence in consumer willingness to pay for green electricity. Failures in such domain act as barriers/controls and prevent the consumer to act accordingly to his will.

The existence of a gap between intended green electricity consumption and actual consumption is evident from the literature review and goes according to the behavioural theory. While the existence of other factors as income, electricity prices, education, household size, habits, enrolment on environmental organizations appear as factors that might influence such breach, the analysed literature let clear that information discrepancies are the biggest cause for the gap. The disclosure legislation and the use of Guarantees of Origin to track electricity deliver a solid institutional environment to promote the demand for green electricity. But, there is still great path to be walked to successfully provide consumers with knowledge about possibility of purchasing renewable electricity in a credible way. Besides that, flaws in informing the consumers about the society’s consumption patterns have a negative effect on the perceived moral conduct and consequently are harmful to the main driver of consumer willingness to pay, self-image. Moreover, lack of information on environmental consequences of the purchased green electricity damage altruistic values. These are the main barriers identified in this thesis and what possibly explain the existence of a considerable gap between intended and actual consumption of green electricity.
The formation of consumers’ willingness to pay for green electricity can be summarized in the figure that follows. Other attempts to connect the behavioural models seen to the particular case of green electricity have been taken before. Hansla et al. (2009) is an example. However, it is believed that the bellow framework better connects to the empirical literature and that it gives the deserved importance that information and credibility must have.

**Figure 4 – Formation of Willingness to Pay for Green electricity**

Once it is understood the main drivers of consumers’ WTP, the thesis aims to presents economic models that connect to these findings. Elaborate economic models should take into account the decision factors seen and study the consumer behaviour when given environmental choice vs a conventional option. The models will allow the thesis to answer the subsequent questions that arise: how demand for green electricity changes when the other factors (as income and prices) vary and which policies can have an effect on this demand.
4. Models

Although there have been substantial empirical efforts to analyse the consumers’ behaviour towards green electricity, the theoretical literature is breaking new ground to embrace such findings. The textbook models employed by standard economics are viewed to be oversimplified and unrealistic (Turaga et al., 2010, and Nyborg, 2001). These models tend to look at electricity choice without any regards to the attributes it carries and electricity consumption only leads to the benefits of “turning lights on”. Clearly, such models do not fit the empirical results described before.

To address pro-environmental behaviour, more elaborated economic models discuss how consumption options can not only lead to the satisfaction of consuming the private good but also benefit others. Such models typically exemplify individuals who voluntary attempt to provide an environmental public good when a private benefit is also possible (Turaga et al., 2010). Private provision of public good models fit very well the green electricity case. Green electricity has a particularity that it provides the consumer with private goods (physical electricity and self-image) and an environmental benefit (public good), while no public benefit or self-image benefit arise from the consumption of conventional electricity.

Initially, these models focussed only on environmental concerns of the consumer and considered that he has a pure altruistic performance. The influences from norm activation theory and single altruistic reasons, that is contribute to a clean environment, were clear. However, as seen in the previous chapters, pure altruism is not a sufficient reason to explain consumer’s willingness to pay. And either are such models. Turaga et al., (2010) explain that in the last few years, economic models of private provision of public goods are converging with the theory of moral motivation to incorporate the possibility that some individuals obtain a “warm glow” benefit from their own contribution to the public good in addition to the utility already derived from the provision of the public good itself (Turaga et al., 2010).

This section of the thesis aims to present different economics models that study the consumer behaviour when given a green choice. This chapter will develop three different models, showing the evolution of the theory. The first is a simple model, by Abaidoo (2010), where the consumer views the green and conventional electricity as perfect substitutes and his decision is influenced only by the price of the goods. There is no doubt that such model is oversimplified given the empirical results found. In
sequence, the thesis presents a model of private provision of public good considering a pure altruism framework. This model, by Kotchen (2005), argues that the individuals derive utility from the characteristics of the goods rather than the goods themselves that is, choosing green electricity leads to an increase in the utility due to the benefits such choice causes to the environment, and thus the rational decision will be to choose green electricity over the “brown” one. Moving forward, section 4.3 expand the second model and takes into account impure altruism as well. This third model follows ideas from Nyborg et al., (2006) and it best represents the empirical findings: it considers not only that the green choice has contributions to the environment and to the society, but also that the egoistic sphere, that is the increase in self-image due to a morally responsible behaviour, is also a product from the green choice.

Once the thesis has drawn an elucidative model that fits the empirical findings, it can then focus on derivation of comparative statics that describe how the demand for green electricity changes as exogenous parameters in the second and third model vary. If the reader considers necessary to review basic concepts of microeconomics, Appendix 1 briefly discusses the notions that are used in the following models.

4.1. A Simple Model of “Brown” and “Green” as Perfect Substitutes

As emphasized by Abaidoo (2010), the rational consumer on who this section of the thesis is focusing has a unique demand dilemma:

“This consumer is confronted with a choice set with two bundles of services (electricity from carbon based sources and electricity from green based sources) which in terms of their basic household, commercial, or industrial energy requirement, offers similar levels of utility or satisfaction. To this rational consumer, these two products or services (electricity from carbon based sources and electricity from green based sources) lie on the same indifference curve because they offer the same level of utility (with regards to satisfying basic energy needs).” (Abaidoo, 2010, p.4-5).
Thus, at the consumption stage, “green” and conventional, “brown”\(^5\), electricity are seen as perfect substitutes. When analysing the consumers’ problem in this case the following assumptions apply:

A1. Electricity from green \((g)\) and conventional \((c)\) sources are perfect substitutes;
A2. The price of green electricity, \(p_g\), is relatively higher than the carbon based sources’ price, \(p_c\), at a premium \(\pi\);
A3. All other factors affecting demand are held constant;
A4. The consumer is rational and aims to maximize his utility.

Two goods are called perfect substitutes if the consumer is willing to substitute one for the other a constant rate, what gives the indifference curve a constant slope (Varian, 2003). In such a case, the utility function of the consumer can be expressed by a CES function as

\[
U(c, g) = ac + bg, \tag{1}
\]

where \(a = b = 1\); \(c\) represents the brown, conventional electricity and \(g\), the green one.

And the budget constraint of the consumer is expressed as

\[
p_c c + (p_c + \pi)g \leq m, \tag{2}
\]

where \(m\) is the income of the consumer, \(p_c\) is the price of the brown option and \((p_c + \pi) = p_g\) refers to the price of the green option\(^6\).

The consumer will maximize his utility subject to the budget constraint. It follows that in such a case, the optimum bundle for the consumer will be a corner solution as it is seen in the figure 5. Because of the price difference \(\pi\), \(p_g > p_c\) and the slope of the budget line is flatter than the slope of the indifference curves.

\(^5\) From now on “green” and “brown” sources will be referred simply by green and brown without need for “”. Such denomination clearly refers to renewable and conventional electricity.

\(^6\) The variables’ notation was changed to maintain uniformity with what will be presented next.
Consequently, the consumer will choose to consume only $c$, the brown electricity (Varian, 2003).

**Figure 5 – Utility Maximization in Perfect Substitutes case**

Thus, in a simple case of perfect substitutes, all things being equal, “going green” is not a viable alternative for the rational consumer. As explained in Abaidoo (2010), as long as consumers see the two sources as perfect substitutes that can either meet their electricity needs, and they obtain similar utilities from green and brown options, they will chose the latter one because of its lower price.

However, as extensively discussed in this thesis, price is no longer the single factor affecting consumers’ decision. Thus, green and brown are not simply perfect substitutes. Because the attributes that each source of electricity caries, they make electricity much more than a simple way of turning lights on.

4.2. A Model that Embraces Environmental Contribution and Public Good Provision

The work of Kotchen (2005) focuses on the private provision of public goods in green market. As already discussed in this thesis, green electricity generated from renewable sources creates a positive externality, clean environment that is a public good. In his paper, the author stresses that green products are impure public goods once they generate both a private characteristic and an environmental public characteristic. He uses the term *joint product* to refer to an end product, as green electricity, that provides the consumer with the good itself (physical electricity) and an environmental benefit.
His paper develops a general model of private provision of a public good that embraces the option of impure public good consumption. Moreover, his paper presents such framework when a substitute for the impure public good, also called a conventional-good substitute, is available for consumption as well. His study provides interesting insights for this stage of the thesis and allows the consumer problem to be expanded. Thus, the model presented in Kotchen (2005) is studied below. This section also makes use of two other publications by Kotchen: one written together with Moore (2007) and the other by Kotchen alone in 2006. All studies follow the same core idea, private provision of public goods, but when studied together they allow better understanding of the problem.

A key assumption of this model is that consumers derive utility from the characteristics of the good rather than from the good itself. This notion was presented by Lancaster in early 70’s and gives light to a new idea that “goods have intrinsic properties that are relevant to the consumer theory”. Thus, the consumers’ utility is given by a quasiconcave function dependable on three characteristics: Z, X and Y. Z and X have properties of a private good, while Y has properties of a pure public good (non-rival and non-excludable), e.g. environmental quality.

There are three goods in the market z, g and c. Good z can be understood as any other good and it denotes its characteristics and also the physical good itself. In contrast, g generates both characteristics X and Y, and in a very direct relationship: one unit of g generates one unit of X and one unit of Y. Finally, good c only generates the characteristic X, also in a one-one relation.

Bringing this framework presented by Kotchen (2005) closer to electricity markets, it is possible to understand that c refers to the brown electricity that provides the consumer with the physical electricity X; while g refers to green sources that generate a positive externality (the public good) Y at the same time that provide the consumer with physical electricity X. As stressed by Kotchen, c and g are substitutes. Moreover, since Y is a public good, consumers enjoy their own provision g, and what other consumers provide, Y, an exogenously given level of Y.

---

7 Initially Kotchen says that one unit of g generates \( \alpha \) units of X and \( \beta \) units of Y where \( \alpha > 0 \) and \( \beta > 0 \). But, latter on he states that \( \alpha = \beta = 1 \) when there is a substitute conventional good, what is the case analyzed here. Thus, there is no need to mention \( \alpha \) and \( \beta \).

8 It should be noted that he doesn’t mean perfect substitutes.
The prices of g and c (respectively \( p_g \) and \( p_c \)), are exogenously given and in units of \( z \). Kotchen shows that it is a necessary condition that the relationship between both prices is \( p_c < p_g \). In his words “… the conventional good must generate the private characteristic at a strictly lower price, otherwise consumption of the green version would always be preferred” (Kotchen, 2005, p.5). This suggests that consumers must pay a premium, \( \pi \), for the consumption of green electricity. It will be assumed that \( p_g = p_c + \pi \), where \( \pi \) is the price premium. This change is in accordance with the model from the previous section and with another work by Kotchen & Moore (2007) and allows removing good \( z \) from the problem, making it simpler.

Thus, the framework of this second model of the thesis that takes into account environmental contributions as a result of consumption of green electricity can be summarized as follows:

1. **B1.** Consumers derive utility from the characteristics of the good rather than from the good itself;
2. **B2.** Electricity from green (\( g \)) and conventional (\( c \)) sources are substitutes;
3. **B3.** The price of green electricity is relatively higher than carbon based sources at a premium \( \pi \); such that \( p_g = p_c + \pi \).
4. **B4.** Consumption of one unit \( g \) generates one unit of public good \( Y \) characteristic and one unit of physical electricity \( X \) characteristic;
5. **B5.** Total public good provision is given by the sum of individual provision plus exogenous contribution, \( \tilde{Y} \) such that \( Y = g + \tilde{Y} \).
6. **B6.** Consumption of one unit \( c \) generates only one unit of physical electricity \( X \) characteristic;
7. **B7.** All other factors affecting demand are held constant;

The consumer’s utility maximization problem in this case can be written as

\[
\max_{c,g} \{U(X,Y)\} \quad \text{subject to} \quad \begin{cases} 
    p_c c + p_g g = m, \text{ where } p_c + \pi = p_g \\
    X = c + g \\
    Y = g + \tilde{Y}
\end{cases}
\]  

(3)
This problem has a unique solution. The consumers will never chose \( c > 0 \) once they derive a positive utility from \( Y \) and \( X \) when consuming \( g \) and the utility from consuming \( c \) is only \( X \).

The introduction of the notion of a joint product for the case of green goods and the notion of impure public goods as studied by Kotchen allowed this thesis to expand the consumer problem. It is not possible to regard green and conventional electricity as a mere case of perfect substitutes as in section 4.1. As stressed through the entire thesis, green consumers see more in green electricity than a simple good that allows them to turn on the lights. They see in it an opportunity to positively impact the environment. The results provided by Kotchen’s model so far reflect these preferences and explain why the consumption of green electricity is no longer zero as it was in the previous case.

4.2.1. Comparative Statics

Once it is clear that the demand for green electricity is positive, this work follows Kotchen’s paper and analyses how the demand for \( g \) responds to changes in the exogenous parameters of the model, i.e., income \((m)\), prices \((p_g \text{ and } p_c)\) and the exogenous contribution of public good, \( \tilde{Y} \). In order to do so, it was chosen to analyse the consumer problem in terms of \( X \) and \( Y \) only, and replace \( g \) and \( c \) in the budget constraint using \( c = X - g \) and \( g = Y - \tilde{Y} \). This leads to the reformulation of the maximization problem as it can be seen below.

\[
\max_{X,Y} \{ U(X,Y) \} \quad \text{s.t.} \quad \begin{cases} p_cX + (p_g - p_c)Y = m + (p_g - p_c)\tilde{Y} \\ 0 \leq Y - \tilde{Y} \leq X \end{cases},
\]

where \( p_g - p_c = \pi \), and \( m + (p_g - p_c)\tilde{Y} \) represents the full income \((w)\), i.e., the consumer’s income \((m)\) plus the benefit he gets from the exogenous amount of \( \tilde{Y} \) given its premium price.

It follows that the demand for \( Y \) that results from the maximization problem expressed in (4) is given by a function of the implicit prices and the full income as
\[ \hat{Y} = \hat{Y}(\pi, p_c, w). \] (5)

By implicit prices, it is meant the prices of each of the characteristics available \((X\text{ and } Y)\). Since \(X\) and \(Y\) are not the goods themselves, the implicit prices represent the prices being paid to obtain the characteristic. The implicit price of \(Y\) is \(\pi\) and the implicit price of \(X\) is \(p_c\).^9

Assuming that the solution of the problem is an interior solution and not a corner solution as seen before in the model of section 4.1, the demand equation can be differentiated with respect to any of the exogenous parameters of interest \((m, p_g, p_c\text{ and } \hat{Y})\). Differentiating equation (5) leads to comparative static results, i.e., comparison of different outcomes that resulted from changes in the exogenous parameters. Letting \(\theta\) represent any of these parameters, the comparative static results are:

\[
\frac{\partial \hat{Y}}{\partial \theta} = \frac{\partial \hat{Y}}{\partial \pi} \cdot \frac{\partial \pi}{\partial \theta} + \frac{\partial \hat{Y}}{\partial p_c} \cdot \frac{\partial p_c}{\partial \theta} + \frac{\partial \hat{Y}}{\partial w} \cdot \frac{\partial w}{\partial \theta}.
\]

The result can also be written in a more compact notation as

\[ \hat{Y}_\theta = \hat{Y}_\pi \pi_\theta + \hat{Y}_{p_c} p_{c_\theta} + \hat{Y}_w w_\theta, \] (6)

where \(\hat{Y}_\theta = \frac{\partial \hat{Y}}{\partial \theta}\), \(\hat{Y}_\pi \pi_\theta = \frac{\partial \hat{Y}}{\partial \pi} \cdot \frac{\partial \pi}{\partial \theta}\), \(\hat{Y}_{p_c} p_{c_\theta} = \frac{\partial \hat{Y}}{\partial p_c} \cdot \frac{\partial p_c}{\partial \theta}\) and \(\hat{Y}_w w_\theta = \frac{\partial \hat{Y}}{\partial w} \cdot \frac{\partial w}{\partial \theta}\).

Next, substituting (6) in the Slutsky decomposition, it leads to (see Appendix 1 for basic notions on Slutsky equation and Appendix 2 for this specific derivation):

\[ \hat{Y}_\theta = (\tilde{Y}_\pi - \tilde{Y}_w) \pi_\theta + (\tilde{Y}_{p_c} - \tilde{X}) p_{c_\theta} + \hat{Y}_w w_\theta, \]

or

\[ \hat{Y}_\theta = \tilde{Y}_\pi \pi_\theta - \tilde{Y}_w \pi_\theta + \tilde{Y}_{p_c} p_{c_\theta} - \tilde{X} p_{c_\theta} + \hat{Y}_w w_\theta, \] (7)

where \(\tilde{Y}_\pi, \pi_\theta\) and \(\tilde{Y}_{p_c}, p_{c_\theta}\) denote the compensated price responses or substitution effects. \(\hat{Y}\) denotes the demand for environmental quality (Marshalian demand) and similarly \(\hat{X}\).

---

^9 The author refers to \(\pi\), not only \(\pi\) for the implicit price of \(Y\) and \(\pi\), for the implicit price of \(X\). But, to maintain the uniformity with what was explained in previous sections, \(\pi\) will be used for the implicit price of \(Y\) and \(p_c\) for \(X\). Although the notation is different than in Kotchen’s work, it goes accordingly with the analysis of the author who explains that \(\pi_c = p_g - p_c\) and \(\pi_x = p_x\).
represents the Marshalian demand of the private characteristic. Thus, \( \hat{\mathcal{Y}} \hat{\mathcal{Y}}_w \), \( \pi_\theta \) and \( \hat{\mathcal{X}} \hat{\mathcal{Y}}_w p_{e\theta} \) represent full-income effects. Finally, the last term \( \hat{\mathcal{Y}}_w w_\theta \) captures changes in the full-income itself caused by changes in any of the parameters.

Once the Slutsky equation for this model has been exposed, it is possible to study the responses of the demand for the environmental characteristic as parameters change. These will lead to equations (7.1) to (7.4) as will be explained in sequence.

Focusing on changes in income \( m \), equation (7) gives,

\[
\hat{Y}_m = \hat{Y}_w > 0. (7.1)
\]

This result comes from the fact that, as discussed before, \( w \equiv m + \pi \hat{Y} \) and thus, changes in income lead to changes in full-income by the same amount while it has no effect on the other terms of equation (7). Since it is assumed that environmental quality is a normal good, i.e. a good which consumption increases as income increase, it can be understood that demand for environmental quality, \( Y \), is increasing in income\(^{10}\).

Now solving equation (7) for changes in market prices of green electricity, \( p_g \), results in

\[
\hat{Y}_{p_g} = (\bar{\mathcal{Y}}_\pi - g \hat{Y}_w) < 0. (7.2)
\]

One should note that in this equation it was used the fact that \( g = Y - \bar{Y} \) and thus \( \hat{Y} = \hat{g} + \bar{Y} \). But \( \bar{Y} \) does not change with prices of green electricity, \( p_g \).

The sign of the substitution effect, \( \mathcal{Y}_\pi \), is always negative and being \( Y \) a normal good, the income effect is assumed to be positive. Thus, the overall sign of the expression (7.2) will be negative what implies that the demand for environmental quality decreases as the price of green electricity increases. This is an intuitive result: an increase in the price of the green good leads to an increase in the price premium \( \pi \) what causes a decrease in the quantity demanded of \( Y \).

---

\(^{10}\) As Kotchen says it would be easy to derive the results if one decides to see environmental quality as inferior goods. But in this work it is believed the \( Y \) is a normal good.
The effect of a change in prices of the conventional electricity, \(p_c\), is a bit more delicate than the ones cause by \(p_x\). Equation (7.3) explains this effect:

\[
\hat{Y}_{p_c} = (\bar{Y}_\pi + \bar{Y}_{p_c} - c\hat{Y}_w) < 0 \text{ or } > 0. \tag{7.3}
\]

It should be noticed that changes in \(p_c\) negatively affect the price premium, \(\pi\), what explains the presence of \((-\bar{Y}_\pi)\) on the right hand side of the equation (7.3). And, again the equation used the fact that \(X = g + c\) and thus \(\hat{X} = \hat{g} + \hat{c}\).

The effect of \(p_c\) in the demand of \(Y\) is said “delicate” because the overall sign of expression (7.3) is ambiguous. It has two substitution effects: \(\bar{Y}_\pi\) and \(\bar{Y}_{p_c}\). The first effect \(\bar{Y}_\pi\) has a negative sign while \(\bar{Y}_{p_c}\) can have either positive or negative signs depending if \(X\) and \(Y\) are substitutes or complements. Besides that \(\hat{Y}_w\) has a positive sign. It results that even if \(X\) and \(Y\) would be for sure complements or for sure substitutes, the overall sign of (7.3) would still be ambiguous because \(\bar{Y}_\pi\) and \(\hat{Y}_w\) have opposite signs. It is easy to reason this: a decrease in the price of conventional electricity leads to an increase in the premium and consequently to an decrease in the demand for environmental quality, \(Y\); at the same time, the decrease in the price gives the consumer the idea of having more income what positively affects the demand of \(Y\); and these effects put together lead to an overall ambiguous result. Thus, changes in \(p_c\) can either increase or decrease the demand for environmental quality.

Finally, considering changes in the exogenous parameter \(\bar{Y}\), equation (7) gives

\[
\hat{Y}_\varphi = \pi \hat{Y}_w > 0, \tag{7.4}
\]

which differs from (7.1) by the multiplication of \(\pi\) due to the relation \(w \equiv m + \pi \bar{Y}\) seen before. In this relation, \(\pi\) affects \(\hat{Y}\) but not \(m\).

The sign of (7.4) is positive but, as mentioned in Kotchen (2005), is worth nothing also if \(\hat{Y}_\varphi\) is greater or lower than 1, not only that it is greater than 0. According to the author, whether \(\hat{Y}_\varphi\) is greater or lower than 1 has an important interpretation in terms of crowding-out of private provision of environmental quality. Crowding-out refers to a situation where existing government policies reduce private investment or, in
this case, when existing support policies might mitigate the demand for green electricity and lead to the sub-optimal provision of public good by consumers.\textsuperscript{11}

The effects on the demand for the green product can be easily explained as well. Following the work of Kotchen, given the relationship \( g = Y - \tilde{Y} \) the differentiation for the demand of \( g \) can be written as

\[
\frac{\partial \hat{g}}{\partial \theta} = \left( \frac{\partial \tilde{Y}}{\partial \pi} \cdot \frac{\partial \pi}{\partial \theta} + \frac{\partial \tilde{Y}}{\partial p_c} \cdot \frac{\partial p_c}{\partial \theta} + \frac{\partial \tilde{Y}}{\partial w} \cdot \frac{\partial w}{\partial \theta} \right) - \frac{d\tilde{Y}}{d\theta},
\]

and as before, using a more compact notation as

\[
\hat{g}_\theta = \tilde{Y}_\theta - \overline{Y}_\theta. \tag{8}
\]

Comparing (8) to equation (7), this new equation has an additional term \( \overline{Y}_\theta \), that is \( Y_\theta \equiv \frac{d\tilde{Y}}{d\theta} \). It follows that \( Y_\theta \) is equal to zero for changes in all parameters other than \( \tilde{Y} \), and equal to 1 when \( \tilde{Y} \) varies. This implies that the results of changes of the exogenous parameters on the demand of \( g \) will have the same sings as \( \tilde{Y}_\theta \) seen above for all parameters other than the exogenous contribution of the public good (\( \overline{Y} \)). That is., the green demand \( g \) is increasing in income \( (m) \), decreasing in prices of green electricity \( (p_e) \) and ambiguous for changes in prices of conventional electricity \( (p_c) \).

When focusing on \( \tilde{Y} \), equation (8) leads to

\[
\hat{g}_{\tilde{Y}} = \tilde{Y}_\theta - 1. \tag{8.1}
\]

This means that changes in the demand for green electricity are also ambiguous; it depends whether \( \tilde{Y}_\theta < 1 \) or \( \tilde{Y}_\theta > 1 \). Here again the possibility of crowding-out of private provision of public good calls one attention\textsuperscript{12}.

The Table 1 that follows summarizes the results found for changes in green demand and in demand for the environmental characteristic for all parameters of

\textsuperscript{11} Although an important topic, this thesis has chosen not to discuss further the interaction of the voluntary scheme with existing support policies.

\textsuperscript{12} See note 11
interest. In this table “+” means that the demand increases when the given parameter changes, “-” means that the demand is decreasing and “?” that the result is ambiguous.

<table>
<thead>
<tr>
<th>X and Y as complements or substitutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substitutes</td>
</tr>
<tr>
<td>( \tilde{Y}_m )</td>
</tr>
<tr>
<td>( \tilde{Y}_{pg} )</td>
</tr>
<tr>
<td>( \tilde{Y}_{pc} )</td>
</tr>
<tr>
<td>( \tilde{Y}_Y )</td>
</tr>
</tbody>
</table>

Source: Kotchen (2005)

Next, the thesis goes further and expands this model to also take into account impure altruism, i.e. the possibility of receiving a self-enhancing benefit when consuming the green good. It doesn’t mean that the Kotchen’s ideas just seen should be completely forgotten. No, Kotchen himself acknowledges that “it is also possible that consumers who purchase green products do so because it simply makes them feel good about “doing their part” to protect the environment. In other words, green-product consumption may be motivated by “warm glow,” rather than provision of a public good” (Kotchen, 2005, p.298). And, as he emphasises, his model is useful for studying this case as well. Kotchen suggests that \( Y \) should then be reinterpreted as another private characteristic, as self-image.

The addition of a personal benefit goes accordingly to the WTP framework developed before and summarized in Figure 4: self-enhancing motivation, as self-image, is the strongest factor to determine consumers’ demand for green electricity. To introduce self-image, the thesis will follow what is proposed in Nyborg et al. (2006).
4.3. A Model that Embraces Self-Image and Moral Motivations as Drivers of Green Consumption

The paper of Nyborg et al. (2006) “explores the potential influence of moral motivation in explaining the green consumer phenomenon” (Nyborg et al., 2006, p. 352). It introduces the idea of self-image as the main driver of consumers’ behaviour.

The model presented in their work has many similarities with Kotchen’s model. As before, the consumer also faces a binary decision of choosing a green product or a conventional alternative and he believes that the green option generates benefits to others (the public good). But a key point in Nyborg et al.’s model, and different from the previous model, is that the consumer also strives for sustaining a self-image (S) associated with moral behaviour. This self-image is a result of two factors that interact: doing good, i.e. believing that the individual actions may have a beneficial impact to others, and also realizing that other individuals in the community observe one’s actions. In the authors’ own words:

“In particular, we will assume that if an individual makes the choice that she finds morally superior, this provides a subjective benefit S that may be interpreted as the effective value of attaining a favourable self-image. (…) We assume that the self-image improvement S achieved by choosing the green alternative is increasing in the positive external effects of this choice; or rather, the individual’s beliefs about these external effects. Moreover, S is assumed to increase in the extent to which the consumer acknowledges a personal responsibility for the issue at hand.” (Nyborg et al., 2006, p. 353 and 354)

Thus, in Nyborg et al. (2006), the benefits from generating a public good do not enter the utility function directly as in Kotchen’s model. Here, the benefits from generating the public good cause an increase in utility by positively impacting S.

Besides that, S is also subject to the individual’s personal responsibility over the issue, i.e., his obligation in contributing for a cleaner environment. This personal responsibility is affected by two factors: descriptive norms and concerns about fairness and reciprocity. The first one means what is considered in the society as correct, and the
second one means that the individual is ready to take the socially correct action once that others in the community do the same. Basically, the individual is observing other’s actions in the society and also comprehending how the society expects him to act. According to the authors, both, descriptive norms and concerns about fairness and reciprocity are increasing in relation to the population share that chooses the green alternative, \( d^{13} \).

This representation of \( S \) corresponds to what was said before regarding which factor affects more the consumer’s decision: the demand for green electricity is a result of environmental awareness and altruism to provide the public good \((Y)\), but the strive for self-image in behaving morally has an even stronger effect in determining consumers’ choice.

Reminding Kotchen’s suggestion, when considering private benefits from doing good, \( Y \) from the previous model should be reinterpreted as another private characteristic, as \( S \), in this new case. What has been proposed in Nyborg et al (2006) follows Kotchen’s idea and allows the thesis to better represent the consumer problem in the case of electricity choices. In Kotchen’s suggestion, it was not specified what form \( S \) should have. It could be understood from his paper that the private benefit should be a simple variable. Nyborg et al (2006), however, have a deeper understanding of what influences self-image: the environmental benefit, \( Y \), and the share of individuals who choose the green option in the society, \( d \).

The addition of self-image motivations means that the joint product representation seen in the previous model can be reformulated here so that one unit of the green alternative, \( g \), generates one unit of the physical characteristic of the good, \( X \), one unit of the private benefit, \( S \) and also leads to the public good provision \( Y \). On the other hand, the conventional electricity, \( c \), leads to one unit of the physical electricity only. Although not mentioned in Nyborg et al. (2006)’s model, this one-one relation assumed here does not alter the basic specification of their model.

Therefore, the assumptions of the previous model can be slightly modified to fit the private benefits that arise from the green consumption and match the specifications of Nyborg et al. (2006). The structure of this third model that takes into

\[13\] The original notation from Nyborg et al. (2006) was modified here to avoid confusion with other variables.
account moral motivations for the green choice and provision of the public good can be summarized as follows:

C1. There is finite number of individuals in the society, \( n \).
C2. Each individual faces a binary choice: buy a conventional good \( c \), or an environmentally superior alternative, \( g \).
C3. Consumers derive utility from the characteristics of the good rather than from the good itself;
C4. Electricity from green \( (g) \) and conventional \( (c) \) sources are substitutes;
C5. The price of green electricity is relatively higher than carbon based sources at a premium \( \pi \); such that \( p_g = p_c + \pi \);
C6. Consumption of one unit \( g \) generates one unit of private good \( S \), a status characteristics, and one unit of physical electricity \( X \) characteristic;
C7. Besides that, if a person chooses the green alternative it leads to a benefit \( y \) to her and to all other \((n-1)\) members of the society, where \( y < \pi \) and \( ny > \pi \). The total amount of public good is given by \( Y = ny \).
C8. The consumer maintains a self-image \( S \) as a morally responsible person. And \( S \) is increasing in \( Y \) and \( d \).
C9. \( d \) is a share of the population that chooses the green alternative, such that \( d = \frac{\sum g_i}{n} \). Choosing green would means that \( g_i = 1 \)
C10. Consumption of one unit \( c \) generates only one unit of physical electricity \( X \) characteristic;
C11. All other factors affecting demand are held constant;

Hence, is possible to write self-image as

\[
S = s(Y, d). \tag{9}
\]

And, if the individual chooses green, his payoff equals the self-image minus the net private cost of the green good \( (\pi - y) \), denominated \( h \).

\[
\text{Payoff} = (S - h)g_i. \tag{10}
\]
Thus, the individual will choose green whenever \( S = s(Y, d) > h \). Differently than the previous models, such specification can lead to multiple equilibria. Assuming that, when \( d=0 \) (no one chooses the green alternative) \( (Y, 0) < \pi \), and when \( d=1 \), i.e. all individuals choose the green alternative and the maximum amount of public good is created, \( s(Y, 1) > \pi \), there are two opposite equilibria. These first two equilibria are pure strategy equilibria. One more equilibrium occurs from a mixed strategy in which each individual can choose the green alternative with a probability \( d' \) such that \( d' \) is defined by \( s(Y, d')=\pi \) (simply said, \( 0 < d < 1 \), i.e., the share of the society chooses the green alternative). The three equilibria are represented as NE (0), NE (1) and NE \((d')\) respectively.

It follows that NE (1) is a superior equilibrium if compared to the other two. This makes sense because once all the population chooses the green alternative \( (d=1) \), more public good is created, i.e. the positive externality – environmental quality – is higher when \( d=1 \) and as a consequence, the benefits exceed the premium paid; and in addition, the consumers’ self-image is higher in NE (1) than in NE (0).

Moreover, NE (1) and NE (0) are at “evolutionary stability”, that is once the economy is in such state, any small change on the consumers’ strategy would die out. It is easy to understand why this happens: imagine that an individual A, as all the others in the society, is initially consuming the conventional good but decides to change to the green option. Because all others in the society are consuming the conventional good, the level of public good in this case is only the individual A’s own contribution, \( y \). But, at the same time, A has a positive net cost \( h \), since it was assumed that \( y < \pi \). Moreover, the share of the population to consume the green good can be understood as very small or equal to zero if \( n \) is large. This means that the only positive influence in A’s self esteem comes from \( y \), which is not sufficient to overcome the cost \( \pi \) of the green alternative. And the player who initially did not change their strategy, have no better decision on this situation. Thus, the individual A changes back to the conventional option and the equilibrium return to NE (0). The same reasoning can be used to explain why NE (1) is stable.

While NE (1) and NE (0) are stable equilibria, NE \((d')\) is not a stable equilibrium. That is because any small share of consumers who always choose green over brown alternative will be marginally better than the incumbent players, because
their presence will make $S$ increase just enough to make the green choice strictly better than the brown alternative.

The model derived here fits best the empirical evidence seen before. Once it is clear that the demand for green electricity is a possible result, the thesis will revise the comparative statics done before and examine now how the demand for $S$ and $g$ respond to changes in the exogenous parameters of the model. Because stability of the equilibrium is a requisite for comparative statics derivation, the analyses will distinguish two possible environments: when $d=0$ and when $d=1$. If the equilibrium was not stable, any small changes in one of the external parameters would lead to large “jump” in the endogenous variables, invalidating the analysis.

4.3.1. Comparative Statics Revised

It is clear that there are two different stable equilibria, NE (0) and NE (1). The first is characterised by a situation when no one chooses the green alternative, while the second equilibrium represents an opposite situation where the demand for green electricity is generalised in the society. The comparative statics derivation will be done for each of these equilibria.

Moreover, one might ask why analyse how the demand for the green product changes when it is already stated that when $d=0$ no one buys green electricity and when $d=1$ all the society chooses to consume it. These two different worlds already say what the demand for green characteristic is but the focus here is to explain how the demand changes around these points of equilibrium. With comparative statics derivation, the thesis is interested in explaining infinitesimal deviations from the equilibrium as the exogenous parameters change.

Once the demand for $Y$ in the previous model was expressed as in (5), and here $Y$ was reinterpreted as $S$ it is possible to assume that the demand for self-image can be expressed in a similar way. That is, the demand for $S$ is also a function of the external parameters, income $m$, implicit prices of the green and brown characteristics ($\pi$ and $p_c$), with the addition that it now also depends whether the situations refers to $d=0$ or $d=1$.

Moreover, in the real world, it is reasonable to assume that the consumer has no perception whatsoever of the positive effects of his electricity choice to the
environment, that is why it can be understood that his own contribution, \( y \), is negligible. This implies that the individual is completely dependent on information from external sources about these impacts and his beliefs regarding these external benefits and it is reasonable to assume that \( Y \) denotes a consumer’s subjective beliefs regarding the external benefits provided by the green product, as \( \tilde{Y} \) seen before.

Thus, when \( d=0 \), there is no generation of public good and it makes sense to assume that \( \tilde{Y} = 0 \). Then, the demand for \( S \) when \( d=0 \) can be expressed as

\[
\hat{S}^0 = \hat{S}(\pi, p_c, m),
\]

where the superscript 0 denotes the equilibrium where \( d=0 \). One should note that, as in the previous model, the demand is a function of the implicit prices of the green and brown characteristics. However, now the demand is a function income, \( m \), not full-income as before.

On the other hand, when \( d=1 \), there is full generation of the public good and the demand can be expressed as

\[
\hat{S}^1 = \hat{S}(\pi, p_c, w).
\]

In this case, there is the production of the public good \( Y \) and it affects the demand of self-image. Moreover, with the availability of the public good, it is reasonable to assume that here again the consumers ends up with a full income \( w \) that equals his normal income \( m \) plus the benefit he gets from the exogenous amount of \( \tilde{Y} \) given its premium price, \( (p_g - p_c)\tilde{Y} \).

In either case, according to this new formulation of the problem the demand of green electricity is \( \hat{g} = \hat{S} \).

Differentiating equation (11) with respect to any of the exogenous parameters (here again expressed as 0) leads to

\[
\frac{\partial \hat{S}^0}{\partial \theta} = \frac{\partial \hat{S}^0}{\partial \pi} \cdot \frac{\partial \pi}{\partial \theta} + \frac{\partial \hat{S}^0}{\partial p_c} \cdot \frac{\partial p_c}{\partial \theta} + \frac{\partial \hat{S}^0}{\partial m} \cdot \frac{\partial m}{\partial \theta}.
\]
what is not much different from what was seen for the model in section 4.2 except that now there is no full-income.

The Slutsky equation for this new case will then be

$$\widetilde{S}_\theta = (\overline{S}_\pi - \overline{S}_m \overline{S}_0) \pi_{\theta} + (\overline{S}_{p_c} - \overline{X}_m \overline{S}_0) p_{c\theta}. \quad (13)$$

Again a compact notation was used to facilitate the analysis: $\overline{S}_\theta = \frac{\partial \overline{S}}{\partial \theta}, \overline{S}_\pi \pi_{\theta} = \frac{\partial \overline{S}}{\partial \pi} \cdot \frac{\partial \overline{\pi}}{\partial \theta}$, $\overline{S}_m \pi_{\theta} = \frac{\partial \overline{S}}{\partial m} \frac{\partial \pi}{\partial \theta}$ and $\overline{S}_m p_{c\theta} = \frac{\partial \overline{S}}{\partial m} \frac{\partial p_c}{\partial \theta}$. See Appendix 3 for derivation of (13).

When $d=1$, differentiating equation (12) leads to

$$\frac{\partial \overline{S}_1}{\partial \theta} = \frac{\partial \overline{S}_1}{\partial \pi} \frac{\partial \pi}{\partial \theta} + \frac{\partial \overline{S}_1}{\partial p_c} \frac{\partial p_c}{\partial \theta} + \frac{\partial \overline{S}_1}{\partial w} \frac{\partial w}{\partial \theta}. \quad \text{(14)}$$

It should be noticed that now full income is taken into account. The Slutsky equation for this new case will then be (Appendix 3)

$$\widetilde{S}_\theta = (\overline{S}_\pi - \overline{S}_1 \overline{S}_w) \pi_{\theta} + (\overline{S}_{p_c} - \overline{X}_1 \overline{S}_w) p_{c\theta} + \overline{S}_w w_{\theta}. \quad (14)$$

The same compact notation applies here with the difference that now the superscript is 1, referring to the second equilibrium and there is an additional last term, $\overline{S}_w w_{\theta} = \frac{\partial \overline{S}_1}{\partial w} \frac{\partial w}{\partial \theta}$, which refers to changes in the full-income.

Equations (13) and (14) are the main equations in this new model to understand the behaviour of the demand of $S$ and $g$ when the external parameters vary. Once the Slutsky equations have been derived, it is possible to analyse the effect of each external parameters alone.

In either case of $d=0$ or $d=1$, the results that arise from equation (13) and (14) are not very different than what was seen in model of section 4.2. Because $Y$ was reinterpreted here as a private benefit $S$, the results are maintained for changes in $p_g$ and $p_c$. The demand of $S$ is negatively related to changes in $p_g$ because it increases the
premium $\pi$ and it results in a decrease of the demand for self-image regardless of whether the economy is in the equilibrium where $d=0$ or $d=1$.

\[
\frac{\hat{S}^0}{p_g} = (\bar{S}_\pi - \hat{g}\hat{S}_m) < 0 \tag{13.1}
\]

\[
\frac{\hat{S}^1}{p_g} = (\bar{S}_\pi - \hat{g}\hat{S}_w) < 0 \tag{14.1}
\]

Changes in $p_c$ have again an ambiguous result. The effects in the demand of $S$ due to changes in $p_c$ are expressed as in (13.2) when $d=0$ and as (14.2) when $d=1$\textsuperscript{14}.

\[
\frac{\hat{S}^0}{p_c} = (-\bar{S}_\pi + \bar{S}_p - \hat{c}\hat{S}_m) < 0 \text{ or } > 0. \tag{13.2}
\]

\[
\frac{\hat{S}^1}{p_c} = (-\bar{S}_\pi + \bar{S}_p - \hat{c}\hat{S}_w) < 0 \text{ or } > 0. \tag{14.2}
\]

Because $\bar{S}_\pi$ and $\bar{S}_m$ in equation (13.2), and $\bar{S}_\pi$ and $\bar{S}_w$ in equation (14.2) have opposite signs the results are ambiguous for changes in $p_c$ in both equilibrium points.

However, different from the previous model, now $m$ has no effect on the demand of $S$ when in the point $d=0$. That is due to the fact that in such equilibrium point, there is no generation of public good and thus $\bar{Y}$ is not added to the income. Besides that, there is no reason to discuss effects on demand from changes in $\bar{Y}$ in such case, since when $d=0$, $\bar{Y}$ is assumed inexistent.

On the other hand, when in $d=1$, changes in income $m$ will have an effect on the demand for $S$. In such point, an increase in income leads to a positive shift of the demand for self-image because $w \equiv m + \pi \bar{Y}$ and thus, changes in income lead to changes in full-income by the same amount while has no effect on the other terms of equation (14).

\[
\hat{S}^1_m = \hat{S}_w > 0. \tag{14.3}
\]

When considering changes in $\bar{Y}$, solving equation (14) gives

\textsuperscript{14} One should remember that $X = g + c$ and thus $\hat{X} = \hat{g} + \hat{c}$
\[
\hat{S}_y^1 = \pi \hat{S}_w > 0,
\]  
(14.3)

which is similar to what was demonstrated for model of section 4.2.

Finally, it is possible to make conclusions for the effects on the demand of green electricity \( g \). In this new formulation of the consumer problem, the demand for green electricity is given by \( \hat{g} = \hat{S} \). This means that exogenous parameters’ changes will affect the demand for \( g \) in the same way they affected \( S \), i.e. the comparative statics for \( \hat{g} \) in this third model will have the same sings as \( \hat{S} \) seem above. When in the equilibrium of point 0, the demand is decreasing in prices of green electricity \( (p_g) \), and ambiguous for changes in prices of conventional electricity \( (p_c) \), unaffected by changes in income \( (m) \). When \( d=1 \), similar results are found except for the fact that in this high equilibrium point, \( g \) is positively affected by both income and beliefs in the external level of the public good \( (\bar{Y}) \).

Table 2 summarizes the comparative statics results when self-image is taken into account. Here again, “+” means that the demand increases when the given parameter changes, “-” means that the demand is decreasing and “?” that the result is ambiguous.

Comparing these results with the comparative statics of the previous model (Table 1), it can be understood that, while many of the results remained unchanged, it calls attention the fact that the demand for green electricity \( \hat{g} \) is now positively affected by changes in the beliefs in the external level of the public good \( (\bar{Y}) \), while before such effects were ambiguous. This is another confirmation of the weight that self-image or auto-enhancing benefits have in determining the consumer’s willingness to pay for green electricity.
Table 2 – Qualitative comparative results for changes in exogenous parameters in a model with self-image

### a. Demand for Self-image when $d=0$ and $d=1$

<table>
<thead>
<tr>
<th>$X$ and $S$ as complements or substitutes</th>
<th>Substitutes</th>
<th>Complements</th>
<th>Substitutes</th>
<th>Complements</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tilde{S}_m^0$</td>
<td>na</td>
<td>na</td>
<td>$\tilde{S}_m^1$</td>
<td>+</td>
</tr>
<tr>
<td>$\tilde{S}_{pg}^0$</td>
<td>-</td>
<td>-</td>
<td>$\tilde{S}_{pg}^1$</td>
<td>-</td>
</tr>
<tr>
<td>$\tilde{S}_{pc}^0$</td>
<td>?</td>
<td>?</td>
<td>$\tilde{S}_{pc}^1$</td>
<td>?</td>
</tr>
<tr>
<td>$\tilde{S}_Y^0$</td>
<td>na</td>
<td>na</td>
<td>$\tilde{S}_Y^1$</td>
<td>+</td>
</tr>
</tbody>
</table>

na: not apply

### b. Demand for Green electricity when $d=0$ and $d=1$

<table>
<thead>
<tr>
<th>$X$ and $S$ as complements or substitutes</th>
<th>Substitutes</th>
<th>Complements</th>
<th>Substitutes</th>
<th>Complements</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tilde{G}_m^0$</td>
<td>na</td>
<td>na</td>
<td>$\tilde{G}_m^1$</td>
<td>+</td>
</tr>
<tr>
<td>$\tilde{G}_{pg}^0$</td>
<td>-</td>
<td>-</td>
<td>$\tilde{G}_{pg}^1$</td>
<td>-</td>
</tr>
<tr>
<td>$\tilde{G}_{pc}^0$</td>
<td>?</td>
<td>?</td>
<td>$\tilde{G}_{pc}^1$</td>
<td>?</td>
</tr>
<tr>
<td>$\tilde{G}_Y^0$</td>
<td>na</td>
<td>na</td>
<td>$\tilde{G}_Y^1$</td>
<td>+</td>
</tr>
</tbody>
</table>

na: not apply

The comparative results showed how the demand for green electricity changes as prices and income vary. However, it is true that such results refer to infinitesimal changes in the demand. For example, if demand for green electricity is decreasing in prices when $d=1$, it doesn’t mean that if $p_g$ increases a lot the demand of $g$ will go much far away from $d=1$. Thus, one cannot rely on changes in income or in prices to move the economy from $d=0$ to $d=1$, and achieve the superior equilibrium. Changes in these external parameters only lead to small deviations from the equilibrium point. This is no surprise once it is already known that prices and income are only “other factors” to influence demand.
If the intent of the voluntary programme by the use of Guarantees of Origin is to fully stimulate the demand for green electricity and so achieve a superior equilibrium where the adoption of renewable sources is universal, policy makers’ focus must be on the extent to which social norms for contributing to the collective good are recognized and enforced. It means that they must concentrate on what affect the main driver of consumer willingness to pay, self-image, and not only on external factors. It is clear that differences in recognition of social norms is what distinguishes the two possible equilibria and explains why two otherwise identical economies might exhibit different demands for green electricity.

Following this idea, the thesis will now discuss how to promote behavioural change in the green electricity market by the use of information and advertising campaigns to bring the economy closer to the point where all individuals have a green choice.

5. Promoting Behavioural Change

The importance of information to trigger a pro-environmental behaviour has been a constant in this thesis. The voluntary programme by the use of energy certification tracking systems clearly relays on the information reaching the end consumer in the best possible way. The main purpose of EU legislation on disclosure is to inform the consumer. However, the empirical results studied showed that there are several problems regarding the disclosure of information. Consumers are misinformed about their electricity sources, many distrust in the information given and don’t know the environmental impact of their green purchase. Moreover, consumers cannot distinguish the comportment of others in the society and thus cannot recognise what the morally accepted behaviour is. These pose barriers to behaviour and can set the voluntary scheme to fail.

Behaviouralist theorist as Stern (1999) already called attention to the importance of pursuing proper information. For Stern (1999), the simple action of presenting the consumer with information won’t cause behaviour to change. He says:
“The history of informational programs for residential energy conservation, recycling, and the use of mass transit shows clearly that the most typical result of simply presenting people with information on the benefits of pro-environmental behaviors is that the behavior does not change (e.g., Ester & Winett, 1982; Hirst, Berry, & Soderstrom, 1981; McDougall, Claxton, & Ritchie, 1983).” (Stern, 1999, p.467).

More than only presenting information, for Stern, policy makers should note that behaviour relies on the relation of the personal domain and the contextual domain. The personal domains are the individual´s values, and the contextual domain, the institutional environment where the individual is inserted. In case of demand-sided program for green electricity this interaction is clear: not only the consumers must be inserted in an environment that promotes information and in a clear and reliable way, but also it is important that their individual values also identify with the cause that the information is supporting, i.e., increase generation of electricity from reliable sources and promote a clean environment.

In the contextual domain, EU Directive 2009/72/EC together with EU Directive 2009/28/EC creates an encouraging environment by commanding that suppliers disclose the electricity source to consumers and by means of Guarantees of Origin. However, it is true that there is evidence of many flaws in this process. It is clear that credibility in the information disclosed may pose one of the biggest treats to the system. It should be definitely praised that the electricity market is suffering modifications to improve the decision making process of end consumers, but it is also true that there is space for improvements.

Still, more disturbing than credibility issues, are the deficiencies in information that could affect the personal domain. This thesis made clear that the main factor to affect consumer pro-environmental decision comes from self-image motivations. The strive for status as a socially responsible person that behaves according to social moral is above all what drives consumers demand for green electricity. Besides that, it is understood that the individual perception of others’ behaviour in the society and the perception of the positive effects of his consumption decision are important to build what the he believes to be the socially correct. However, the evidence shows that not only it is difficult for the consumer to observe others’ comportment, i.e. what electricity source the society is choosing, but also he is left empty handed regarding knowledge of
the consequences of choosing green electricity ("does it really lead to an increase of the public good?"). Clearly these deficiencies in information have a negative effect on the consumer’s motivations to purchase green electricity more than contextual problems.

For behavioural theorists as Stern (1999), public policies can achieve much when they aim to affect the personal domain. Such policies can improve, for example, the recognition of social norms, remind people of a social commitment, and consequently, encourage pro-environmental behaviour.

Taking this lead, this last section of the thesis intends to analyse how advertising policies can have a positive impact on the demand of green electricity. With the model developed above it is possible to understand how information policies can affect the consumer’s decision for green electricity and bring the economy to the point where the choice for the green alternative is universal. As seen, the results of the consumer’s problem in the model bring three different equilibria: \( \text{NE} (0) \), \( \text{NE} (1) \) and \( \text{NE} (d') \). The first two exhibit evolutionary stability, in which it is possible to derive the comparative statics seen above. However, the third equilibrium, \( \text{NE} (d') \) is not stable. This opens space for public policies that can have an effect on how perceived responsibility is created based on beliefs on others’ behaviour and also policies that can affect the understanding on how public benefits are generated.

The basic assumption to be done here is that populations can evolve and their probability of a certain choice (for example, \( d' \) for green electricity) can change over time. It means that the individual revise his electricity choice every now and then (in the electricity case it is not wise to say that the individual changes option all the time, but in random times). The population’s choices evolve in a sense of learning or imitation, that is, the individual revise his strategy choice and “simply mimic an arbitrary others person (…) as a way of learning by doing.” (Nyborg et al., 2006, p.357).

Thus, considering that the population revises its strategy in certain periods, \( d \) is time dependent (\( d(t) \), where \( t \) indicates time). And \( \dot{d} \) is the velocity with which it changes. This evolution process can be expressed according to the replicator equation, that is, a model of imitation. Such equation states that the growth rate of the strategy (in this case,\( d \)) “is proportional to the success of that strategy, where “success” is measured by the strategy’s comparative payoff” (Nyborg et al., 2006, p.357). This leads to:
\[ \dot{d} = d(1 - d)(s(Y,d) - h), \quad (16) \]

where \((s(Y,d) - h)\) is the payoff of choosing green as seen before (see Appendix 4 for a simple derivation of the replicator equation). The graph below represents such dynamics.

**Figure 6 – Dynamic development of share of adopters**

![Graph showing dynamic development of share of adopters](source: Nyborg et al. (2006))

The equation (16) shows that the evolution of the strategy taken by the individual is clearly related to the payoff. Considering that the price premium, \(\pi\), is given\(^{15}\), that \(y\) is negligible and that the consumer is completely dependent on external sources for information about the environmental impacts of the green choice as argued in the comparative statics section, \(h\) is settled.

To provoke a dynamic shift in the rate of adoption the government (or private marketers) can by the use of advertising campaigns influence either \(Y\), that is the beliefs about positive externalities caused by the green purchase, or \(d\), beliefs about share of adopters in the society. And, any policy that can, even if temporally, ensures that \(d > d'\) will be sufficient to move the economy permanently to NE (1) (Nyborg et al., 2006). This means that, if governments (or private marketers) can influence consumer’s decision so that the probability of choosing the green opinion is higher than the turning point \(d'\), it is possible to bring the economy to the point where all the individuals have a green choice.

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\(^{15}\) And it is already known from the previous sections that price changes don’t affect the demand for green electricity in a larger extent.
Regarding advertising policies that focus on affecting $Y$, if they can provoke a big enough positive shift of $Y$, ensuring that the gains from $s(Y, d)$ strictly exceeds $h$ for any $d$, NE (0) would no longer be a possible stable equilibrium. That is because $(s(Y, d) - h)$ term in equation (16) would be guaranteed positive for all $d$. Thus, $\dot{d} > 0$.

Moreover, the more difficult it is for individuals to perceive the external benefits of their consumption, the higher will be $d'$. In Nyborg et al. (2006)’s words:

“The external effects of green versus brown energy use, for example, are not visible for the customer, at least not during the process of consumption; nothing obvious happens when you turn on the light that might remind you that somewhere else this action imposes environmental harms.” (Kempton, 1993, in Nyborg et al., 2006, p.362).

And consequently, higher the turning point $d'$, more are the efforts needed to avoid the economy to slide back to NE (0).

Likewise, the government might positively affects the society perception over the rate of adoption of the green electricity. The self-image benefits that arise from the green electricity consumption are also dependent on the individual assessment of the relative rate of adopters, $(d)$. And, it is reasonable to assume that such assessment is problematic, that is, in the electricity market the consumer has imperfect information of the number of adopters. Differently form recycling behaviour, when it is possible to have some information on how one’s neighbour disposes his garbage, electricity choices are made “between four walls” and rarely observed by others. Here again there is imperfect information and thus space for advertising campaigns to influence the beliefs on $d$.

If policies can create an assessment $\hat{d}$ that exceeds the turning point $d'$, it would put the economy in motion towards NE (1) regardless of the true value of $d$. Moreover, even if $\hat{d}$ is proved a false assessment afterwards, the initial push is enough to lead the economy to the full adoption equilibrium and it would not return to the initial NE (0). Nyborg et al (2006) state that “as long as the false belief was replaced by a correct perception after the point is reached at which $d > d'$, the dynamics of consumer
behavior would not be reversed, and the economy would converge to the full participation equilibrium NE (1).”\(^\text{16}\) (Nyborg et al., 2006, p. 361)

No initiative that aims to produce a change in consumer demand behaviour towards green electricity will succeed unless both \(Y\) and \(d\) are addressed. Such policies would guarantee the permanently shift of the equilibrium to NE (1) and since the new reached point is a stable equilibrium the comparative statics results seen for \(d = 1\) are valid.

Hence, information policies can have a great influence the demand for renewable electricity once they tig the consumers’ personal domain. It is clear that there is a beneficial environment to promote the consumption of green electricity due to the EU disclosure directive and the establishment of electricity tracking by the use of Guarantees of Origin. However, behaviour scholars call attention to the fact that the simple disclosure of information is not enough. Policy makers should also pay attention to the personal domain of the consumers inserted in the market. The personal domain refers to the individual values as the quest for self-image.

Discrepancies in the information affecting the personal domain pose the biggest threat to the voluntary demand scheme. As self-image is affected by the awareness of environmental impacts that green electricity has and by the perception of the share of individuals in the society that choose green, policies may seek to alter behaviour by appealing to advertising campaigns that increase the society’s valuation of these variables. Information and advertising campaigns that can increase the society’s perception over the rate of adoption of the green good and the perception over the environmental impacts of the green electricity choice, even if temporally, are enough to bring the economy to an equilibrium were all choose green electricity.

6. Conclusions and Future Work

Green electricity consumption induced by improved information on electricity sources appears as an additional option to target externalities from power production. It is believed that a shift of the demand towards green sources can stimulate renewable

\(^{16}\) The original sentence refers to \(a\) instead of \(d\) and \(a'\) instead of \(d'\). This was altered to match the notation of the thesis.
generation and have a positive impact on the environment. With the liberalization of power markets and the emergence of legislation that requires disclosure of electricity sources by the use of tracking certificates, this idea became a viable alternative to support policies ruling today and now environmental responsibilities are closer to consumers.

This voluntary demand program has a substantial objective and the consumer is in the centre of this approach. In a situation where consumers are gaining more and more space in the energy panorama, understanding the consumer behaviour towards green electricity is key to the success of this initiative. Such system will only work if it is perceived worth paying a premium for electricity generated from green sources. Paying attention to this potential, the present work aimed to: (1) identify and understand the main drivers of consumers’ willingness to pay (WTP) for green electricity; (2) study the economic models that embrace these factors; (3) based on the models, comprehend how the demand for green electricity is affected by external parameters; and finally (4) discuss how policies might affect the behaviour towards green electricity. It is believed that the discussion around these four points can increase the knowledge in the field and contribute to the achievement of ideas set by the voluntary demand mechanism.

It is possible to conclude first that the consumer willingness to pay for green electricity is dependable in a greater extent on the individual’s values than on economic factors. Empirical evidence let clear that self-image motivation that result from acting as a socially responsible person appears as the main driver of consumers’ WTP for a green electric product. Also important are altruistic motivations i.e. concerns about the environmental consequences of their electricity choice. Such drivers of consumer’s willingness to pay shape the individual’s awareness of consequences and his personal responsibility to act leading to an intended behaviour towards green electricity what might result in actual purchase of the green electric product. External factors as market prices, income, household size and education were also revealed as variables to influence consumer behaviour, but are not as relevant as the individual’s values, i.e. as the consumer personal domain.

Moreover, the evidence also let apparent that there are negative factors that influence the green electricity choice. It is clear that green electricity consumption behaviour results from an interaction of the personal domain and the external domain, which is the institutional environment where the individual is inserted. While EU directives set a solid foundation to promote the consumption of renewable electricity,
information discrepancies act as obstacles to behaviour towards green electricity. Lack of knowledge about the possibility of purchasing renewable electricity in a credible way, flaws in informing the consumers about the society consumption patterns and lack of information on environmental benefits that the purchased green electricity holds have a negative effect on behaviour and consequently prevent consumers from fully demanding green electricity. These are the main barriers identified in this thesis and what possibly explain the existence of a considerable gap between intended and actual consumption of green electricity.

Next, the thesis developed three economic models that represent the consumer problem when given a choice between green and conventional (brown) electricity. It is clear that the textbook model of consumer problem, which sees green and brown electricity as perfect substitutes, is an oversimplified framework and it is far from the empirical findings. But, when electricity is understood as not only a way of turning the lights on but also as a good that carries environmental attributes that is, a joint product, the discrepancies between the models and the reality start to narrow.

Two models were built following the joint product idea. In the first, green electricity was interpreted as a good that generates not only a private characteristic (physical electricity) but also a public good (environmental benefit). In the second model, the notion of a joint product was taken even further and it was assumed that green electricity leads not only to an environmental benefit but also to self-image improvements for the individual. This third model adds environmental concerns and self-image motivations into the consumer problem and thus is the best representation of the main drivers of willingness to pay seen.

The comparative statics derived for the model allowed the thesis to analyse how the external factors interact with the demand for green electricity. Here, the effects of changes in prices, in income, and, when available, in the exogenous level of the public good where analysed. It became clear that no matter the equilibrium point (\(d=0\), where no one chooses the green alternative, or \(d=1\), where green is widely adopted), the green demand is decreasing in prices of green electricity \(p_g\) and ambiguous for changes in prices of conventional electricity \(p_c\). However, it is clear that while in the first equilibria, the demand for green electricity is unaffected by changes in income \(m\), in the superior equilibria (when \(d=1\)), \(g\) is positively affected by both income and beliefs in the external level of the public good \(\tilde{Y}\).
Moreover, the fact that the demand for green electricity is positively affected by the external level of the public good (\(\bar{Y}\)) also confirms the importance of self-image as driver of the demand for green electricity. When only environmental concerns were taken into account, the influence of the external level of the public good in \(\bar{g}\) was ambiguous, i.e. it could lead to both an increase and a decrease in demand. However, with impure altruistic motivations, as self-image, such doubt is withdrawn.

Given the evidence of an existing gap between intended and actual willingness to pay for green electricity and the fact that information discrepancies appeared as the main reason for such outcome, the thesis focused next on discussing how to promote behaviour change through improving information. Not only behavioural theorists already called attention to the importance of information in reducing the gap between intended and actual pro-environmental behaviour, but also the results draw from the last model confirm that information and advertising campaigns can have a great impact in increasing the demand for green electricity.

As discussed, although there are institutional problems on the disclosure of information (difficulties in finding information and lack of credibility on it), more disturbing are the problems that directly affect the personal domain. The simple disclosure of information is not enough to achieve behavioural change. Policy makers should also pay attention to the variables that affect the buyers’ quest for self-image, since it is proved the main driver of consumers’ WTP. As it was seen, policies that aim to increase consumers’ awareness over the environmental impacts of their electricity choice and over the consumption patterns of the society will impact the individual’s self-image and consequently cause a positive and long lasting shift in the demand for green electricity. Such policies, even if temporary, could lead the economy to a point where green electricity is largely adopted.

Understanding the consumer behaviour and his demand comportment when given an electricity choice is crucial for the success of demand-sided programs that aims to let the consumer be the driver of change in a green economy. It is clear for this thesis that the liberalization of power markets and the disclosure legislation started a fruitful environment for electricity consumer to have a voice in the energy scenery and make conscious choices. However, this is only a starting point and, to successful promote a behavioural change, policy makers should focus on affecting consumers’ self-image. It is hoped that this thesis fulfilled its objectives contributing to the knowledge in this field and proposing new measures so that the voluntary scheme can fully achieve its goals.
Further research in specific topics discussed in this thesis would be very beneficial. Combining the theoretical analysis of this thesis with empirical evidence on the information policies suggested would provide powerful insights about how information actually affects the demand for green electricity. Future work could, for example, help in determining the “turning point” of an economy, i.e. the point where, once reached, the economy is set into motion achieving the highest equilibrium and green choice is universal. Also, empirical evidence that would support the finding that temporary advertising campaigns are enough to put the economy into motion towards the highest equilibrium so that there is no turning back would benefit the voluntary demand scheme substantially.

Besides that, future research could consider analysing the interaction of green households, firms and a responsible government. Firms are the largest consumers of electricity and thus more likely to have an effect on the generation side if they opt for green electricity as well. While firms behaviour might be a reflection of the decision board values, and thus their consumption would be induced by similar drivers as the ones studied here, there is some evidence that firms are also prompted to buy green goods because they add value to the company’s final product. Going further, the government as an agent that wants to achieve certain environmental targets could also interact with firms and households in an general model. Combining firms, households and the government into one single model where not only firms and households would demand green electricity but also where firms would sell a greener final product to households and both inserted in a structure where the government wants to achieve renewable energy targets would lead to a wide view of the market and provide powerful insights to this topic.

Moreover, it cannot be left unnoticed the fact that nowadays more and more households are producing their own electricity and selling the excess to the grid. Such trend is spreading across Europe and future analysis on this subject is important. Finally, more attention could be given to the combination of support policies and the voluntary scheme. This thesis only briefly mentioned the possibility of crowding-out effects when support policies are also in use. Additional research on the interaction of both schemes is very important to this topic.
7. References


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8. Appendix

8.1. Appendix 1 - Notions of Microeconomics of the Consumer’s Problem and his WTP

The concept of willingness to pay (WTP) arises within the microeconomics of consumer theory, more specifically within the study of consumers’ preferences and demand function, trying to understand the variables that influence choice.

The so called “consumer problem” commonly concerns a rational consumer who aims to maximize his utility and achieves his best possible choice (Jehle & Reny, 2001). A utility function is simply a way of describing preferences and it assigns numbers to every possible consumption bundle, so that a higher number represents a more preferable bundle. The consumer problem is thus equivalent to the problem of maximizing the consumer’s utility \( u(x) \) subject to his budget constraint, \( p.x \leq m \) (where \( p \) is corresponding to a vector of market prices, \( x \) to the units of the good and \( m \) is the consumer’s income, \( m \geq 0 \)). As can be seen in the first part of the figure below, the optimal choice of the consumer, \( x^*(p, m) \), lies where the budget constraint intercepts the highest indifference curve of the consumer, i.e. the highest utility that the consumer can reach. If the prices of the goods change, it leads to a movement of the budget constraint and to a new optimum solution. The relationship between the quantity demanded of the good \( x_i \) and its own price \( p_i \), while all the other goods’ prices are held fixed, is known as Marshallian demand function or ordinary demand function and it can be seen in the second graph of Figure A1 (Jehle & Reny, 2001).

\[\text{There are a set of preferences axioms that guarantee the existence of a utility function as a representation of a preference relation. See Jehle & Reny (2001)}\]
Likewise, the consumer problem can be studied in terms of expenditure minimization subject to a certain level of utility. Here, the question is what is the minimum expenditure that a consumer must have, given a level of prices, to achieve a certain level of utility? (Jehle & Reny, 2001). In this case, the restrictions imposed by the income are forgotten. Instead, we have a problem expressed by

$$e(p, u) \equiv \min p \cdot x \quad s.t. \quad u(x) \leq u,$$

The solution to the problem is this second approach is known as Hicksian demand, $x^h(p, u)$ (Jehle & Reny, 2001).

The Hicksian demand and the Marshallian demand are equal at $u$ maximum point. Thus,

$$x^h(p, u^*) = x(p, m)$$

(A1)
Moreover, the expenditure function $e$ seen can substitute $m$ in this equality because $m=e$, in the maximum utility point (where $u = u(x^*)$) (Jehle & Reny, 2001). This leads to

$$x^h(p, u^*) = x(p, e(p, u^*)). \quad (A2)$$

Another important question within the consumer problem and his behaviour is to understand how the demand of a given product is affected by price and income changes. The Slutsky equation decomposes the changes into income effect and substitution effect and allows to better understanding of the changes.

The total effect of price changes in the demand of goods can be decomposed into two separated ones: the substitution effect and the income effect. Substitution effect refers to changes in the quantity demanded of goods due to changes in the relative prices. For example, if $p_1$ decreases, the substitution effect leads to an increase on the amount consumed of $x_1$ and the consumption moves away from $x_2$. At the same time, with the same initial budget $m$, the consumer can now purchase more than before. In this sense, the consumer “gained” some income due to the decrease of $p_1$. This second effect is known as income effect.

The figure that follows explains the Slutsky decomposition. Image that initially the consumer faces prices as $p^0_1$ for good 1 and $p^0_2$ for good 2. With such prices, the consumers achieves a utility level $u^0$ and buys quantities $x^0_1$ and $x^0_2$. Supposing a decrease in the price of good 1 to $p^1_1$, the total effect of this decrease would shift the budget constraint to the point where the consumer chooses $x^1_1$ and $x^1_2$, i.e. the price decrease leads to an increase of the consumption of good 1 and a decrease of good 2. To apply the Slutsky decomposition, this total effect is broken into a substitution effect and an income effect.

It is first observed the quantity choices at the new prices, but allowing the consumer to maintain his original level of utility. In this case, the consumer hypothetical budget constrain is represented by the dashed line, and the quantities consumed would be $x^h_1$ and $x^h_2$. Under these circumstances, it can be noted that the consumer would increase the consumption of good 1, which is now relatively cheaper, and would decrease his consumption of good 2. This is the substitution effect and it is “purely” due to changes in the relative prices (Jehle & Reny, 2001). Secondly, the changes from $x^h_1$
and $x_2^h$ to $x_1^1$ and $x_2^1$ occur because at the new prices and the initial level of utility, the consumer was given an increase in his real income, what leads to the movement from the dashed budget constrain to the final one. This is the income effect, and it is “due purely” to income –like changes that accompanies a price changes” (Jehle & Reny, 2001, p. 51).

**Figure A2 – Slutsky Decomposition**

The Slutsky equation summarizes the relationship of total effect (TE), substitution effect (SE) and income effect (IE). It is given as follows (Jehle & Reny, 2001)

$$
\frac{\partial x_i(p, m)}{\partial p_j} = \frac{\partial x_i^x(p, u^*)}{\partial p_j} - x_j(p, m) \frac{\partial x_i(p, m)}{\partial m},
$$

where $i,j = 1, ..., n$ and $x_i(p, m)$ represents the demand of $x_i$ as a function of prices and income (i.e., the Marshalian demand system). Let $u^*$ represents the level of utility that

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18 The notation is slightly different from the one in Jehle & Reny (2001) so it matches the rest of the thesis.
the consumer can achieve at prices $p$ and income $m$; then $x_i^h(p, u^*)$ represents the Hicksian demand system.

The derivation of this equation comes from the relation expressed in (A2). The partial differentiation of (A2) with respect to $p_j$ leads to

$$\frac{\partial x_i^h(p, u^*)}{\partial p_j} = \frac{\partial x_i(p, m)}{\partial p_j} + \frac{\partial x_i(p, m)}{\partial e} \cdot \frac{\partial e}{\partial p_j},$$

rearranging,

$$\frac{\partial x_i(p, m)}{\partial p_j} = \frac{\partial x_i^h(p, u^*)}{\partial p_j} - \frac{\partial x_i(p, m)}{\partial e} \cdot \frac{\partial e}{\partial p_j}$$

and because $m=e$ in the maximum utility point and $\frac{\partial e}{\partial p_j} = x_j(p, m)$ due to Shepard’s lemma, it results in

$$\frac{\partial x_i(p, m)}{\partial p_j} = \frac{\partial x_i^h(p, u^*)}{\partial p_j} - x_j(p, m) \cdot \frac{\partial x_i(p, m)}{\partial m},$$

that is equal to (A3), the Slutsky equation.

The Slutsky equation, also called “Fundamental Equation of Demand Theory”, plays an important role in understanding the effects that price, income or any other parameter that may affect the demand for a certain good has on the amount consumed. The first term on the right side of the equation, the substitution effect, will always have a negative signal. The signal of the income effect is, however, not clear, it can be positive of negative depending of the type of goods. Normally, if a price of a product declines, the demand for it will increase all things being equal, what gives a positive sign for the term. Although this is often correct, it is not a universal the case. The so called inferior goods decrease in demand as prices fall\textsuperscript{19}.

These are all basic concepts within microeconomic theory and clarify that understanding consumer’s willingness to pay doesn’t fall way apart from analysing the behaviour of the demand for a given product that result from the maximization problem and how the demand is affected in case of income and prices changes.

\textsuperscript{19} Examples of inferior goods are uncommon, and also depend on geographical characteristics but studies have seen such behavior in the demand of rice and wheat flour in poor countries.
8.2. Appendix 2 – Slutsky Equation Derivation – Model with environmental concern

Having in mind equation (A2), in a model with environmental contribution the equation can be rewritten as

\[ Y^h(p_c, \pi, u^*) = Y(p_c, \pi, e(p_c, \pi, u^*)) \]  

(A4)

where \( e(p_c, \pi, u^*) \) replaces the full income, \( w \).

The same steps to derivate the Slutsky equation in Appendix 1 can be taken here. Taking the partial differentiation of (A4) with respect to \( \pi \) it leads to

\[ \frac{\partial Y}{\partial \pi} = \frac{\partial \hat{Y}}{\partial \pi} + \frac{\partial \hat{Y}}{\partial e} \cdot \frac{\partial e}{\partial \pi}, \]

where \( \hat{Y} \) represents demand for \( Y \), such that \( \hat{Y} = \hat{Y}(\pi, p_c, w) \) and \( \hat{Y} \) the Hicksian demand for \( Y \). Rearranging it and using the fact that \( e = w \) and that \( \frac{\partial e}{\partial \pi} = \hat{Y} \), it leads to

\[ \frac{\partial \hat{Y}}{\partial \pi} = \frac{\partial \hat{Y}}{\partial \pi} - \hat{Y} \cdot \frac{\partial \hat{Y}}{\partial w} \]  

(A5)

Similarly, the partial differentiation of (A4) with respect now to \( p_c \) leads to

\[ \frac{\partial \hat{Y}}{\partial p_c} = \frac{\partial \hat{Y}}{\partial p_c} + \frac{\partial \hat{Y}}{\partial e} \cdot \frac{\partial e}{\partial p_c} \]

rearranging and using the fact that \( e = w \) and that \( \frac{\partial e}{\partial p_c} = \hat{X} \); where \( \hat{X} \) represents demand for \( X \), it leads to

\[ \frac{\partial \hat{Y}}{\partial p_c} = \frac{\partial \hat{Y}}{\partial p_c} - \hat{X} \cdot \frac{\partial \hat{Y}}{\partial w} \]  

(A6)

Now, letting \( \theta \) represent any of the exogenous parameters \( (m, p_c, \pi, \hat{Y}) \), the comparative static results for the demand of \( Y \) is given by
Using these results together with (A5) and (A6) it leads to

\[ \frac{\partial \gamma}{\partial \theta} = \left( \frac{\partial \gamma}{\partial \pi} - \hat{Y} \cdot \frac{\partial \gamma}{\partial \pi} \right) \cdot \frac{\partial \pi}{\partial \theta} + \left( \frac{\partial \gamma}{\partial p_c} - \hat{X} \cdot \frac{\partial \gamma}{\partial p_c} \right) \cdot \frac{\partial p_c}{\partial \theta} + \frac{\partial \gamma}{\partial w} \cdot \frac{\partial w}{\partial \theta} \]

which is the final Slutsky equation and can be written in a more compact notation as

\[ \hat{Y}_\theta = \hat{\pi}_\pi \pi_\theta - \hat{Y}_w \pi_\theta + \hat{Y}_p \pi_{c\theta} - \hat{X}_w p_{c\theta} + \hat{Y}_w w_\theta, \]

or

\[ \hat{Y}_\theta = \left( \hat{\pi}_\pi - \hat{Y}_w \right) \pi_\theta + \left( \hat{Y}_p - \hat{X}_w \right) p_{c\theta} + \hat{Y}_w w_\theta \]

where \( \hat{Y}_\theta = \frac{\partial \gamma}{\partial \theta}, \) \( \hat{\pi}_\pi \pi_\theta = \frac{\partial \gamma}{\partial \pi} \cdot \frac{\partial \pi}{\partial \theta}, \) \( \hat{Y}_p \pi_{c\theta} = \frac{\partial \gamma}{\partial p_c} \cdot \frac{\partial p_c}{\partial \theta} \) and \( \hat{Y}_w \pi_{w\theta} = \frac{\partial \gamma}{\partial w} \cdot \frac{\partial w}{\partial \theta}. \) This proofs equation (7) seen.

### 8.3. Appendix 3 – Slutsky Equation Derivation – Model with self-image

In this new model, the derivation of the Slutsky equation follows the process done in Appendix 2. The difference now is that instead of \( Y \), the equations should refer to self-image. Besides that, two equilibrium points are being analysed, when \( d=1 \) and \( d=0 \), what means that \( \hat{Y} \) is replaced here by either \( \hat{S}^0 \) or by \( \hat{S}^1 \).

In the case of \( d=0 \), (A5) can be rewritten as

\[ \frac{\partial \hat{S}^0}{\partial \pi} = \frac{\partial \hat{S}^0}{\partial \pi} - \hat{S} \cdot \frac{\partial \hat{S}^0}{\partial m}. \]  \hspace{1cm} (A7)

and for the differentiation with respect to \( p_c \),

\[ \frac{\partial \hat{S}^0}{\partial p_c} = \frac{\partial \hat{S}^0}{\partial p_c} - \hat{X} \cdot \frac{\partial \hat{S}^0}{\partial m}. \]  \hspace{1cm} (A8)

The comparative results in this case are
\[
\frac{\partial \tilde{S}^0}{\partial \theta} = \frac{\partial \tilde{S}^0}{\partial \pi} \cdot \frac{\partial \pi}{\partial \theta} + \frac{\partial \tilde{S}^0}{\partial p_c} \cdot \frac{\partial p_c}{\partial \theta} + \frac{\partial \tilde{S}^0}{\partial m} \cdot \frac{\partial m}{\partial \theta},
\]

and substituting (A7) and (A8) in it, it leads to

\[
\tilde{S}^0_\theta = (\tilde{S}^0_\pi - \tilde{S}^0_{\overline{\pi}})\pi_\theta + (\tilde{S}^0_{p_c} - \tilde{X}^0_{\overline{S}^0_{\overline{m}}})p_{c\theta}.
\]

the first Slutsky equation for this model. And where again a compact notation was used
to facilitate the analysis: \( \tilde{S}^0_\theta = \frac{\partial \tilde{S}^0}{\partial \theta} \cdot S_\pi^0 \pi_\theta = \frac{\partial \tilde{S}^0}{\partial \theta} \cdot \frac{\partial S_\pi^0}{\partial \theta} \cdot \tilde{S}_p^0 p_{c\theta} = \frac{\partial \tilde{S}^0}{\partial \theta} \cdot \frac{\partial p_c}{\partial \theta} \cdot \tilde{S}_m^0 \pi_\theta =
\]

\[\frac{\partial \tilde{S}^0}{\partial m} \cdot \frac{\partial \pi}{\partial \theta} \text{ and } \frac{\partial \tilde{S}^0}{\partial p_c} \cdot \frac{\partial p_c}{\partial \theta} \text{ and } \frac{\partial \tilde{S}^0}{\partial m} p_{c\theta} = \frac{\partial \tilde{S}^0}{\partial m} \cdot \frac{\partial p_c}{\partial \theta} \cdot \tilde{S}_m^0 \pi_\theta =
\]

In the case of \( d=1 \), (A5) can be rewritten as

\[
\frac{\partial \tilde{S}^1}{\partial \pi} = \frac{\partial \tilde{S}^1}{\partial \pi} - \tilde{\pi} \cdot \frac{\partial \tilde{S}^1}{\partial \pi}.
\] (A9)

and for the differentiation with respect to \( p_c \),

\[
\frac{\partial \tilde{S}^1}{\partial p_c} = \frac{\partial \tilde{S}^1}{\partial p_c} - \tilde{\pi} \cdot \frac{\partial \tilde{S}^1}{\partial \pi}.
\] (A10)

The comparative results in this case are

\[
\frac{\partial \tilde{S}^1}{\partial \theta} = \frac{\partial \tilde{S}^1}{\partial \pi} \cdot \frac{\partial \pi}{\partial \theta} + \frac{\partial \tilde{S}^1}{\partial p_c} \cdot \frac{\partial p_c}{\partial \theta} + \frac{\partial \tilde{S}^1}{\partial w} \cdot \frac{\partial w}{\partial \theta}.
\]

Note that now full income is taken into account. Adding (A9) and (A10) into it, the
Slutsky equation for this new case will then be

\[
\tilde{S}^1_\theta = (\tilde{S}^1_\pi - \tilde{S}^1_{\overline{S}^1_{\overline{w}}})\pi_\theta + (\tilde{S}^1_{p_c} - \tilde{X}^1_{\overline{S}^1_{\overline{w}}})p_{c\theta} + \tilde{S}^1_{w} w_{\theta}.
\] (14)
The same compact notation applies here with the difference that now the superscript is 1, referring to the second equilibrium and the additional last term is
\[ \tilde{S}^{1}_w w_\theta = \frac{\partial \tilde{S}^{1}_w}{\partial w} \cdot \frac{\partial w}{\partial \theta} . \]

8.4. Appendix 4 – Replicator Equation

Evolutionary game theory focuses on the dynamics of strategy change. It assumes that populations can evolve in sense that their probability of a choice changes with time. Thus, in the case studied in this thesis, \( d \) is dependent on time such that \( d(t) \) and \( \dot{d}(t) \) is the velocity which \( d \) changes. The interest here is on the growth rate \( \dot{d}/d \) of the frequencies of the strategies and how it evolves. (Sigmund, 2011)

The replicator equation is a good representation of such evolution. Such equation states that the growth rate of the strategy (in this case, \( d \)) corresponds to the strategy’s payoff or, more precisely, to the strategy’s payoff minus the average payoff in the society (Sigmund, 2011, p.9).

In the model game, a share \( d \) chooses green with probability \( d' \) and receives a payoff of

\[ \text{Payoff} = (S(Y, d) - h)1 , \]

while those who choose the conventional electricity have a payoff of 0.

According to the formulation of the replicator equation, it leads to

\[ \dot{d} = d(s(Y, d) - h) - \{d'[d(s(Y, d) - h)] + 0\} , \]

and to

\[ \dot{d} = d(1 - d)(s(Y, d) - h) , \]

which correspond to equation (16) seen.